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# Anaesthesiology Intensive Therapy

## Anestezjologia Intensywna Terapia

Official Journal
of the Polish Society
of Anaesthesiology
and Intensive Therapy

### Poster presentations, invited abstracts and learning objectives

## 6th International Fluid Academy Days

### November 23–25, 2017
### Antwerp, Belgium

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**Editorial Address:**
Prof. Radosław Owczuk MD, PhD
Klinika Anestezjologii i Intensywnej Terapii
Gdańskiego Uniwersytetu Medycznego
ul. Smoluchowskiego 17, 80–214 Gdańsk, Poland
phone: +48 58 349 32 81, +48 58 349 32 80, fax: +48 58 349 32 90
e-mail: ait@gumed.edu.pl, www.ait.viamedica.pl

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# 6th International Fluid Academy Days

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## Poster presentations

# INVITED ABSTRACTS — LEARNING OBJECTIVES

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# Poster presentations

## P002. Hemodynamic goal-directed therapy in high blood pressure

*Francisco Chacon–Lozsan, Maryan Rodriguez–Torres, Ruben Rojas*

Critical Care Department, Caracas Central University Hospital, Universidad Central de Venezuela, Caracas, Venezuela
Contact: franciscojlk@hotmail.com

**Background:** Hypertension is one of the most important risk factors to cardiovascular and cerebrovascular events. Since 1996. researchers are trying to make a different approach to control high blood pressure. Hemodynamic method takes parameters to estimate fluid retention, cardiac index and vascular resistance to guide pharmacotherapy according witch parameters are high.

**Objectives:** Determine blood pressure control using goal directed hemodynamic parameters.

**Methods:** A prospective non-randomized study was performed, 86 patients with primary non-controlled hypertension using two or more hypertensive agents were recruited, 1 week placebo treatment with captopril washout before hemodynamic analysis and treatment indication. we measured blood pressure using oscillometric sphygmomanometer, Cardiac index calculated using transthoracic echocardiogram and systemic vascular resistance index by formula (SVRi = mean blood pressure * central venous pressure/ /cardiac index * 79.9), inferior vena cava variation index using ultrasound and classified in Hyperdynamic, hypodynamic, vasoconstricted or fluid retention using Sramek et al classification, pharmacotherapy was also guided by Sramek et al algorithm with a 3 months follow up.

**Results:** 86 patients was recruited between 30 and 76 years old, 59% female, 41% male, basal blood pressure was 178 ± 23.5 mm Hg, basal diastolic blood pressure was 99 ± 16.5 mm Hg, basal mean blood pressure was 126 ± 16.7 mm Hg, Cardiac index 3.09 ± 1.07 L min $m^{-2}$. SVRi 3543 ± 1553 dynes, no statistic variation was observed in parameters during washout, after classification 25 patients were hyperdynamic, non-hypodynamics patients, 46 in vasoconstricted group and 15 patients in fluid retention group. Statistical significant blood pressure reduction ($P < 0.0001$) was observed in the first month after hemodynamic directed therapy with a 69.7% of controlled patients at first month, and 91.8% at three months of treatment according European hypertension guidelines with normalization in hemodynamic parameters.

**Conclusions:** Hemodynamic goal-directed therapy resulted in a significant reduction of blood pressure and improvement in blood pressure control.

**Key words:** hypertension, hemodynamics, goal-directed therapy

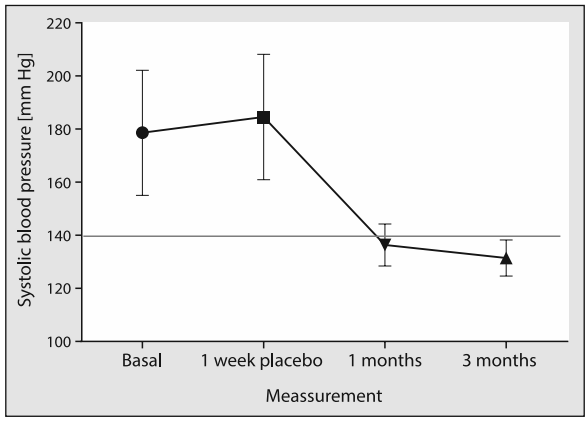


**Figure 1.** Systolic blood pressure control using hemodynamic goal--directed therapy (below left)

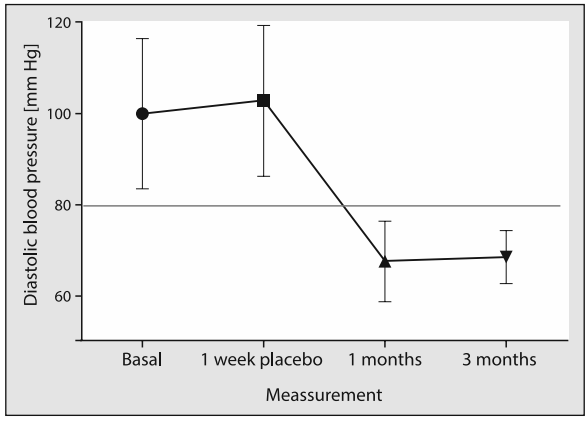


**Figure 2.** Diastolic blood pressure control using hemodynamic goal--directed therapy (above right)

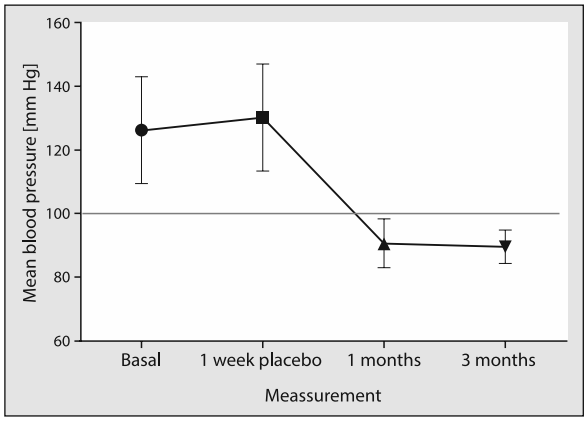


**Figure 3.** Mean blood pressure control using hemodynamic goal--directed therapy

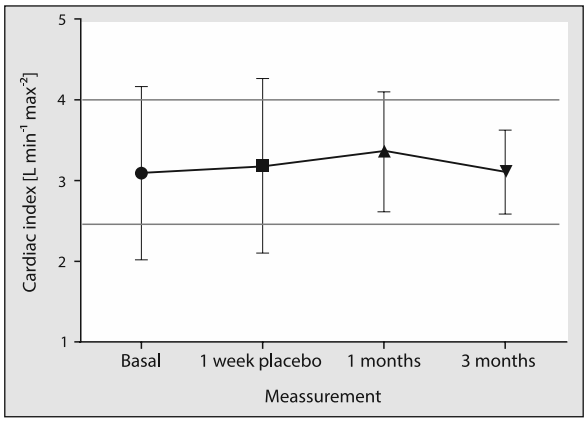


**Figure 4.** Cardiac index control using hemodynamic goal-directed therapy

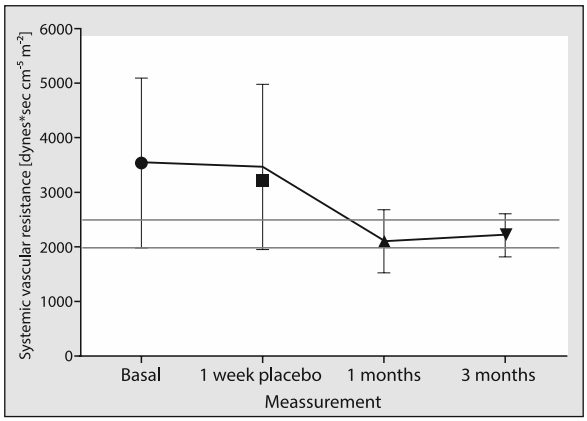


**Figure 5.** Systemic vascular resistance control using hemodynamic goal-directed therapy

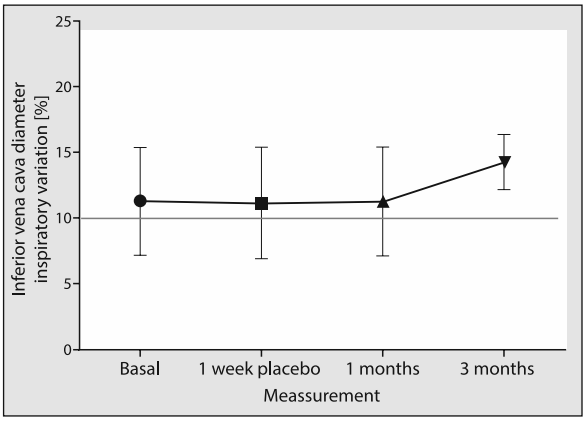


**Figure 6.** Inferior vena cava diameter variation using hemodynamic goal-directed therapy

## P004. Role of diaphragm excursion in prediction of weaning from mechanical ventilation

*Syed Tariq Reza[1], Mozaffer Hossain[2], Syeda Nusrat Jahan[3]*

[1]Intensive Care Unit, Dhaka Medical College Hospital, Dhaka, Bangladesh

[2]Anaesthesia, Analgesia, Palliative and Intensive Care, Dhaka Medical College Hospital, Dhaka, Bangladesh

[3]Community Medicine, Shaheed Suhrawardy Medical College, Dhaka, Bangladesh

Contact: reza-tariq@yahoo.com

**Background:** Diaphragm is the principal muscle of respiration. Impaired function of diaphragm can lead to difficulty in weaning. Mechanical ventilation can cause fatigue and weakness of diaphragm. Bedside ultrasonography is a simple noninvasive method of direct visualization of diaphragm function and diaphragm excursion can be a useful tool to assess weaning from mechanical ventilation.

**Objectives:** The aim of the study was to evaluate the efficacy of diaphragm excursion in guiding weaning from mechanical ventilation.

**Methods:** It was a prospective observational study and conducted among purposively selected 35 patients with mechanical ventilation in ICU of Dhaka medical College Hospital as per inclusion criteria. Patients underwent spontaneous breathing trial when they fulfill the following criteria: $FiO_2 < 0.5$, PEEP ≤ 5 cm of H2O, $PaO_2/FiO_2 < 200$, respiratory rate < 30 breaths/min, absence of fever, alert and co–operative and hemodynamically stable without any vasoactive drug. Right sided diaphragm was visualized using liver as

an acoustic window at the mid clavicular line using 1–5 MHz low frequency probe and diaphragm excursion was measured in M-Mode in quiet breathing. Patients were grouped into normal diaphragm excursion and reduced diaphragm excursion (cut of value 1.00 cm). Each group was followed up to 48 hours to see success of weaning.

**Results:** Among 35 patients enrolled in the study 51.4% had normal diaphragm excursion and 48.6% had reduced diaphragm excursion. Mean duration of ventilator support and length of ICU stay were prolonged in reduced diaphragm excursion group. There was significantly increased success rate in normal diaphragm excursion group compared to reduced diaphragm excursion group (94.1% vs. 61.1%) in spontaneous breathing trial ($P = 0.41$). Significant difference was found in Kaplan-Meier plots between normal and reduced diaphragm excursion group and probability of remaining on spontaneous breathing was higher in normal diaphragm excursion group (Log rank $P = 0.017$).

**Conclusions:** This study concluded that diaphragm excursion can predict weaning from mechanical ventilation. Table 1 shows baseline characteristics of study population. Table 2 shows 51.4% patients had normal diaphragm excursion and 48.6% patients had reduced diaphragm excursion. Table 3 shows there is no significant association between age group and diaphragm excursion. Table 4 shows that reduced diaphragm excursion was higher among male patients than female but it is not statistically significant. Table 5 shows ICU stay was prolonged in reduced diaphragm excursion patients group though it is not statistically significant. Mean duration of mechanical ventilation was also significantly higher in reduced diaphragm excursion patients group. Table 6 shows that there was significantly higher success in weaning in normal diaphragm excursion than reduced diaphragm excursion (94.1% vs. 61.1%). Figure 1 shows significant difference was found in Kaplan-Meier plots between normal and reduced diaphragm excursion group and higher probability of remaining on spontaneous breathing in normal diaphragm excursion group (Log rank $P = 0.017$).

**Table 1.** Patients characteristics at baseline (n = 35)

| Characteristics | Value |
|---|---|
| Age in year (mean ± SD) | 35.63 ± 13.14 |
| Sex | |
| Female | 17 (48.6%) |
| Male | 18 (51.4%) |
| Diaphragm excursion in cm (mean ± SD) | 1.0069 ± 0.474 |
| Length of ICU stay in days (mean ± SD) | 12.77 ± 5.24 |
| Length of ventilator support (mean ± SD) | 11.17 ± 5.14 |

**Table 2.** Distribution of patients by diaphragm excursion (n = 35)

| Variables | f | % |
|---|---|---|
| Normal diaphragm excursion[a] | 17 | 51.4 |
| Reduced diaphragm excursion[a] | 18 | 48.6 |
| Total | 35 | 100 |

a = cut of value of diaphragm excursion was 1.00 cm
f = frequency

**Table 3.** Distribution of patients by age between normal and reduced diaphragm excursion group (n = 35)

| Age group in years | Normal diaphragm excursion f (%) | Reduced diaphragm excursion f (%) | Total f (%) | *P*-value |
|---|---|---|---|---|
| ≤ 21–40 | 14 (77.8) | 8 (47.1) | 41 (62.9) | ns |
| 41–≥ 60 | 4 (22.2) | 9 (52.9) | 69 (37.1) | |
| Total | 18 (51.4) | 17 (48.6) | 35 (100) | |

ns = not significant, *P*-value extracted from $\chi^2$ test
f = frequency

**Table 4.** Distribution of patients by sex between normal and reduced diaphragm excursion group (n = 35)

| Sex group | Normal diaphragm excursion f (%) | Reduced diaphragm excursion f (%) | Total f (%) | *P*-value |
|---|---|---|---|---|
| Female | 11 (61.1) | 6 (35.3) | 17 (48.6) | ns |
| Male | 7 (38.9) | 11 (64.7) | 18 (51.4) | |
| Total | 18 (51.4) | 17 (48.6) | 35 (100) | |

ns = not significant, *P*-value extracted from $\chi^2$ test
f = frequency

**Table 5.** Comparison of mean duration of ventilator support and length of stay (in days) in ICU in normal and reduced diaphragm excursion group of patients (n = 35)

| Variables | Normal diaphragm excursion Mean (± SD) | Reduced diaphragm excursion Mean (± SD) | *P*-value |
|---|---|---|---|
| Duration of ventilator support (n = 35) | 10.18 (± 5.89) | 12.11 (± 4.26) | ns |
| Length of stay in ICU (n = 35) | 11.94 (± 6.20) | 13.56 (± 4.19) | ns |

ns = not significant, *P*-value extracted from independent two sample t test

**Table 6.** Comparison of weaning outcome in normal and reduced diaphragm excursion group (n = 35)

| Weaning | Normal diaphragm excursion f (%) | Reduced diaphragm excursion f (%) | Total f (%) | *P*-value |
|---|---|---|---|---|
| Success | 16 (94.1) | 11 (61.1) | 27 (77.1) | 0.041[s] |
| Failed | 1 (5.9) | 7 (38.9) | 8 (22.9) | |

s = significant, *P*-value extracted from fisher exact test
f = frequency

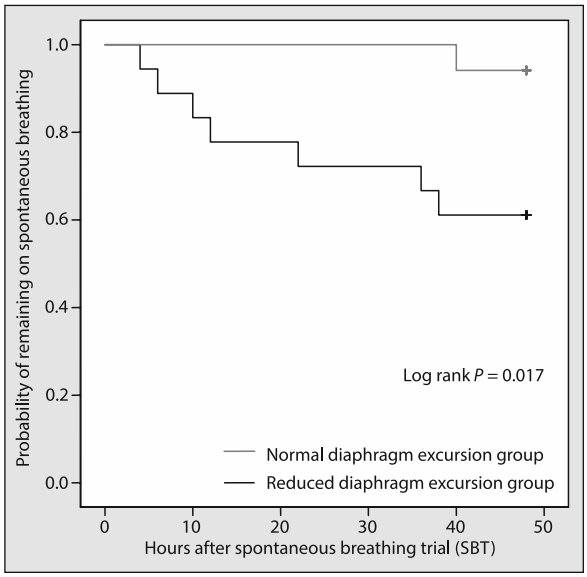


**Figure 1.** Plot of Kaplan-Meier for normal and reduced diaphragm excursion group

## P005. The impact of hypernatremia on endothelial glycocalyx in sublingual microcirculation in rabbit

*David Astapenko, Vlasta Dostálová, Vlasta jr Dostálová, Jaroslav Kraus, Pavel Dostál, Věra Radochová, Vladimir Černý*

Department of Anesthesia, Resuscitation and Intensive Care Medicine, University Hospital Hradec Kralove Hradec Kralove, Czech Republic

Contact: astapenko.d@seznam.cz

**Background:** The endothelial glycocalyx (EG) plays a significant role in the regulation of microcirculation. Due to its sugar-based nature it is very fragile structure. Hypernatremia belongs to factors damaging EG [1].

**Objectives:** Our aim was to describe the influence of hypernatremia on the EG in sublingual microcirculation in the rabbit.

**Methods:** Hypernatremia was induced in 26 rabbits by intravenous infusion of hypertonic saline: 3.2% and 10%. The microcirculation was evaluated by the Side-steam Dark Field imaging in the sublingual area at 3 time points: baseline, 20 minutes after infusion of 3.2% saline and 20 minutes after infusion of 10% saline. Damage of the EG was quantified automatically by GlycoCheck software by Perfused Boundary Region (PBR) variable indicating the amount of penetration of red blood cells (RBC) into the EG closer to endothelial cells. At the same time points, the blood samples were taken for assessment of the levels of syndecan–1. EG degradation product.

Data of PBR and syndecan–1 are presented as mean (standard deviation).

**Results:** There was correlation between hypernatremia and PBR changes (r = 0.61). As the serum natremia was rising in subsequent time points: 139.1 (1.7); 140.8 (3.0); 157.1 (2.5) mmol $L^{-1}$ the PBR raised in the same fashion: 1.98 (0.25); 2.06 (0.26); 2.17 (0.17) μm. The level of syndecan–1 did not reflect this trend: 1.22 (0.34); 1.37 (0.45); 1.26 (0.34) ng $L^{-1}$.

**Conclusions:** Hypernatremia increased PBR values in our animal model, probably due to compression of the EG related to temporary intravascular hypervolemia and changes of the EG charge in RBC instead of direct damaging effect on EG, that has been excluded by unchanged levels of syndecan–1.

**Acknowledgements:** Supported by Ministry of Health of the Czech Republic, grant nr. 15–31881A. 

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## P006. The impact of blood group on survival following critical illness

*Robert Slade, Raza Alikhan, Matt P. Wise, Lam Germain, Matt P.G. Morgan*

Department of Critical Care, University Hospital of Wales, Cardiff, Wales, UK

Contact: rslade1@doctors.org.uk

**Background:** Predicting patient outcomes following critical illness is challenging. Although genetic variation is known to be one factor in determining survival following admission to intensive care, these are difficult to measure in clinical practice [1]. Recent evidence has suggested that patients with blood group AB are more likely to survive following major cardiac surgery and this is associated with a reduced number of blood transfusions [2]. There is a body of evidence which suggests that blood group AB has higher levels of Von-Willebrand factor and factor VIII [3, 4], making this group more pro-thrombotic. Whilst this may increase the risk of both arterial and venous thrombotic events [5, 6] it may be beneficial in patient groups where bleeding risks are high. However, there are no current data to indicate whether a patient's blood group affects general intensive care outcomes.

**Objectives:** The objective of the study was to determine if ABO blood group affects survival in intensive care. The primary outcome measure was 90-day mortality with a secondary outcome measure of the percentage of patients receiving a blood transfusion.

**Methods:** We performed a retrospective cohort analysis of all patients admitted to the Intensive Care Unit of a major tertiary University Hospital (mixed surgical and medical) between 2006 and 2016 where ABO blood group data were available. Baseline characteristics for each blood group were collected including, age, gender, BMI, surgery during admission, days in hospital, ethnicity and APACHE II score. 90-day survival was estimated by Kaplan-Meier plots, with binary logistic regression used to calculate odds ratios between different blood groups. ABO blood groups were individually compared and then pooled to compare AB vs. non-AB blood groups. A subgroup analysis was performed on patients that had surgery during their admission.

**Results:** 7340 patients were included in the study, blood group AB accounted for 3% (221), A 41% (3008), B 10.6% (775) and O 45.4% (3336). These values are similar to UK averages (7). Baseline characteristics between the groups were similar. Blood group AB had the greatest survival benefit when assessing per individual blood group (blood group AB 90–day survival estimate 76.75. 95% CI 72.89–80.61 with the overall estimate 72.07. 95% CI 71.31–72.82) (Log rank Chi square 16.128 $P = 0.001$). Transfusion requirements were similar in all groups with no significant difference between the percentages of patients transfused (AB 23.1%, A 21.5%, B 18.7%, O19.9%, Pearson chi square 5.060 p = 0.167). When pooling blood group data, Kaplan-Meier analysis showed blood group AB (n = 221) to have improved survival compared to non-AB blood groups (n = 7119) (blood group AB 90-day survival estimate 76.75, 95% CI 72.89–80.61 non-AB groups 71.92, 95% CI 71.15–72.69) (log rank Chi Square 3,890 $P = 0.049$). Compared with AB, non-AB groups had an odds ratio of for death of 1,413 (95% CI 1.002–1.992, $P = 0.049$). Blood group AB also showed an improved 90 day survival (blood group AB 83.89, 95% CI 79.64–88.14 with the overall estimate 78.26 95% CI 77.32–79.20) in the subgroup of patients who underwent surgery during their hospital admission, however this benefit was not statistically significant (log rank Chi Square 5.537, $P = 0.136$).

**Conclusions:** Intensive care patients with blood group AB have a higher 90-day survival compared with other blood groups. There was no correlation between blood group and percentage of patients receiving transfusion. Blood group AB is relatively rare accounting for 3% of the study population and therefore our study may have been underpowered to determine this bleeding risk. Improved survival outcomes in blood group AB are a promising area for further study including any mechanistic basis for this finding.

**Acknowledgements:** Thanks to Blood Bank at University Hospital of Wales for their help with extraction of blood group and transfusion data.

**Key words:** blood group; ICU; survival benefit

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## P007. Traumatic brain injury in children

*Amine Naili, Hadjer Triki, Salima Bouderra, M. Krime, N. Benani, K. Bouaita*

Department of neuro-critical care, Hospital Sidi Ghiles, Tipaza, Algeria

Contact: drnailiamine@yahoo.fr

**Background:** Brain injury in children is common and mild in most cases, but it remains the leading cause of death and disability in children over one year of age worldwide. The peculiarity of the child is that he possesses not mature brain and that the consequences of injuries acquired by traumatic brain injury can lead to the loss of capacities, as well as the non-acquisition of function, but above all the risk impact on learning abilities.

**Objectives:** The objective of the study is to define the incidence rate of cranial trauma in children as well as the mortality and morbidity of this scourge which presents a major public health problem.

**Methods:** It is a descriptive retrospective study of a series of 186 children hospitalized in neuro-resuscitation service during the period January 01 to December 31, 2016, including 22 children admitted for cranial trauma. Clinical, para-clinical, etiological and therapeutic data were collected from hospitalization records

**Results:** In a series of 186 children hospitalized during the defined period, 22 children were admitted for cranial trauma, i.e. a frequency of 12%. The average age was 6 years [6h of life–14 years], with a sex ration of 1/Among the 22 children, 12 had severe head trauma, a rate of 55%; whose causes are variable: 6 road accidents, 3 domestic accidents, 2 traffic accidents, and 1 obstetric accident, admitted with a pediatric Glasgow score between 5 and 10, and all required mechanical ventilation. Of the 22 head trauma, 10 were operated for different lesions: 3 extra-dural hematomas, 3 cranio-cerebral wounds, 2 sub-dural hematomas, 1 decompressive craniectomy, and 1 embarrure. 02 children had died following severe head trauma, i.e. a mortality rate of 9%, the morbidity rate of head trauma in the Tipaza wilaya was 1.1/100,000 children/year, the average length of stay in intensive care units was 22 days, with several complications of decubitus, and functional due to the primary and secondary lesions of the cranial trauma.

**Conclusions:** The head trauma of the child is a public health problem, its functional prognosis can be dramatic when it is severe, its management must be early and multidisciplinary

## P008. Management of hemorrhagic risk in children during neurosurgery

*Amine Naili, Hadjer Triki, Salima Bouderra*

Department of neuro-critical care, Hospital Sidi Ghiles, Tipaza, Algeria

Contact: drnailiamine@yahoo.fr

**Background:** The hemorrhagic risk in children in neurosurgery is considered to be high because the life expectancy can be rapidly brought into play, if its management is not immediate, unlike the adult, child and especially in the infant and the newborn can lead to a hemorrhagic shock because the mechanisms of adaptation of the $TaO_{2\ t}$o the needs of the organism are more fragile than in the adult.

**Objectives:** The objective of the study is to evaluate this hemorrhagic risk and to understand its pathophysiological mechanism in order to prevent it before curing it.

**Methods:** It is a descriptive retrospective study of a series of 122 children hospitalized in neuro-resuscitation service during the period January 01 to December 31, 2016.
Clinical, para-clinical, etiological and therapeutic data are collected from hospital records

**Results:** Of the 122 hospitalized children, 45 operated for tumor pathology, 32 operated for craniostenosis, 23 children operated for congenital malformations of the spine, and 22 admitted for cranial trauma of which 10 operated. The age ranged from (1 day to 15 years), 68% were 3 years or less. The main objective was to prevent the risk of bleeding in these children, especially since most of them were anemic preoperatively due to dehydration, tumor pathologies, but also due to bleeding in head trauma. The transfusion threshold was: hemoglobin < 10 g $dL^{-1}$ or < 30% hematocrit in the newborn, and Hb < 8 g $dL^{-1}$ or < 25% in infants less than one year of age, and Hb < 7 g $dL^{-1}$ in the rest of the children, with the exception of traumatized cranial or transfusion threshold was Hb < 10 g $dL^{-1}$, no matter the age of the child.In per-operative, strict monitoring of clinical signs of hypovolemia + temperature, hourly diuresis non-invasive monitoring of PAM, biology (rate of hematocrit in per-op). Of the 122 children, 85 showed signs of hypovolemia on bleeding, and required early resuscitation with rapid and effective filling, 58 required transfusion of iso-Rh isogroup phenotyped blood, and two showed hemorrhagic shock requiring transfusion and the introduction of cathecholamines, one of which died in per-operative.

**Conclusions:** The hemorrhagic risk in children and in particular in neurosurgery is certainly not negligible, that is why it is necessary to watch for it in preoperative, to monitor and to take care of it early in peroperative, to avoid its complications which can be rapidly harmful in children.

## P009. Surgical tracheotomy in neuro-reanimation

*Amine Naili, Hadjer Triki, Salima Bouderra, M. Morsli, K. Bouaita*

Department of Neuro-Critical Care, Hospital Sidi Ghiles, Tipaza, Algeria

Contact: drnailiamine@yahoo.fr

**Background:** The weaning of mechanical ventilation is an essential and delicate phase in the management of a resuscitation patient. The neurosurgical patient presents a number of specific problems, such as impaired control ventilatory control, coughing or the pharyngo-laryngeal intersection. However, it often allows short-term ventilatory withdrawal in the neurosurgical patient, probably largely by the simple fact that it authorizes the definitive cessation of sedation. The objective of the study and demonstrate the place of tracheotomy in neuro-resuscitation patients, and prevent its complications.

**Methods:** A retrospective descriptive study of 597 patients hospitalized in the neuro-resuscitation unit during the period 1 January to 31 December 2016, of which 113 patients benefited from surgical tracheotomy, is a frequency of 19% of all inpatients during this period. Clinical, para-clinical, etiological, and therapeutic data were collected from hospitalization records.

**Results:** In a series of 597 hospitalized patients, during the defined period, 113 patients had surgical tracheotomy, a frequency of 19%, in the literature two studies or the data were extremely variable, with 29% in the study Namen versus 2.9% in the Coplin study. Of the 113 tracheotomies, 6 were performed by neurosurgeons, and 107 by resuscitators at a frequency of 95%. The tracheotomy was performed on average 7 days after the intubation of the patients, after verification of the impossibility of the extubation of the latter either for central affection of the ventilatory controls, or reached the mixed nerves and disorders of the laryngo--pharyngeal intersection and according to expert recommendations in 2017: Tracheotomy should not be performed in the intensive care unit before the fourth day of mechanical ventilation. Different pathologies that patients suffered and required tracheotomy were: post-operative complications of brain tumors (brain stem and mixed nerves) with 52 patients, a rate of 46%, vascular pathologies (stroke and CVT), with 32 patients (28%), traumatic pathologies (severe cranial trauma and trauma of the cervical spine with signs of severity + occipital-vertebral hinge malformations), with 29 patients, i.e. 26%, 21 cases, 19%, 4 cases of secondary bleeding of the orifice, 2 cases of tracheal stenosis, and 1 case of trachea-malacia. The decannulation was made after pharyngolaryngeal neurological examination, and according to SFAR 2017 recommendations experts suggest that a multidisciplinary decannulation protocol available in resuscitation services.

**Conclusions:** Tracheotomy in neuro-resuscitation has its place, especially in view of the different complications specific to this type of patient, but no study has demonstrated its improvement in vital prognosis. Post-tracheotomy complications can be considerably reduced if the protocols and expert recommendations are rigorously applied.

## P010. Ability of a new smartphone pulse pressure variation and cardiac output application, to predict fluid responsiveness in patients undergoing cardiac surgery

*Alexandre Joosten[1], Celine Boudart[1], Jean Louis Vincent[1], Luc Van Obbergh[1], Olivier Desebbe[2]*

[1]Department of Anaesthesia, ULB Erasme Hospital, Brussels, Belgium

[2]Department of Anaesthesia, Clinique de la Sauvegarde, Lyon, France

Contact: joosten–alexandre@hotmail.com

**Background:** Fluid responsiveness (FR) can be predicted using pulse pressure variation (PPV) in mechanically ventilated patients. Capstesia™ is a novel smartphone application which automatically calculates PPV and cardiac output (CO) from a digital picture of the invasive arterial pressure waveform obtained from any monitor screen.

**Objectives:** The primary objective of this study was to compare the ability of PPV obtained with the Capstesia™ (PPVcap) and PPV obtained with a pulse contour analysis monitor (PPVpc) to predict FR. Secondary objectives were to assess the agreement and the trending ability of CO obtained with the Capstesia™ (COcap) against the transpulmonary bolus thermodilution method (COTD).

**Methods:** We studied 57 patients undergoing CABG. COTD, COcap, PPVcap and PPVpc measurements were obtained simultaneously before and after a volume expansion of 5 mL $kg^{-1}$ of colloid solution given in 10 minutes. A ROC curve analysis determined the ability of PPVcap and PPVpc to predict FR. Agreement between COcap and COTD was assessed with a Bland-Altman analysis. The trending ability of COcap as compared to COTD after a volume expansion was assessed using a four-quadrant plot analysis.

**Results:** 28 patients were studied before surgical incision and 29 after sternal closure. Overall, there was no significant difference in the ability of PPVcap and PPVpc to predict FR [area under the ROC = 0.74 (CI95%: 0.60–0.84) vs. 0.68 (CI95%: 0.54–0.80, $P = 0.3$]. PPVcap > 7.6% could predict FR with a sensitivity of 85% and a specificity of 58% whereas PPVpc > 10.3% could predict FR with a sensitivity of 54% and a specificity of 81%. Areas under the ROC were gre-

**Table 1.** Patient characteristics

| | |
|---|---|
| Age (years) | 66 ± 12 |
| Gender (M/F) | 47/10 |
| BMI (kg $m^{-2}$) | 28 ± 5 |
| ASA (II/III/IV) | 13/39/5 |
| Co-morbidities | |
| Hypertension | 49 (86%) |
| Diabetes | 22 (39%) |
| BPCO | 8 (14%) |
| Stroke | 3 (5%) |
| Treatment | |
| Statins | 48 (84%) |
| Beta-blockers | 41 (72%) |
| Aspirin | 51 (89%) |

BMI: body mass index; ASA: American Society of Anesthesiologist score; COPD: chronic obstructive pulmonary disease

**Table 2.** Reproducibility of hemodynamic variables

| | Median | 25–75 percentiles |
|---|---|---|
| COcap LSC | 6.1 | 4.2 to 8.9 |
| COcap precision | 4.3 | 3.0 to 6.2 |
| PPVcap LSC | 19.4 | 12.0 to 27.7 |
| PPVcap precision | 17.1 | 10.6 to 24.5 |
| COpc LSC | 2.7 | 1.6 to 4.8 |
| COpc precision | 1.9 | 1.1 to 3.4 |
| PPVpc LSC | 16.9 | 9.7 to 27.8 |
| PPVpc precision | 11.9 | 6.8 to 19.7 |
| $CO_{TD}$ LSC | 4.2 | 3.2 to 6.9 |
| COTD precision | 3.7 | 2.8 to 6.1 |

All values are expressed in percentage (%)
**Legends:** COcap: cardiac output from the capstesia ; PPVcap: pulse pressure variation from the capstesia; COpc: cardiac output from the pulse contour monitor; PPVpc: pulse pressure variation from the pulse contour monitor; COTD: cardiac output from bolus intermittent transpulmonary thermodilution; LSC: least significant change

**Appendix 1**

| | ROC | CI 95% | *P*-value | Threshold value | Grey zone | Se (%) | Sp (%) |
|---|---|---|---|---|---|---|---|
| Total n = 57 | 0.736 | 0.603 to 0.844 | 0.0006 | 7.6 | 5.2–10.0 | 85 | 58 |
| Before surgical incision n = 28 | 0.818 | 0.627 to 0.937 | 0.0001 | > 13.57 | 10.0–17.1 | 58 | 94 |
| After skin closure n = 29 | 0.645 | 0.447 to 0.813 | 0.19 | > 8.47 | 6.1–20.6 | 71 | 73 |
| Patients with no noradrenaline infusion n = 42 | 0.803 | 0.651 to 0.909 | < 0.0001 | > 10.03 | 7.2–13.6 | 69 | 85 |
| Before surgical incision (no noradrenalin infusion) n = 25 | 0.896 | 0.708 to 0.981 | < 0.0001 | > 13.57 | 10.0–17.1 | 78 | 94 |

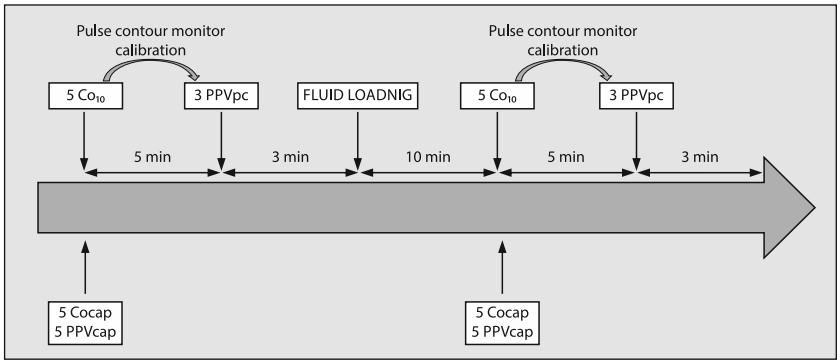
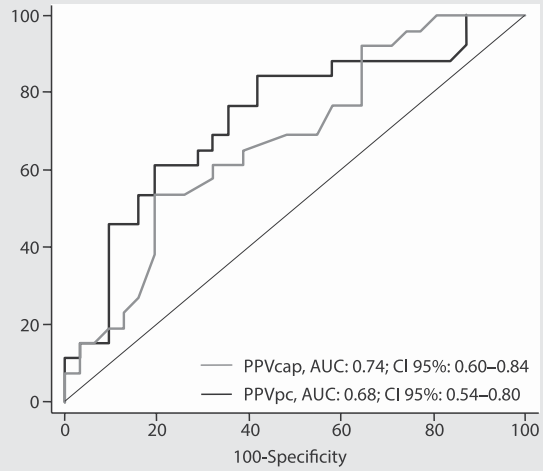



**Figure 1**

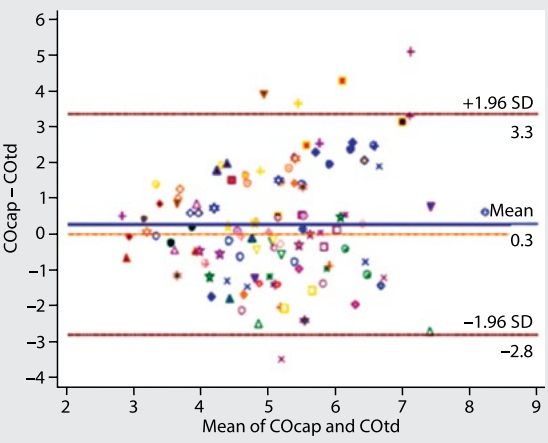
ater when realized before surgery versus after the surgery for both PPVcap (0.818; *P* = 0.0001 versus 0.645; *P* = 0.19) and PPVpc (0.794; *P* = 0.0007 versus 0.552; *P* = 0.6). Bland-Altman analysis between COcap and COTD showed a mean bias of 0.3 L $min^{-1}$ (limits of agreement: –2.8 to 3.3 L $min^{-1}$) and a percentage error of 60%. The concordance rate between variations of COTD and COcap was 71% (95% CI: 66–77).

**Conclusions:** PPVcap predicts FR as well as PPVpc, with a slightly better prediction of FR before surgical incision. Moreover, COcap is not interchangeable with the transpulmonary bolus thermodilution method.




Notes: PPVcap threshold value was 7.6% with a grey zone between 5.2 to 10%, this corresponding to half of the patients. PPVpc threshold value was 10.3% with a grey zone between 5.2 and 10%, corresponding to 51% of the patients. There was no difference between PPVcap and PPVpc ROC curves ($P = 0.3$).

**Figure 2 A.** ROC curves area of PPVcap and PPVpc to predict fluid responsiveness before a fluid challenge




Notes: Results are expressed in L $min^{-1}$, the percentage error between COcap and COtd was 60%.
Legends: COcap: cardiac output measured by Captesia application; COtd: cardiac output measured by the intermittent bolus transpulmonary thermodilution method.

**Figure 2 B.** Accuracy and Agreement between COcap and COTD

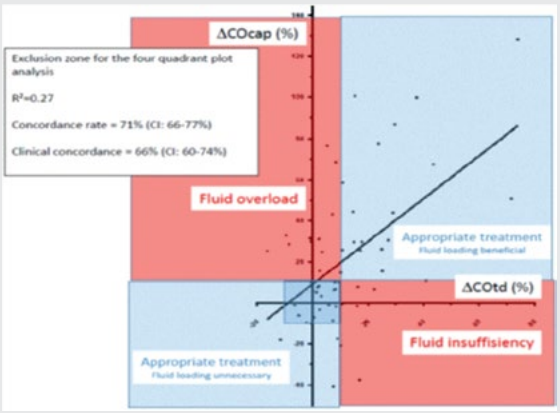
## P011. Comparison of the effects of succinated gelatine and hydroxy ethyl starch (6% 130/0.4) on bleeding among cardiac surgery patients

*Emine Kubra Okur Kavak[1], Bora Aykac[1], Zeynep Celik[2], Fusun Kaya[1]*

[1]Department of Anesthesiology, Cardiology Institute, Istanbul University, Istanbul, Turkey

[2]Department of Anesthesiology and Reanimation, Yedikule Women and Maternity Hospital, Istanbul, Turkey

Contact: drkubra28@gmail.com




Legends: ΔCOcap: variation of the cardiac output before and after fluid loading measured by the smartphone application; ΔCOtd: variation of the cardiac output before and after fluid loading measured by the transpulmonary thermodilution method.
Notes: values are expressed in percentage of change of CO; values inside the dark blue square have been excluded for the calculation of the concordance rate. All variations of CO have been integrated to calculate the clinical concordance. Values in the red zones demonstrate an inappropriate risk of fluid management; values in the blue zones demonstrate a potential appropriate fluid management.

**Figure 3.** Scatter diagram with regression lines and 4-quadrant plots showing changes (ΔCO) in COcap when compared with $CO_{TD}$

**Background:** Volume therapy is often necessary to treat hypovolemia. Especially for the cardiac surgery patients, volume deficit-replacement is more important. There are several causes of hypovolemia and should be treated according to the cause and deficit. Depends on the reason of hypovolemia we can treat it with different fluids such as crystalloids, colloids, blood, plasma […]. All kind of surgeries even the minor one intravenous fluid replacement is necessary and done. But which solution it should be done has controversies. Crystalloids or colloids? In our study we compared two different colloid solutions and especially their effects on bleeding for cardiac surgery patients.

**Objectives:** This study was to compare the effects of HES 130/0.4 and Modified Fluid Gelatine on coagulation in patients undergoing cardiac surgery.

**Methods:** Patients were randomized into 2 groups; group I (n:30) and group II (n:30). Group I contains the patients who had modified fluid gelatine infusion and group II contains the patients who had HES 130/0.4 infusion. Both groups had similar demographic characteristics. For both groups patients charts checked and noted pre-op, post-op 1sth hour and postop 1st day hgb, hct,plt, PT, aPTT, INR, BUN, Cr, ALT and AST results. These results were analyzed SPSS statistic package. These two different colloids effects on coagulation in cardiac surgery patients. We measured the total hgb decrease to compare, and postop 1st hour; we observed that group II patients statistically significant hgb and hct decrease. Apart from our study we also observed that group II patients had statistically significant ALT and Cr abnormal test results which should be discussed for another

**Table 1.** Demographic properties of the patients mean ± SD

| | Group G (n:30) | Group 2 (n:30) | *P* |
|---|---|---|---|
| Age | 62.4 ± 11.7 | 63.2 ± 9.0 | 0.75 |
| Sex, woman (%) | 14 (58.3) | 10 (41.7) | 0.29 |

**Table 2.** Pre-op values Mean ± SD

| | Group G (n:30) | Group V (n:30) | *P* |
|---|---|---|---|
| Hb | 12.6 ± 1.6 | 12.4 ± 1.4 | 0.66 |
| Hct | 38.0 ± 4.6 | 37.8 ± 4.2 | 0.86 |
| Bun | 19.7 ± 4.9 | 26.1 ± 16.1 | 0.04 |
| Creatinin | 0.9 ± 0.1 | 1.2 ± 1.0 | 0.1 |
| ALT | 22.6 ± 15.3 | 27.3 ± 17.3 | 0.2 |
| AST | 23.4 ± 16.1 | 26.6 ± 19.8 | 0.4 |
| Plt | 239266.6 ± 65437.4 | 263733.3 ± 88539.4 | 0.22 |
| PT | 12.4 ± 1.1 | 13.2 ± 1.7 | 0.04 |
| aPTT | 31.2 ± 7.7 | 31.9 ± 4.2 | 0.9 |
| INR | 0.9 ± 0.1 | 0.9 ± 0.1 | 0.8 |

**Table 3.** Post-op 1st hour values *$P < 0.05$ (Mean ± SD)

| | Group G (n:30) | Group V (n:30) | *P* |
|---|---|---|---|
| Hb | 10.5 ± 1.2 | 9.2 ± 2.0 | 0.004* |
| Hct | 31.8 ± 4.0 | 29.3 ± 3.9 | 0.01* |
| Plt | 158233.3 ± 54985.6 | 168933.3 ± 112027.3 | 0.6 |
| PT | 14.1 ± 1.1 | 16.5 ± 11.9 | 0.2 |
| aPTT | 34.0 ± 5.7 | 44.8 ± 37.5 | 0.1 |
| INR | 1.1 ± 0.1 | 1.3 ± 1.4 | 0.4 |

**Table 4.** Post-op day 1 values *$P < 0.05$ (Mean ± SD)

| | Group G (n:30) | Group V (n:30) | *P* |
|---|---|---|---|
| Hb | 10.0 ± 1.6 | 9.7 ± 0.9 | 0.3 |
| Hct | 30.4 ± 4.7 | 30.0 ± 3.1 | 0.71 |
| Bun | 21.4 ± 8.8 | 26.7 ± 11.3 | 0.05 |
| Creatinin | 1.1 ± 0.4 | 1.5 ± 0.7 | 0.03* |
| ALT | 24.5 ± 15.9 | 40.3 ± 32.3 | 0.02* |
| AST | 57.5 ± 34.1 | 90.1 ± 89.5 | 0.06 |
| Plt | 194666.7 ± 87744.2 | 197800.0 ± 131587.7 | 0.9 |
| PT | 14.4 ± 3.6 | 14.3 ± 1.7 | 0.9 |
| aPTT | 33.2 ± 6.0 | 36.8 ± 14.4 | 0.2 |
| INR | 1.1 ± 0.4 | 1.0 ± 1.1 | 0.3 |

study. After all according to 1st day lab results hgb and hct were in normal range and there were no differences between HES 130/0.4 and modified fluid gelatin on coagulation. Probably the blood and plasma transfusion in ICU and also postop surgical bleeding usually occurs in the 1st–24 hour.

**Results:** First 24 hours HES 130/0.4 caused coagulation impairment and significant Hgb and Hct decrease among post cardiac surgery patients. We also found that HES 130/0.4 caused significant ALT and Cr abnormality which should be further studied.

**Conclusions:** Although postop 1st hour HES 130/0.4 preparation caused more hgb and hct decrease in cardiac surgery patients it was temporary, safe and not dangerous amount, and for the volume replacement therapy new HES preparation was as safe as modified fluid gelatin.

**Acknowledgements:** It is declared that there is no conflict of interest between the participants of this study.
No financial aid has been received for this study.

## P012. Unintended fluid load (UFLO) in elective coronary artery bypass surgery patients: a retrospective analysis

*Annelies Meuwissen[1, 3], Tina Maes[1, 4], Mark La Meir[5], Marc Diltoer[1], Manu L.N.G. Malbrain[1], Elisabeth De Waele[1, 2]*

[1]Intensive Care Unit, UZ Brussel, Vrije Universiteit Brussel (VUB), Brussels, Belgium

[2]Department of Nutrition, UZ Brussel, Vrije Universiteit Brussel (VUB), Brussels, Belgium

[3]Department of Internal Medicine, UZ Brussel, Vrije Universiteit Brussel, (VUB), Brussels, Belgium

[4]Department of Anaesthesiology, UZ Brussel, Vrije Universiteit Brussel, (VUB), Brussels, Belgium

[5]Department of Cardiac Surgery, Vrije Universiteit Brussel, (VUB), Brussels, Belgium

Contact: annelies.meuwissen@uzbrussel.be

**Background:** Post CABG, patients are subject to intravenous fluid therapy which plays an important role during their ICU stay [1]. Standardized protocols are often provided for maintenance and replacement fluids. Non-intended sources of fluids contain analgesics and sedative drugs, antibiotics and enteral intake by the patient.

**Objectives:** The aim is to know the ratio between Intended Fluid Load (IFLO) being the actual prescribed IV fluids, Intentional Unintended Fluid Load (IUFLO) which are extra fluids prescribed and administered in a short time interval, as an individual response to the situation of the patient (e.g. fluid challenges, blood transfusions) and Unintentional Fluid Load (UFLO) (analgesics and sedative drugs, antibiotics) in elective CABG patients during the first and second day of ICU stay.

**Methods:** In 20 patients, data concerning intravenous and oral fluid administration was collected from the electronic medical file. Prescriptions by the physician concerning baseline and additional fluid and blood products were assembled. Effective intake was evaluated and ratios were made:

IFLO to total intake, IUFLO to total intake and UFLO to total intake. Composition of IUFLO and UFLO was documented.
**Results:** In 5 female and 15 male patients, age 56 ± 10 years, body weight 86 ± 17 kg, a mean fluid administration of 2906 mL on day 1 and 3009 mL on day 2 was observed. IFLO represented 1272 mL (44%), IUFLO 747 mL (26%) and UFLO 888 mL (30%) on day 1. IFLO represented 1166 mL (39%), IUFLO 353 mL (12%) and UFLO 1490 mL (49%) on day 2. IUFLO was in 56% composed of extra fluid on medical prescription, in 35% of colloids and in 9% of transfusion. UFLO was accounted for by oral intake in 51%, by paracetamol in 24%, by medication in 20% and by antibiotics in 5% of fluid volume. Mean oral intake increased by almost 4 times on the second day of ICU stay, analgesics remained a stable load with a mean of 282 mL $day^{-1}$.
**Conclusions:** The intended prescription of fluids, baseline and patient–specific, leads to a fluid load which is responsible for 70% of the effective fluid load on day one and 30% on day two. Unintended fluid load represents overall 40% of intake, caused primarily by medication on the first day and oral intake on the second day of CABG patients in ICU. Health care providers in ICU should be aware of these data when prescribing fluids and considering postoperative protocols concerning fluid prescription [2].

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## P013. Clinibil: an open, monocentric, observational study to investigate fluid and electrolyte balance in post cardiac-surgery patients in the ICU


*Lucas Pflanzl-Knizacek[1, 2], Karin Mattersdorfer[1, 2], Michael Maximilian Schober[1, 3], Katharina Bergmoser[1, 6], Lukas Pein[1, 2], Matthias Hafner[1, 5], Gernot Schilcher[4], Philipp Eller[4]*

[1]CBmed-Center for Biomarker Research in Medicine, Graz, Austria
[2]Medical University of Graz-Division of Endocrinology and Metabolism, Graz, Austria
[3]Medical University of Graz-Core Facility Clinical Research Center, Graz, Austria
[4]Medical University of Graz-Intensive Care Unit, Department of Internal Medicine, Graz, Austria
[5]Medical University of Graz-Department of Anesthesiology and Intensive Care, Graz, Austria
[6]Graz University of Technology-Institute of Health Care Engineering with European Testing Center of Medical Devices, Graz, Austria
Contact: lucas.pflanzl@cbmed.at


**Background:** Fluid disorders and electrolyte derailments are common complications in critically ill patients. Acute kidney injury (AKI) is linked to fluid disorders and associated with high mortality of 46% if there is a need for renal replacement therapy [1]. In general, incidence of AKI in ICU ranges from 19.2% to 74.5% [2, 3]. Biomarkers in blood and urine may provide a more timely and efficient way of diagnosis. However, until today there exist no reliable early onset biomarkers for diagnosing AKI [4, 5]. Besides biomarkers found in blood and urine, fluid balance could be used as a biomarker for critically ill patients [6]. A comprising approach to clinical data of a homogenous cohort of patients at intensive care units (ICU) could generate new insights on correlations between changes in fluid and electrolyte balance, biomarkers and the individual clinical course of each patient. This may enable earlier diagnosis of complex intensive care complications, such as AKI.
**Objectives:** As "Clinibil" is a data acquisition and observational study, the main objectives are acquiring, clustering and analyzing extensive amounts of data throughout a patient's stay at the ICU, correlating it with clinical outcome. Specifically, changes in kidney function compared to baseline characteristics are examined and multiple influencing parameters in fluid and electrolyte management are considered. A second objective aims for identifying new early onset biomarkers for AKI on a molecular level. A delineation of identified biomarkers and dependencies between parameters in fluid and electrolyte management can be used to create a concept for a clinical decision support system (CDSS).
**Methods:** The "Clinibil" study period is from September 2016 to December 2017 at Medical University of Graz on cardio-thoracic ICUs 1.1 and 1.2. Approval by ethics committee of Medical University of Graz has been granted (clinicaltrials.gov identifier number NCT02914782). Patients are to sign an informed consent before being admitted to the study. Data of more than 50 adult patients admitted for an elective major cardio-thoracic surgery, such as coronary artery bypass graft (CABG), with a subsequent ICU stay for more than 48 hours is collected and analyzed. Baseline characteristics including clinical lab parameters are obtained during a preoperative screening visit. These characteristics include serum and urine. Thus, a valid comparison of post-surgical parameters regarding electrolytes and biomarkers is possible. After admission to the ICU, blood and urine samples are taken four times in 24 hours to offer a high resolution in respect to the clinical course of each patient. All samples are analyzed for routine lab diagnostics, as well as stored in BioBank Graz for subsequent analysis, identification and validation of biomarkers. In a follow-up task, biomarker identification for AKI is performed and compared to already known biomarkers such as neutrophil gelatinase-associated

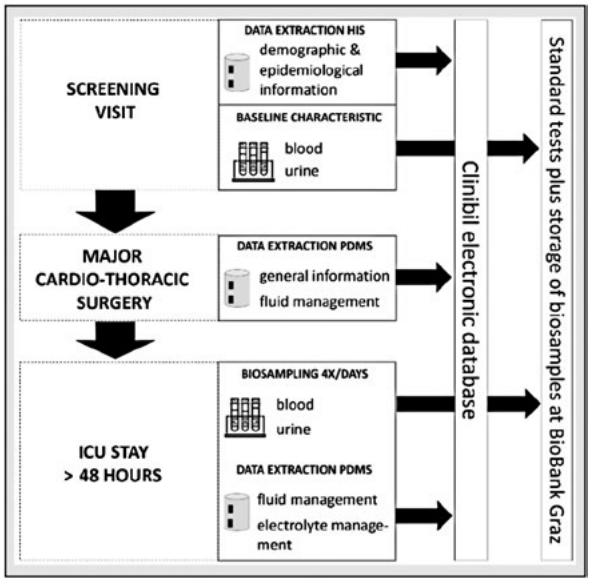


**Figure 1.** Overview of the "Clinibil" workflow. Patient data is extracted continuously during the complete workflow. Electronically available data is stored in a database for statistical analysis and knowledge discovery. Biospecimens taken from the patients are stored at BioBank Graz. HIS…hospital information system, PDMS…patient data management system

lipoprotein (NGAL) or Cystatin C. Electronic data acquired by the hospital information system is.h.med (Cerner, North Kansas City, U.S.A.) and the patient data management system Centricity EMR (GE Healthcare, Chalfont St Giles, UK) on site are read out. Read-outs include general information on surgery and patient, intraoperative fluid management, cumulative fluid balance during ICU stay, detailed fluid intakes including medication, detailed fluid outtakes including drains and urinary losses, point-of-care laboratory data, vital signs documentation, ventilation parameters and intensive care score values (TISS28 and SAPS3) (Fig. 1).

**Results:** "Clinibil" is currently ongoing with n = 49 patients admitted. Last patient last visit is planned for end of December 2017. Data is constantly processed and stored in a local database. Data related to fluid management of all included patients is analyzed and depicted to examine the behavior of each patient according to inputs and outputs. Biomarker identification will start by beginning of 2018.

**Conclusions:** "Clinibil" observational study could provide new insights by relating multiple patient specific data regarding therapy and diagnosis to the detection of complex intensive care complications. Analysis of the obtained data may show new correlations in respect to biomarkers identified in blood and urine, leading to knowledge discovery for earlier diagnosis and quicker treatment. Using fluid balance as a biomarker for assessing a patient's clinical course in respect to AKI possibly provides a more promising method for early detection. A comprising approach on combining electronically captured patient data and biomarkers might define a novel way for earlier recognition of AKI.

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## P014. Assessing the kidney's function in ICU-comparing baseline parameters and impact of peri- and postoperative fluid management

*Lukas Pein[1, 2], Lucas Pflanzl-Knizacek[1, 2], Karin Mattersdorfer[1, 2], Michael Schober[1, 3], Katharina Bergmoser[1, 6], Matthias Hafner[1, 5], Gernot Schilcher[4], Philipp Eller[4]*

[1]CBmed-Center for Biomarker Research in Medicine, Graz, Austria

[2]Medical University of Graz-Division of Endocrinology and Metabolism, Graz, Austria

[3]Medical University of Graz-Core Facility Clinical Research Center, Graz, Austria

[4]Medical University of Graz-Intensive Care Unit, Department of Internal Medicine, Graz, Austria

[5]Medical University of Graz-Department of Anesthesiology and Intensive Care, Graz, Austria

[6]Graz University of Technology-Institute of Health Care Engineering with European Testing Center of Medical Devices, Graz, Austria

Contact: lukas.pein@cbmed.at

**Background:** The glomerular filtration rate is an established and recognized parameter for assessing kidney function. Until today, several formulas for calculating estimated glomerular filtration rate (eGFR) exist. Most commonly used equations include Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) or Modification of Diet in Renal Disease (MDRD). In order to assess eGFR during the clinical course of a patient, comparison to patient's baseline

is recommended to recognize possible renal injury [1, 2]. Serum creatinine concentration (sCr) is used for calculation of eGFR in daily clinical practice. It is also used as a diagnostic biomarker for staging of acute kidney injury (AKI). However, administration of fluids may alter sCr, leading to underestimation of AKI severity [3]. Macedo et al propose a formula for calculating adjusted creatinine concentration (adjCr) to raise accuracy in detecting AKI [3]:

$$\text{adjCr} = \text{sCr} * \left(\frac{\text{hospital admission weight [kg]} * 0.6 + \Sigma\ (\text{daily cumulative fluid balance [L]})}{\text{hospital admission weight [kg]} * 0.6}\right)$$

Fluid balance adjustment is therefore suggested for AKI detection and has been subject to several trials examining ICU patients [4–9]. Results yield improvements in recognition of AKI, i.e. more accurate detection, modest increase in number and difference in staging of severity.

**Objectives:** The aim is to assess and compare eGFR of postoperative elective cardio-thoracic patients directly admitted to ICU (post-OP) and 12h after admission (12h post-OP) to baseline values (pre-OP) obtained within 14 days prior to surgery in maximum. In a second step, the formula for adjCr shall be used to quantify the influence of peri- and postoperative fluid management on unadjusted eGFR.

**Methods:** Data acquisition is carried out in the "Clinibil" trial study at cardio-thoracic intensive care units (ICU) at the Medical University of Graz, Austria. Approval by the ethics committee of the Medical University of Graz, Austria has been granted in September 2016 (clinicaltrials.gov identifier NCT02914782). General patient information, demographic and epidemiological data is obtained after informed consent and admittance to the trial. Data regarding fluid administration and management, as well as laboratory parameters, are extracted out of the hospital information system i.s.h.med (Cerner, North Kansas City, USA) and patient data management system Centricity EMR (GE Healthcare, Chalfont St Giles, UK). Statistical analysis is performed with GraphPad Prism 6 (GraphPad Software, La Jolla, USA). Normal distribution is tested with Shapiro Wilk test, outlier testing is done with GraphPad outlier calculator. eGFR Groups are compared using nonparametric Kruskal-Wallis test for matched data with Dunn´s post hoc multiple comparison correction. Statistical significance is accepted for *P*-values < 0.05, eGFR (mL $min^{-1}/1.73\ m^{-2}$) is described using median and interquartile range; percentage change is calculated as change from eGFR median whereas baseline is assumed as 100%.

**Results:** Out of preliminary data we included n = 33 patients (27 male and 6 female). Average age was 64 years. Pre-OP baseline was assessed between 14 days and 22 hours prior to surgery. Median eGFR baseline was 77.04 (Q75 = 87.76; Q25 = 57.76; IQR = 31.02). Average duration of surgery was 239 ± 55 minutes. Patients received in average 2734 ± 1000 mL during surgery, whereby intraoperative cumulative fluid balance was 1117 ± 1330 mL. During the first 12 hours of ICU stay, patients received in average 3756 ± 971 mL, whereby cumulative fluid balance was 1464 ± 1871 mL. In comparing baseline to the immediate post-OP value after ICU admission, median eGFR increased significantly by 21.22% ($P < 0.0007$), respectively by 19.61% ($P < 0.0020$), when adjusting for cumulative intraoperative fluid balance. In comparing baseline to the 12 hours post-OP value after ICU admission, median eGFR increased by 5.05% ($P = 0.6678$), respectively increased by 0.09% ($P = 0.3421$) when adjusting for the total cumulative fluid balance (sum of intraoperative and ICU stay).When assuming post-OP eGFR as 100%, this corresponds to a decrease during the first 12 hours of ICU stay in terms of 13.34% unadjusted, respectively to a decrease of 17.43% when using the adjusted formula. After surgery eGFR is decreasing and approaching pre-OP baseline during the first 12 hours of ICU stay.

**Conclusions:** The preliminary data of the "Clinibil" trial study shows that eGFR increases immediately after surgery follo-

**Table 1.** Descriptive statistics of the preliminary results of "Clinibil" trial study, n = 33 patients

| | pre-OP | post-OP | adj. post-OP | 12h post-OP | adj. 12h post-OP |
|---|---|---|---|---|---|
| Median of GFR, mL $min^{-1}/1.73\ m^{-2}$ | 77.04 | 93.39 | 92.15 | 80.93 | 77.11 |
| IQR | 31.02 | 12.37 | 13.64 | 27.04 | 29.06 |
| *P*-value (tested against pre-OP) | – | 0.0007 | 0.0020 | 0.6678 | 0.3421 |
| Change from Baseline,% | – | 21.22 | 19.61 | 5.05 | 0.09 |
| Change from post-OP Baseline, % | – | – | –1.33 | –13.34 | –17.43 |

**Table 2.** Descriptive statistics of fluid inputs, outputs and cumulative balance during surgery and 12 hours of ICU stay, n = 33 patients. CFB… cumulative fluid balance

| | Intra-OP input | Intra-OP output | Intra-OP CFB | 12h ICU input | 12h ICU output | 12h ICU CFB | Total CFB |
|---|---|---|---|---|---|---|---|
| Mean, mL | 2734 | –1617 | 1117 | 3756 | –2292 | 1464 | 2581 |
| SD, mL | 1000 | 1432 | 1330 | 971 | 617 | 1871 | 1871 |

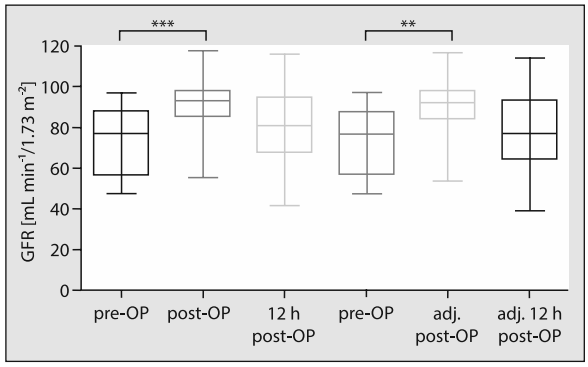


**Figure 1.** Clinical course of eGFR using sCr and ajdCr

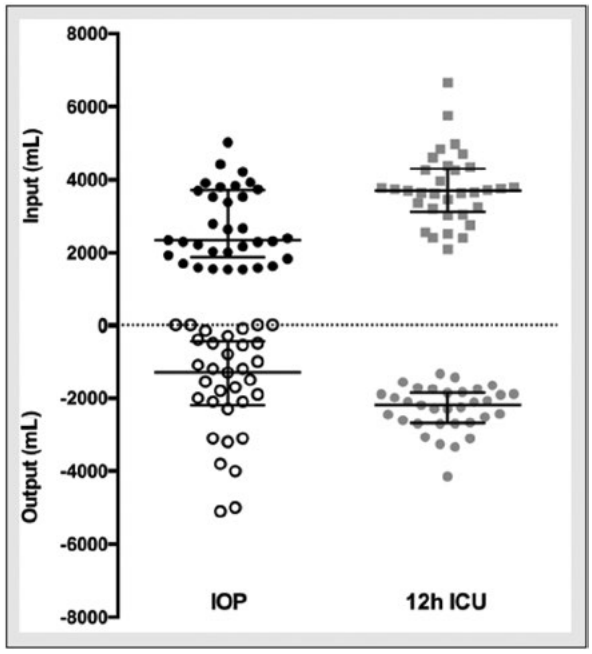


**Figure 2.** Intraoperative fluid input and output in mL (left side); Fluid input and output during first 12 hours of ICU stay in mL (intraoperative fluids not included) (right side)

wed by a rapid decrease towards baseline within 12 hours in patients undergoing cardio-thoracic surgery. Evaluating the perioperative eGFR changes we assume that fluid management affects eGFR significantly. Since monitoring of renal function is crucial in ICU patients such effects might lead to a higher number of false-positive AKI when baseline is lacking. The formula by Macedo *et al.* [3] to adjust serum creatinine for cumulative fluid balance did not lead to significant changes of eGFR. This observation suggests presence of other not yet considered influencing factors such as catecholamine use or colloid administration, possibly affecting renal reserve. Data out of "Clinibil" relating to these factors is currently processed and analyzed. "Clinibil" observational study is currently ongoing, aiming for last patient last visit in December 2017.

**Acknowledgments:** "CBmed" is cooperating together with B.Braun Melsungen AG for this research project. Work done in "CBmed" was funded by the Austrian Federal Government within the COMET K1 Centre Program, Land Steiermark and Land Wien.

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## P015. Describing cardiac ICU patients' fluid transfer characteristics using system analysis: a proof of concept

*Katharina Bergmoser[1, 2], Lucas Pflanzl-Knizacek[1, 3], Sonja Langthaler[2], Christian Baumgartner[2]*

[1]CBmed-Center for Biomarker Research in Medicine, Graz, Austria
[2]Graz University of Technology-Institute of Health Care Engineering with European Testing Center of Medical Devices, Graz, Austria
[3]Medical University of Graz-Division of Endocrinology and Metabolism, Graz, Austria
Contact: katharina.bergmoser@cbmed.at

**Background:** Especially in an intensive care setting, the cumulative fluid balance (CFB) provides easy-to-assess and valuable information on the patient's current health status [1] and the amount of excess fluid currently accumulated within the body. A fluid overload of 10% of a patient's baseline body weight is associated with an increased mortality [2–4] and should therefore be avoided. Estimating a patient's CFB course as a response to different fluid application regi-

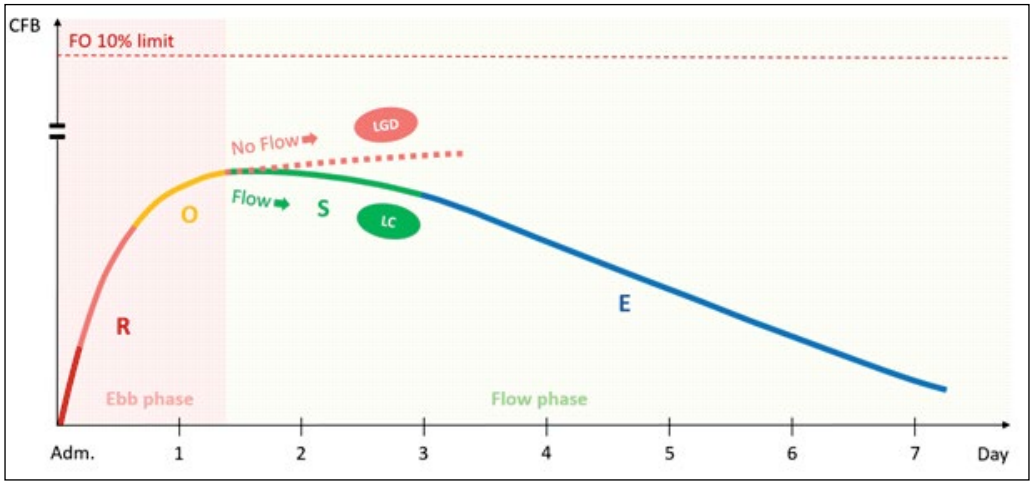


**Figure 1.** The constructed cumulative fluid balance course to be targeted in a postoperative patient staying at the intensive care unit for seven days based on recommendations from literature [10]. Cumulative fluid balance (CFB), Fluid overload (FO), Resuscitation phase (R), Optimization phase (O), Stabilization phase (S), Evacuation phase (E), Admission to ICU (Adm.), Late conservative fluid therapy (LC), Late goal-directed fluid therapy (LGD)

mes may be difficult. Modeling an individual patient's fluid transfer characteristics by considering as many relevant patient parameters as possible can be challenging and easily results in high dimensional and complex models, whose introduction into clinical practice can be difficult. Control system analysis provides efficient tools for the description of complex systems and is commonly used in other areas aiming to model physiological behavior [5–9].

**Objectives:** The identification of individual transfer functions commonly used in system analysis may help in detecting patients being non-responsive to late conservative fluid therapy at an early stage of postoperative fluid management. Clustering the individual patients' transfer functions within a large patient population with respect to diagnosis or other patient features might furthermore allow the definition of cohort-specific model parameters. The use of cohort transfer functions in decision support systems might assist in assessing each patient's actual fluid needs, facilitating fluid management by preventing severe fluid overloads and minimizing the risk of therapies such as renal replacement therapy in advance.

**Methods:** The CFB course of critically ill patients recovering from trauma has already been described qualitatively in literature [10–13]. Malbrain *et al.* [10] suggested the ROSE model, which divides the recovery process into four subsequent stages: Resuscitation, Optimization, Stabilization and Evacuation. Figure 1 shows the CFB course to be targeted in intensive care. In general, the lengths of the four subsequent recovery phases depend on the clinical course of the respective patient. A second order discrete-time transfer function was identified using a selected cardiac patient's individual cumulative fluid intake (CFI) and CFB as input series and output series respectively. The patient's transfer function was estimated using the MATLAB System Identification Toolbox. Model verification was performed using MATLAB Simulink, whereby an approximated intake function fitted to the patient's CFI was used as input series.

**Results:** The identified transfer function comprises a holistic description of the patient's characteristics influencing the individual reaction to administered fluids without necessity for measuring multiple and/or complex vital parameters. The model output of the estimated transfer function for the selected patient after application of the approximated CFI compared to the patient's actual CFB versus the averaged CFBs including four patients with similar lengths of stay are shown in Figure 2.

**Conclusions:** Second order transfer function models provide a valuable option for describing fluid transfer characteristics of ICU patients. The estimated transfer function shows a good congruence with the documented preliminary patient data. A transfer function of higher order does not result in a justifying increase of goodness of fit. Patient-specific transfer functions might act as a key tool reflecting the actual patient within control loops being an essential base for providing decision support in fluid administration.

**Acknowledgments:** "CBmed" is cooperating together with B.Braun Melsungen AG for this research project. Work done in "CBmed" was funded by the Austrian Federal Government within the COMET K1 Centre Program, Land Steiermark and Land Wien.

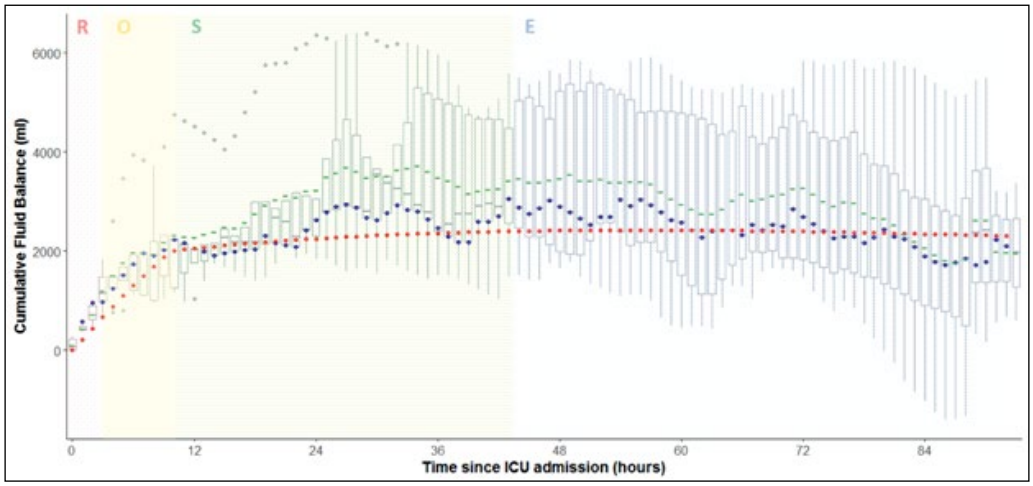


**Figure 2.** The output of the transfer function model (red) as response to the fitted cumulative intake matches the actual cumulative fluid balance (blue) of a selected patient, which is compared to the overall mean cumulative fluid balance (green) including four patients having a similar length of stay. Resuscitation phase (R), Optimization phase (O), Stabilization phase (S), Evacuation phase (E)

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## P016. Crystalloid vs. colloid for intraoperative goal-directed fluid therapy using a closed-loop system: a randomized double blinded controlled trial in major abdominal surgery

*Alexandre Joosten[1], Amelie Delaporte[1], Brigitte Ickx[1], Maxime Cannesson[2], Joseph Rinehart[3], Philippe Van der Linden[4]*

[1]Department of Anaesthesia, ULB Erasme Hospital, Brussels, Belgium
[2]Department of Anesthesiology, UCLA, Los Angeles, USA
[3]Department of Anesthesiology, UCI, Irvine, USA
[4]Department of Anaesthesia, CHU Brugmann, Brussels, Belgium
contact: joosten-alexandre@hotmail.com

**Background:** Type of fluid and volume regimen given intraoperative can both impact patient outcome following major surgery.
**Objectives:** This two-arm parallel randomized controlled double-blind bi-center superiority study tested the hypothesis that when using a closed-loop assisted goal directed fluid therapy, balanced colloids are associated with fewer postoperative complications compared to balanced crystalloids in patients having major elective abdominal surgery.
**Methods:** One hundred and sixty patients were enrolled in the protocol. All patients had maintenance balanced crystalloid administration of 3 mL $kg^{-1}hour^{-1}$. A closed-loop system delivered additional 100 mL fluid boluses (patients randomized to either a balanced-crystalloid or colloid solution) according to a predefined goal-directed strategy, using a stroke volume and stroke volume variation monitor. All patients were included in the analysis. The primary outcome was the Post-Operative Morbidity Survey (POMS) score, a 9-domains scale, at day two after surgery. Secondary outcomes included all postoperative complications.

**Results:** Patients randomized in the colloid group had a lower POMS score [median [IQR] of 2 (1–3) vs. 3 (1–4), difference –1 (95% CI: –1 to 0); $P < 0.001$] and a lower incidence of postoperative complications. Total volume of fluid administered intraoperative and net fluid balance were significantly lower in the colloid group.

**Conclusions:** Under our study conditions, a colloid based goal directed fluid therapy was associated with fewer postoperative complications than a crystalloid one. This beneficial effect might be related to a lower intraoperative fluid balance when a balanced colloid was used. However, given the study design, the mechanism for the difference cannot be determined with certainty.

## P017. A comparative study on the efficacy of acetated isotonic electrolyte solution, normal saline solution, and lacteted ringer's solution in the initial fluid resuscitation of children aged 1 month to 18 years old diagnosed with severe dengue admitted at the Philippine

*Allen Kilby Palon, Mellinor Aspuria-Ang*

Pediatric Intensive Care Center, Philippine Children's Medical Center, Quezon City, Philippines

Contact: allenkilby26@gmail.com

**Background:** Fluid management in severe dengue continues to be a critical issue as the WHO guidelines change over time. But despite these changes, the same intravenous fluids during the initial fluid resuscitation were used-normal saline and Lactated Ringer's solutions. In our institution, acetated isotonic electrolyte solution, another balanced solution, was introduced as the fluid being used on the initial fluid resuscitation in severe dengue. However, there is still no local study conducted comparing the use of acetated isotonic electrolyte solution against normal saline and Lactated Ringer's solutions during the initial fluid resuscitation in severe dengue.

**Objectives:** This study aims to determine efficacy of (AIES) acetated isotonic electrolyte solution compared to (NSS) normal saline and (LRS) Lactated Ringer solutions in the initial fluid resuscitation among severe dengue patients. The primary outcome was the time to achieve sustained cardiovascular stability from the initial fluid resuscitation. Secondary outcome measures were the time to achieve initial cardiovascular stability, total volume of fluid used to achieve cardiovascular stability, presence of electrolyte imbalances and acid base disturbances, presence of re-shock, use of colloids and inotropes, length of ICU stay, and the mortality rate among the groups.

**Methods:** Retrospective Cohort Study. All children aged 1 month to 18 years of age diagnosed with severe dengue admitted at the PICU from 2014 to 2016 were considered. Out of 175 patients, only 166 were included. They were divided into three groups based on the initial intravenous fluid used: 58 patients on (AIES) acetated isotonic electrolyte solution, 58 patients on (LRS) lactated Ringer's solution, and 50 patients on (NSS) normal saline solution.

Inclusion Criteria: Assessed as severe dengue based on the 2009 WHO classification and PPS guidelines, confirmed by either positive dengue NS1-antigen or dengue IgM.

Exclusion Criteria: Already received fluid resuscitation from other centers and institutions. Has co-morbidities. Initially presented with hemorrhagic manifestations and transfusion is deemed necessary. Initially admitted and managed as dengue with or without warning signs. Has no signs of shock. Colloids were initially used.

**Results:** All three groups have the same gender distribution (1:1) and have the same serum pH levels on admission but NSS is the youngest with mean age of 7.54 years, LRS group as the oldest at 9.3 years old, and AIES at 8.0 years old. AIES had the shortest time to achieve initial stability (2.29 hours; $P = 0.03$) and sustained stability (4.37 hours; $P = 0.01$) among those patients without re-shock after the initial fluid resuscitation. Also, AIES had tendencies to have less re-shock, (17%; $P = 0.26$) vs. 28% for LRS and 29% for NSS, and used less colloid (18.9%; $P = 0.17$) vs. 34% for LRS, and 31% for NSS, and less need for inotropes (10.3%; $P = 0.09$) vs. 12% and 22% for LRS and NSS respectively, and less need for mechanical ventilation (2%, $P = 0.08$) vs. 14% for LRS and 14% for NSS. NSS had the most re-shock (29.3%), most use of inotropes (22.4%), and needed to be shifted to AEIS and/or colloid (LRS had the most colloid used (34%). AEIS had the same rate of infusion as NSS to establish stability, but AEIS needed less fluids to establish initial stability (0.84 L, $P = 0.06$) vs. 1.1 L for LRS and 1.0 L for NSS and less fluids to maintain stability (1.3 L, $P = 0.06$) vs. 2.0 L for LRS and 1.9 L for NSS. Since LRS had a longer time to achieve initial and sustained stability, it had the least amount of fluid to achieve initial stability (13.22 mL $kg^{-1}$; $P = 0.01$) and sustained stability (10.09 mL $kg^{-1}$; $P = 0.25$). Hypernatremia ($P = 0.006$) and hyperchloremia ($P = 0.001$) were mostly seen on NSS with consequent hyperchloremic acidosis (normal anion gap and decreased strong ion difference) as evident on blood gases on the $4^{th}$, 8th, and $12^{th}$-hour after the initial shock ($P = 0.73$, $P = 0.24$, $P = 0.10$. respectively). The length of ICU stay was almost the same in all groups and not statistically significant ($P = 0.53$). No mortality was recorded on Group A as compared to 3 in Group B (5.17%), and 2 in Group C (4%).

**Conclusions:** Acetated Isotonic electrolyte solution is more effective as the fluid of choice in the initial fluid resuscitation among severe dengue patients compared to lactated Ringer's solution and Normal saline solution.

## P018. Intensive care unit (SICU) of a tertiary care hospital effect of fluid balance on outcome of patients admitted to the surgical

*Muhammad Sohaib, Madiha Hashmi, Faisal Shamim, Fazal Khan*

Department of Anesthesiology, Aga Khan University Hospital, Karachi, Pakistan

Contact: muhammad.sohaib@aku.edu

**Background:** Fluid balance remains a highly controversial topic in the critical care field, and there is no consensus about the amount of fluid required by critically ill patients.
**Objectives:** In this study, the objective was to find the relationship between fluid balance and in hospital mortality in critically ill surgical patients. Our secondary objective was to identify the association between use of colloid and acute kidney injury and use of blood products and development of ARDS.
**Methods:** The medical records of adult patients admitted to a surgical intensive care unit (ICU) ≥ 48 hours, from August 2014 to February 2016 (18 months) were reviewed retrospectively. The study was conducted in the surgical intensive care unit of a tertiary care hospital .Medical records of 18 months from August 2014 to February 2016 were reviewed. Abstracted data of patients admitted to surgical intensive care included body mass index, Acute Physiology and Chronic Health Evaluation (APACHE) II scores, fluid balance during first 5 days of ICU stay, length of ICU stay and in hospital mortality. All statistical analysis was performed using statistical packages for social science version 19 (SPSS Inc., Chicago, IL). Frequency and percentage were computed for qualitative observation and were analyze by chi square test. Mean (± standard deviation) and median (IQR) were presented for quantitative variables and analyze by independent sample t test and Mann-Whitney test. Normality of quantitative data was also be checked by Kolmogorov-Smirnov test. Statistically significant results had a *P*-value less than 0.05.
**Results:** A total of 100 patients fulfilled the inclusion criteria. The average age of patients was 44.08 ± 18.14 (years), BMI (kg $m^{-2}$) 27.84 ± 5.56 and APACHE II Score 17.28 ± 6.96. The in hospital mortality was 26%, median length of ICU and hospital stay was 6.91 ± 4.07 and 14.74 ± 7.78 days. In non-survivors fluid balance was significantly positive on 2nd, 3rd, 4th and 5th day of SICU (*P*-value: 0.005, 0.0005 and 0.024), APACHE II score ($P < 0.02$), incidence of acute kidney injury ($P < 0.004$) and mechanical ventilation days were significantly more. There was association between the of use of colloid and acute kidney injury ($P < 0.014$). Use of blood products was significantly associated ($P < 0.03$) with development of ARDS.
**Conclusions:** Positive fluid balance, high APACHE II score and acute kidney injury is significantly associated with hospital mortality of non-cardiac surgical ICU patients.
**Key words:** acute kidney injury, body mass index, intensive care unit, mechanical ventilation

## P019. Feasibility and design of a device for patient controlled intravenous fluid administration

*Fintan Hughes*, Jonathan Lacey*, Hugh Montgomery and Monty Mythen*

Institute of Sport Exercise & Health, University College London, UK (*contributed equally)

Contact: jonathan.lacey.16@ucl.ac.uk

**Background:** Dehydration is prevalent within healthcare [1–3]. Risks for acute kidney injury, myocardial infarction, venothromboembolic disease and in-patient mortality are increased with dehydration [4–8]. Dehydration is poorly understood: there is no gold standard definition; clinical signs are unreliable [9, 10]; and there are no objective measures with everyday clinical utility [11]. Dehydration is inadequately managed and there is a lack of available technology to allow patients to manage their own hydration in response to thirst.
**Objectives:** Our objective was to design a prototype device that enables patients to control their own intravenous fluids. To this end, secondary objectives were: to conduct a literature search reviewing thirst as a reliable marker of dehydration; to perform a feasibility study investigating the sensation of thirst as a guide to titrate intravenous fluid therapy.
**Methods:** We performed a meta-analysis of trials investigating the sensitivity of human thirst. Included studies reported the threshold plasma osmolality above which thirst is sensed, in artificially dehydrated subjects. Our feasibility study compared patient controlled fluid administration with NICE guidelines. 16 healthy volunteers, dehydrated over 12 hours with furosemide, completed our double cross-over trial. The patient controlled fluid system allowed dehydrated subjects to administer 200 mL intravenous hypotonic fluid boluses up to every 15 minutes in response to their sense of thirst. Finally, we identified the principal functions that would be required of a patient-controlled intravenous fluid device: volume & flow measurement, flow control and patient input signal. Through iterative processes we finalised a design to achieve the proposed objective.
**Results:** Our meta-analysis included 167 participants, ranging from 20 to 78 years, both healthy controls and those with a range of pathologies (e.g. diabetes and chronic kidney disease). The trials studied each participant's data

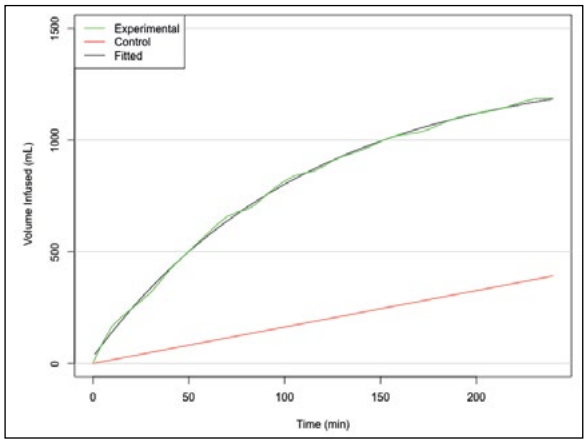


**Figure 1.** Volume administered over time in patient controlled intravenous fluid feasibility study

during a hypertonic saline infusion [12]. The threshold value of pOsm above which thirst is sensed, was found to be 285.23 mOsm $kg^{-1}$. In our feasibility study, the dehydration protocol resulted in a 1–1.5 L fluid deficit. Subjects in the experimental arm who controlled their own administration of intravenous fluids received 1138 mLs over a 4 hour period. This was significantly greater than the 394 mLs received in the control arm, with a mean difference of 743 mLs ($P = 0.0005$). In the experimental arm subjects' rate of administration reduced exponentially during the infusion (Fig. 1). Larger reductions in urine specific gravity and subjective thirst scores were seen over the course of the experimental arm, with mean difference of 0.0053 $kgm^{-3}$ ($P = 0.002$) and 3.3 ($P = 0.0034$) respectively. The prototype design is a gravity-driven fluid device that allows patients to control their own intravenous fluid (Fig. 2). A mouthpiece containing a pressure transducer is used as the patient signal input to the device-this was chosen specifically to avoid confusion with PCA buttons. When thirsty, the patient will suck on the mouthpiece triggering input from the pressure transducer and opening a pinch valve. An acoustic flowmeter will be used to ensure a total of 394 mLs of intravenous fluid is given before the pinch valves closes. Once a bolus has been delivered there will be a 15 minute 'lockout' period. The signal processing will be controlled by a Raspberry pie.

**Conclusions:** Our analysis demonstrated that across a diverse population of participants the threshold for thirst activation is exactly in the middle of the normal range of plasma osmolality. Our pilot study suggests the administration of intravenous fluid, titrated against the subjective thirst response of a healthy subject, will allow for restoration of euhydration, within one to six hours. We have designed a device, using existing technology, which empowers a patient to control their intravenous fluid therapy in response to the sensation of thirst. We believe this represents a paradigm shift in the management of hydration. We intend to undertake further clinical studies to refine the design and establish efficacy.

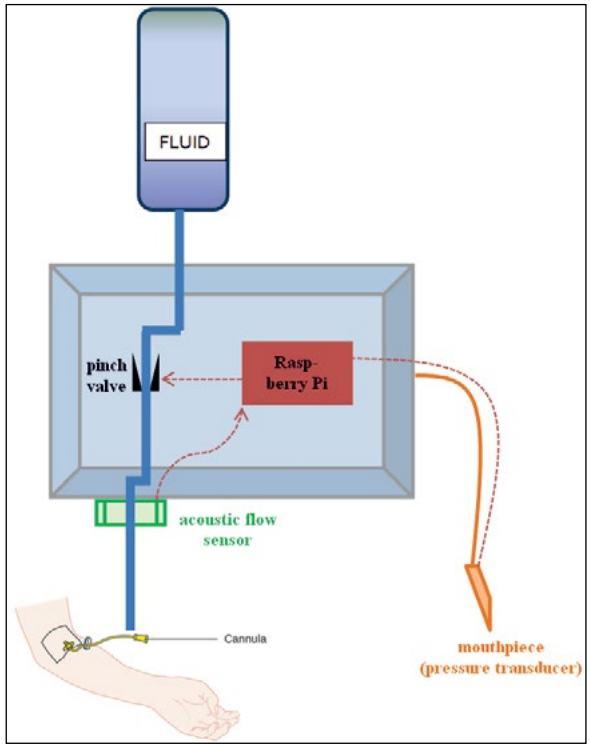


**Figure 2.** Diagram demonstrating design of patient controlled intravenous fluid device

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## P020. Point of care ultrasound; are junior physician trainees being left behind?

*Gethin Hosford*

Department of Medicine, Southmead Hospital, North Bristol NHS trust, Bristol, UK

Contact: gethinhosford@gmail.com

**Background:** Point of care ultrasound (POCUS) use has increased markedly over recent years with decreased cost and increased portability of machines. Its application is well established in trauma patients, shocked, breathless patients as well as focussed echocardiography in a range of clinical environments. Its use in invasive procedures is shown to reduce morbidity and mortality, numerous United Kingdom (UK) royal colleges have recognised this and incorporated it into their curricula. There is some data showing that POCUS can be reliably taught, studies ranging from medical students up to consultant level have demonstrated this, with some countries outside the UK incorporating its use into the undergraduate curriculum.

**Objectives:** To assess the use and experience of point of care ultrasound among junior medical trainees.

**Methods:** Severn deanery core medical trainees were asked 7 questions via web based survey tool "survey monkey". Information on year of training, whether they had attended an accredited ultrasound course, amount of weekly exposure using POCUS, the indication for using ultrasound, the course they had attended and the speciality they intended to apply to for advanced training were included.

**Results:** 42 responded to the survey over a 4 week period in autumn 2016, all of which were core medical trainees, 57% were CT1, 43% CT2. No respondents were officially accredited in an ultrasound discipline. 7% had attended a course but were not accredited, 33% had used ultrasound but had not attended a course, 50% had not used ultrasound and had not attended a course and 10% of trainees were not interested in POCUS.

87% of respondents had used ultrasound less than monthly or never, with only 5% of trainees using POCUS 1–3 times monthly or weekly respectively. The most common indication for performing POCUS was peripheral venous cannulation (71%), followed by thoracic ultrasound (67%), central venous cannulation (45%) and echocardiography (26%). Only 19% of trainees who responded were intended on applying for a speciality with POCUS as part of the curriculum. 90% of trainees had not attended a course, and 5% had attended a level 1 thoracic ultrasound course.

**Discussion:** A surprisingly low amount of trainees had received formal training in ultrasound. The data is also consistent with previous surveys of both respiratory and cardiology trainees who found difficulties in achieving adequate experience and accreditation in their respective ultrasound disciplines. This raises the questions; are junior medical trainees being left behind with the lack of adoption of POCUS into the curriculum? Could it be introduced earlier for trainees interested in acute and procedural specialities to facilitate a smooth transition to higher training? Or at least could ultrasound guided peripheral cannulation be introduced into the core medical trainee curriculum with it being the most frequent indication for using ultrasound?

There are however a number of caveats; POCUS is operator dependent, and should be used by appropriately trained and supervised individual subject to the same rigorous standards set by the Royal College of Radiologists. Not all departments have access to portable ultrasound machines that also have the appropriate expertise on hand to teach

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## P021. Learning curve for insertion of a peripherally introduced central catheter using echo guidance on a phantom model

*Niels Peyls, Milica Matic, Lucie Choustoulakis, Jigme Bhutia, Jan Poelaert*

Dept Anesthesiology and Perioperative Medicine, UZ Brussel, Brussels, Belgium

Contact: niels.peyls@uzbrussel.be

**Background:** The placement of a peripherally inserted central catheter (PICC) is resurging in certain settings as an alternative for the placement of the classical central venous line (CVC). This is mainly due to advancements and availability of ultrasound equipment. Medical learning centres are increasingly introducing simulated training of techniques, including PICC placement. To date no information is available on individual and institutional learning in this respect.
**Objectives:** In this study we aim to draft a learning curve for the procedure of placing a PICC on a phantom model.
**Methods:** We screened and selected trainees amongst doctors in training in the university hospital of Brussels. The trainees were instructed, first in theory, then in practice. In the following days beginners performed the technique on the model over several sessions, while having their completion times and number of errors for each step recorded. We defined an error as either an event that would put a patient's safety at risk or a deviation from a properly taught order. Using an instructor with mastery of the technique we obtained a mean baseline time for each step of the procedure. The mean times for the trainees for each attempt were then plotted out against this mastery baseline ± 2 standard deviations. Using the CUSUM method we drafted a learning curve based on the number of errors per attempt.
**Results:** We found that by the sixth session various steps of the technique were being performed at an adequate pace and by the eleventh session, all steps were (Fig. 1). We found that the entire procedure can be performed error free after the sixth session. Using the CUSUM criteria not every trainee acquired a mastery for every step however (Fig. 2).
**Conclusions:** We considered both time and error-free execution of the procedure as indicators of mastery. The number of required simulated training sessions to achieve and assess a sufficient performance is at least 11 for completion time and at least 6 for an error free technique.

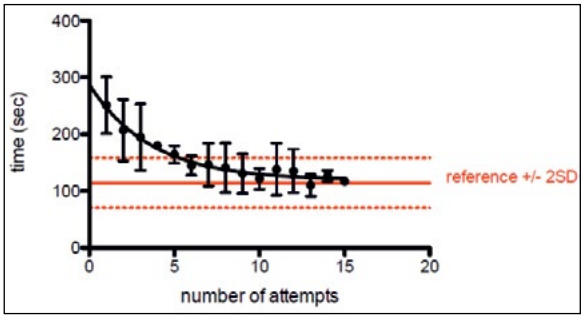


**Figure 1**

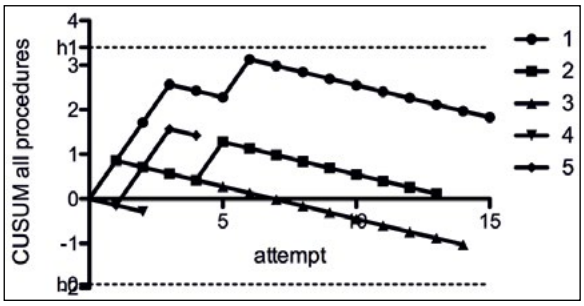


**Figure 2**

## P022. Minimal shedding of endothelial glycocalyx after fluid load during general anesthesia

*Janis Nemme[1], Robert G. Hahn[2], Camilla Krizhanovskii[2], Stelia Ntika[2], Olegs Sabelnikovs[1], Indulis Vanags[1]*

[1]Department of Anaesthesiology and Intensive Care, Riga Stradins University and Paul Stradins Clinical University Hospital, Riga, Latvia
[2]Research Unit, Södertälje Hospital, 152 86 Södertälje, Sweden
Contact: janis.nemme@gmail.com

**Background:** The glycocalyx is a thin layer of membrane-bound proteoglycans (hyaluronic acid, heparin sulphate) and glycoproteins (syndecans), covering the endothelium from the luminal side. It is negatively charged and form a network in which soluble molecules, either plasma or endothelium-derived, are incorporated. This fine layer has many functions, also determines vascular permeability to plasma proteins. Removal of any of its constituents dramatically affects glycocalyx properties leading to tissue edema formation [1]. Hypervolemia caused by liberal fluid administration during operation can lead to glycocalyx damage through release of natriuretic peptides from heart [2].

**Table 1.** Haemodynamics and the plasma and urinary concentrations of shedding products at baseline and during an abdominal surgery procedure and postoperative care (n = 7)

| Before surgery During surgery and PACU Statistics |
|---|
| Haemodynamics |
| Systolic arterial pressure (mm Hg) 144 ± 22 112 ± 11 $P < 0.021$ |
| Diastolic arterial pressure (mm Hg) 84 ± 15 68 ± 7 $P = 0.053$ |
| Heart rate (bpm) 92 ± 12 69 ± 7 $P < 0.003$ |
| Shedding products, plasma |
| Syndecan-1 (ng mL$^{-1}$) 21.0 ± 3.6 19.7 ± 5.1 $P = 0.312$ |
| Hyaluronic acid (ng mL$^{-1}$) 38.0 ± 6.9 27.7 ± 5.3 $P < 0.016$ |
| Heparan sulfate (µg mL$^{-1}$) 3.4 ± 0.9 5.5 ± 0.8 $P < 0.001$ |
| Shedding products, urine |
| Syndecan-1 (ng mL$^{-1}$) 42.9 (36.9–139.8) 24.0 (15.6–46.0) $P < 0.028$ |
| Hyaluronic acid (ng mL$^{-1}$) 10.8 (8.2–29.0) 35.5 (30.9–37.1) $P < 0.043$ |
| Heparan sulfate (µg mL$^{-1}$) 5.5 (5.1–5.9) 5.7 (5.3–6.7) $P < 0.043$ |

Data are the mean ± SD or median (25$^{th}$–75$^{th}$ percentiles), as appropriate. PACU: postoperative care unit

**Methods:** This preliminary report is a part of ongoing larger clinical trial designed to establish relation of massive fluid load and shedding of glycocalyx. The plasma and urine concentrations of three biomarkers of glycocalyx shedding (syndecan-1. hyaluronic acid and heparan sulfate) and plasma concentration of B type natriuretic peptide (BNP) were measured in patients before, during, and after elective open hysterectomy. The intervention fluid therapy consisted of 25 mL kg$^{-1}$ of Ringer's lactate infused over 30 min started right after the induction of anesthesia. The resulting plasma volume expansion was estimated from the haemodilution. Inclusion criteria were ages between 25 and 55 years, no chronic cardiopulmonary or renal diseases, an expected operating time < 90 min, and expected blood loss < 500 mL. Blood samples were taken after general anaesthesia had been induced, but just before the fluid load was initiated, and then 30, 60, and 90 min later. A final sample was taken 2h after the anesthesia had been terminated. Urine was collected from the catheter output on the same occasions as the blood samples were taken, 21 patient has been recruited till September 30$^{th}$. Full data sets including shedding product's concentrations currently are available for 7 patients.

**Results:** Mean age for the patients recruited was 49 years, mean weight 76 kg and volume of Ringer's lactate infused reached 1964 ± 387 mL. Average blood loss was 164 ± 48 mL. As expected, systolic and diastolic arterial pressure decreased significantly during anesthesia (144 ± 22 and 112 ± 11 respectively). Despite the plasma volume expansion by 37 ± 6% there was no significant change in BNP concentration before, during and after surgery (25.1 ± 1.1 pg mL$^{-1}$ and 22.7 ± 1.9 pg mL$^{-1}$). The plasma concentrations of syndecan-1 also were unchanged during anaesthesia, surgery, and postoperative care (21.0 versus 19.7 ng mL$^{-1}$, respectively). The hyaluronic acid concentrations decreased (from 38.0 to 27.7 ng mL$^{-1}$) while those of heparan sulfate slightly increased (from 3.4 to 5.5 µg mL$^{-1}$). The urinary concentration of syndecan–1 decreased significantly (42.9 ng mL$^{-1}$ vs. 24.0 ng mL$^{-1}$) (Table 1).

**Conclusions:** No clear evidence was found for shedding of the glycocalyx layer during an abdominal hysterectomy after a rapid infusion of 25 mL kg$^{-1}$ of Ringer's lactate.

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## P023. Improving i.v. fluid prescribing

*Abdul-Rahman Gomaa, Jonathan N Wilkinson*

Department of Critical Care, Northampton General Hospital NHS trust, Northamptom, UK

Contact: abdul-rahman.gomaa@nhs.net

**Background:** Intravenous (i.v.) fluids are some of the most commonly prescribed day-to-day drugs. They have their indications, benefits, risks, side-effects and complications. Often, the task is delegated to the junior most members of the team. Evidence suggests that such prescriptions are rarely ever done correctly despite the presence of clear guidelines (NICE CG174) [1–3]. This is thought to be due to lack of knowledge and experience, which often breeds confusion. Consequently, this puts patients at increased risk of harm and may incur unnecessary costs to the Trust. Northampton General Hospital NHS Trust is a busy acute Trust with 630 beds covering a population of 380.000. On average, there are usually 48 to 60 patients on i.v. fluids in any one day. Retrospective review of prescriptions within the Trust between 2012–2016 identified poor control of the process. There were considerable variations in i.v. fluid prescriptions; none of which adhered to NICE's guidelines. At times, some prescriptions were placing patients at increased risk of associated complications.

**Objectives:** Establish a quality improvement project to ensure that all i.v. fluid prescriptions are safe, appropriate and adhere to NICE guidance by August 2017.

**Methods:** Using three simultaneous approaches (Fig. 1) we set out to review and improve the prescribing process of "i.v. fluid prescribing". Teaching sessions were delivered to all junior doctors in order to improve knowledge and awareness of appropriate i.v. fluid prescribing and promote familiarity with the current NICE i.v. fluid guidelines. This inc-

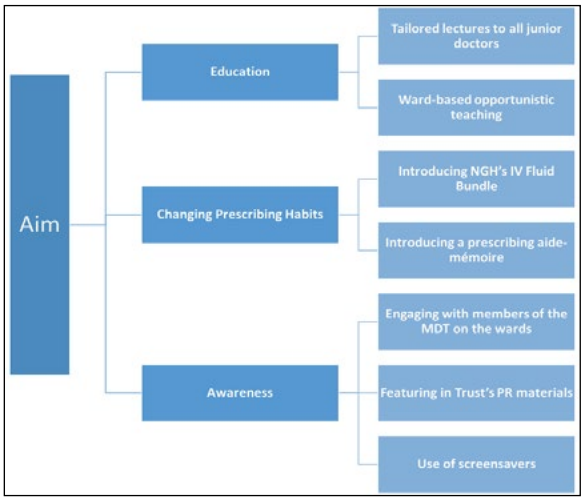


**Figure 1.** A driver diagram outlining how the aim will be achieved

luded a 'feature session' at our local hospital's Grand Round. A point-of-care aide-memoire (Fig. 2) containing a summary of the information needed for correct prescription was designed and printed. This complimented the teaching sessions and supported good clinical practice. Using serial Plan-Do-Study-Act (PDSA) cycles, a novel "i.v. fluid bundle" (Fig. 2) was developed, fine-tuned and trialled on five wards (three surgical, two medical). The aim of the bundle was to ensure that patients were clinically reviewed in order to assess their volaemic status in order that appropriate i.v. fluids could then be selected and prescribed safely. The impact of these interventions was assessed on the trial wards via a weekly point prevalence audit of the i.v. fluid bundles for the duration of the trial. Parameters looked at were: incidence of deranged U&E's, incidence of AKI and the number of days between the latest U&E's and the patient's IV fluid prescription.

**Results:** Baseline data. A total of 100 consecutive i.v. fluid prescriptions across all adult wards were reviewed. Volumes — 16% had the correct volumes prescribed for maintenance fluids. Electrolytes & Glucose-patients received excessive

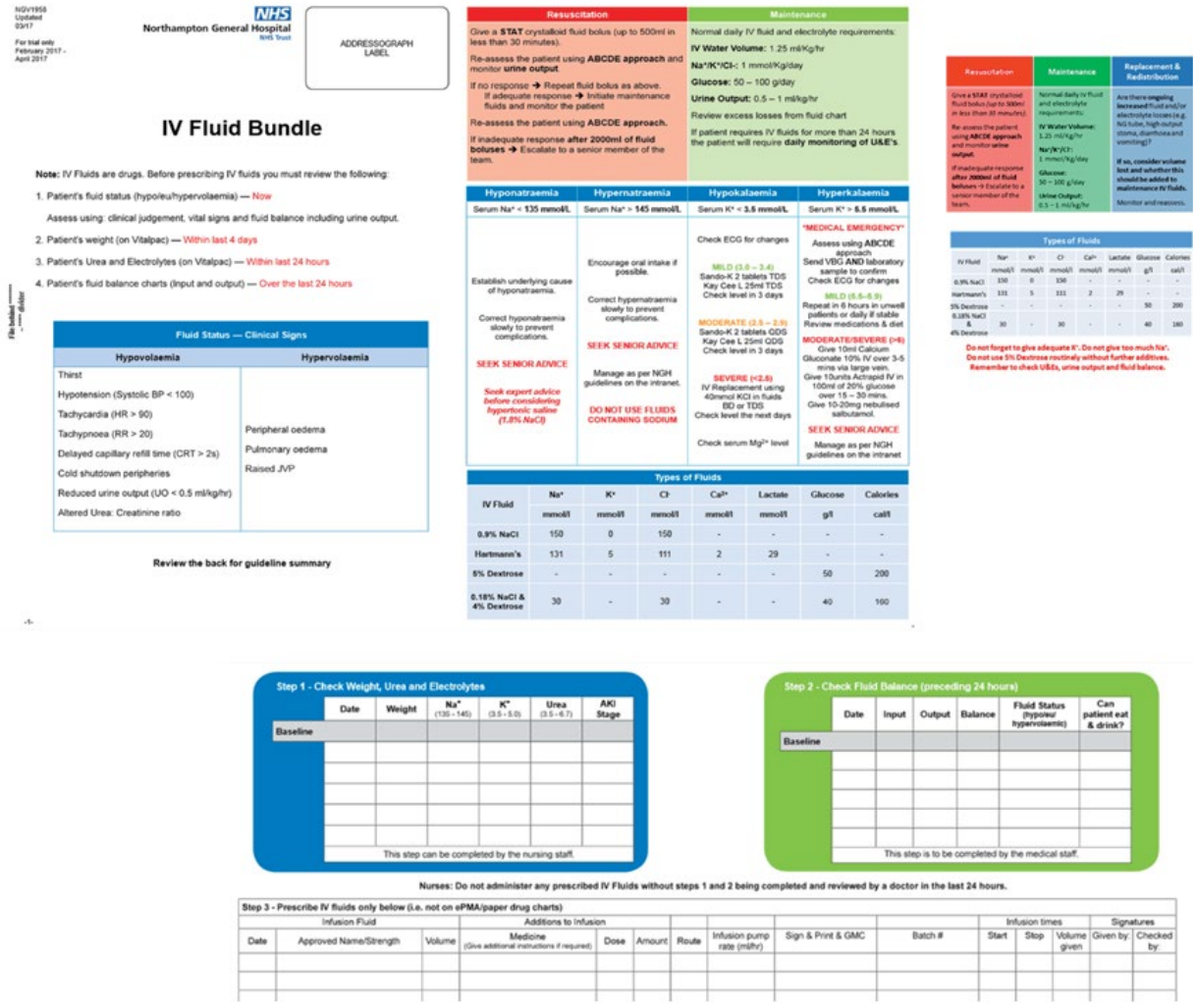


**Figure 2.** NGH i.v. fluid bundle and the prescribing aide-mémoire

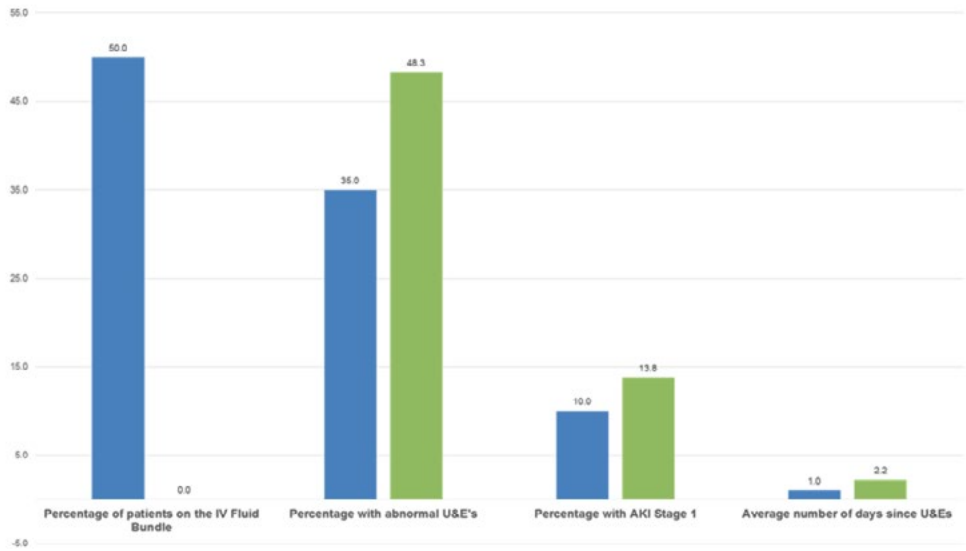


**Figure 3.** Outcome comparison after introducing the NGH's i.v. Fluid Bundle during a two week period. Dark blue bars (2 weeks with i.v. fluid bundle) vs. lighter green bars (2 weeks without i.v. fluid bundle)

amounts of sodium within their i.v. fluid prescriptions yet minimal potassium. Only 25% contained the correct amount of glucose.

With a limited uptake (50%) of the i.v. fluid bundle we were able to significantly improve the measured outcomes and balancing measures (Fig. 3).

Of the patients on the i.v. fluid bundle:

- All patients had a documented review of both fluid status and balance.
- Incidence of deranged U&E's decreased from 48% to 35%.
- Incidence of AKI decreased 14% to 10%.
- The average number of days between the latest U&E's and a fluid prescription decreased from 2.2 days to 1.0 day.

**Discussion:** We aimed to tackle these issues with some simple changes, geared to each of the confounding issues we identified from previous audits and process mapping runs. This is an ongoing quality improvement project within a PDSA cycle; various interventions are being implemented currently. Early results are encouraging. With the increased uptake of NGH's i.v. fluid bundle (Fig. 2) we saw improvements in the observed measures (Fig. 3).

We are currently in the process of delivering teaching sessions to all junior doctors, as well as rolling out NGH's i.v. fluid bundle Trust-wide. Once all the interventions have been delivered and established, we aim to re-assess the i.v. fluid prescriptions within our trust and evaluate the impact of the changes.

**Conclusions:** Prescribing i.v. fluids correctly is a complex task. Ensuring that all i.v. fluid prescriptions within the Trust are safe, appropriate and adhere to evidence-based NICE guidance requires a careful, measured, long-term approach. Changing prescribing habits is the most challenging change to accomplish. Though provisional data goes some way to show that introducing NGH's i.v. fluid bundle can change prescription habits and reduce the incidence of associated complications, further work needs to be done before more reliable results and conclusions may be drawn.

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## P025. Mathematical model of the fluid status after intravenous fluid infusion

*Tilaï T. Rosalina, Peter H.M. Bovendeerd*

Dept. of biomedical engineering, University of Technology Eindhoven

Contact: t.t.rosalina@tue.nl

**Background:** Finding the optimal fluid balance in critically ill patients during and after major surgery is complex due to the lack of information on circulatory and interstitial volume through direct measurements. Mathematical models, that describe underlying physics and physiology, might be able to assist in translating available measurement data

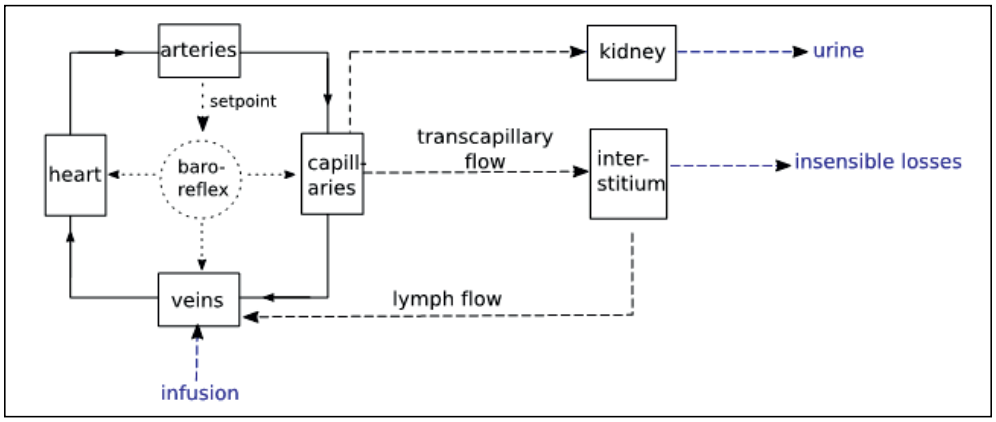


**Figure 1.** Schematic overview of the mathematical model, including interactions of the different modules

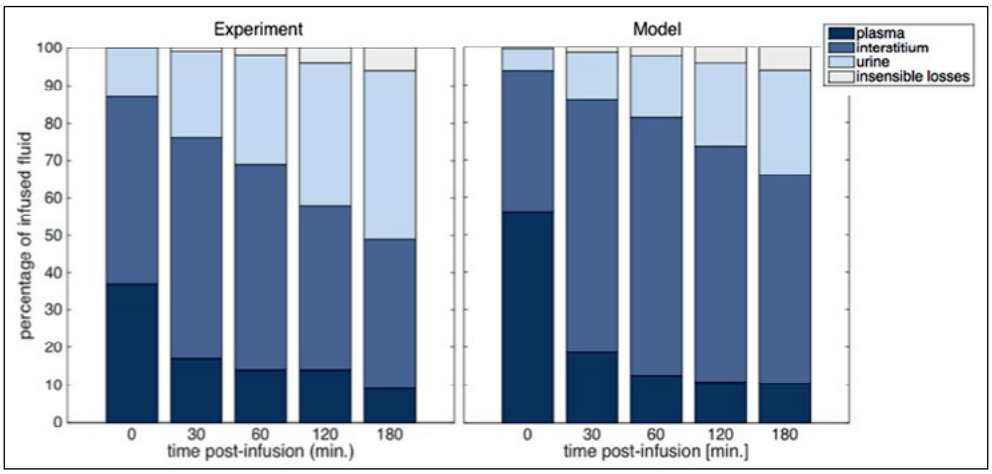


**Figure 2.** Fluid distribution after the infusion of 2.3 liters of saline to healthy volunteers as reported by Watenpaugh *et al.* [3], compared to the model results (right)

into quantitative information on patient fluid status. In this study we present and test a pilot model.

**Methods:** The model (Fig. 1) contains a cardiovascular module, coupled to a baroregulation module [1], from which mean arterial and capillary pressure are calculated. Capillary pressure in combination with osmotic pressure drives transcapillary flow between the vascular and interstitial space, as governed by the Starling equation. The fluid exchange is completed by considering a passive lymphatic flow towards the veins [2]. Urine flow is assumed to be driven by the deviation of plasma volume from a baseline. In this study we use the model to simulate an experiment in which 2.3 L of saline was infused over 23 minutes in healthy volunteers with an average weight of 78 kg [3]. The distribution of the infused volume over plasma, interstitium, urine and insensible losses is compared.

**Results:** The modelled distribution of infused fluid over the different compartments is shown in Figure 2. In agreement with the experiment data, initially a substantial part of the infused fluid enters the interstitial space, while eventually it leaves the body through urine flow. Quantitatively there are some differences: initial plasma expansion is higher in the model than in the experiment. However, after 30 minutes the modelled plasma expansion stabilizes at levels similar to those in the experiment.

The model also underestimates the urine production and consequently overestimates interstitial volume. This may indicate a missing driving force in the renal module. The discrepancies may also be related to experimental limitations, in which data were acquired sequentially and not simultaneously. This may influence especially the early results, where the transcapillary flow is high. Finally, the experimental data are subject to a typical error margin of 10%, related to measurement uncertainty and inter subject variation.

**Conclusions:** Our simple model of cardiovascular fluid exchange shows the interaction of different systems related to fluid balance. The model can provide information that is not readily obtainable through direct measurements, such

as the interstitial volume. For eventual use in clinical decision support, this pilot model must be extended and coupled to the clinical workflow through measurements (such as pulse pressure variation), as well as tested extensively.

**Acknowledgements:** This work was performed within the IMPULS II perioperative monitoring framework.

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## P026. Comparison of ICU transfusion practice (with and without autologous transfusion) in a cardiac surgery population

*Saskia Van Nieuwenhove, Jan Verbeke, Nikolaas De Neve, Koen De Decker*

Department of Intensive care, OLV hospital, Aalst, Belgium

Contact: saskia.van.nieuwenhove@hotmail.com

**Background:** Several trials concluded that postoperative transfusion increases the risk for complications in cardiac surgery patients [1–2]. Although this idea was challenged by other reports, it has led to the development of cell saving devices that collect autologous blood and — after washing of the red blood cells — deliver an end product with a high hematocrit.

**Objectives:** For several years, some of our surgeons used the CardioPat device (Haemonetics, Braintree, Massachusetts, USA), but due to production problems and the company takeover, autologous transfusion was reduced in 2016 and finally stopped early January 2017. In order to look at the impact of this management change, we evaluated our transfusion numbers and several other outcome data.

**Methods:** We compared the transfusion data from the previous years (2015–2016) with the data from 2017, in which the device was no longer used. With regard to transfusion data we looked at the amount of blood products used and the percentage of patients receiving them in the postoperative phase. Furthermore, we made a comparison of these data between the group receiving autologous transfusion and the group that did not. Finally we also describe several other outcome parameters (reintervention rate, new onset of atrial fibrillation, acute kidney injury, length of ICU stay and mortality).

**Results:** The number of procedures in 2015. 2016 and 2017 was 674. 640 and 456 (until August 31st) respectively. A total amount of 351 and 186 units of cell saved blood, correlating with 82.9 and 33.6 liters of autologous blood, were retransfused in the first two years. The percentage of patients receiving allogeneic red blood cells increased (6%) in parallel with the reduction of cell saving, but the amount of blood products did not (Table 1). The ICU length of stay did not change over the years (3.05, 3.08 and 3.01 days respectively), nor did the mortality.

We then divided all patients receiving blood products in two groups, one group with and another one without the retransfusion of autologous blood. Transfusion data are presented in Table 2.

**Table 1**

| | Packed cells | Fresh frozen plasma | Platelets |
|---|---|---|---|
| 2015 | 574 (21) | 289 (12) | 148 (10) |
| 2016 | 601 (25) | 290 (13) | 173 (11) |
| 2017 | 353 (27) | 118 (10) | 65 (9) |

**Table 2**

| | CS | no CS |
|---|---|---|
| Number of patients | 401 | 224 |
| Total amount of packed cells given | 403 | 719 |
| Packed cells/patient | 1 | 3.21 |
| Total amount of fresh frozen plasma given | 232 | 309 |
| Fresh frozen plasma/patient | 0.58 | 1.38 |
| Total amount of platelets given | 130 | 178 |
| Platelets/patients | 0.32 | 0.79 |

Previous reports on the use of the CardioPAT device were contradictory. A large Italian trial [3], investigating intra- and postoperative autotransfusion, showed a significant reduction in exposure to allogeneic RBC's. Complications were also less frequent and the use of CardioPAT appeared to be safe. A more recent Dutch trial [4] did not show reduced transfusion requirements compared to intraoperative cell salvage alone and showed higher CK levels. Transfusion is significantly higher in the non-cell save group. The data are somewhat higher than the percentages mentioned in the two previous trials. When comparing our two groups of transfused patients, we noticed differences in various outcome parameters between the group receiving autologous blood and the group that did not. The incidence of reinterventions was 8.73% in the cell saved group vs. 16.52% in the non-cell saved group ($P = 0.005$). There was also a statistically significant change in severity of acute kidney injury (26.75% vs. 55.13% rise in post- vs. preoperative serum creatinine ($P < 0.0001$), and the length of stay on the ICU (3.79 vs. 5.76 days, $P < 0.0001$). There was no statistical significant difference between the incidence of postoperative new onset atrial fibrillation (16.71% vs. 18.75%, $P = 0.5$) nor mortality (3.99% vs. 6.7%, $P = 0.17$) (Table 3).

**Table 3**

| | CS | no CS |
|---|---|---|
| Reintervention (%) | 8.73 | 16.52 |
| New onset atrial fibrillation (%) | 16.71 | 18.75 |
| % rise in creatinine post- vs preoperatively | 26.75 | 55.13 |
| LOS ICU (days) | 3.79 | 5.76 |
| Deaths (%) | 3.99 | 6.7 |

**Conclusions:** Abandoning autologous postoperative transfusion did not result in higher transfusion rates of allogeneic blood. The number of patients receiving RBCs increased slightly, but the total amount of blood products was not statistically significant. There was a significant difference in the group of transfused patients when comparing patients that received autologous retransfusion vs. the ones that didn't concerning length of stay on the ICU, reintervention rates and the severity of acute kidney injury.

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## P027. RS3PE syndrome as a rare differential diagnosis in edema of the upper extremity. Presentation of two patients with edema refractory to de-resuscitation after volume overload in sepsis


*Daniel Raepple, Thomas Schilling*

Department of Internal Medicine Intensive Care, Katharinen Hospital, Klinikum Stuttgart, Germany

Contact: d.raepple@klinikum-stuttgart.de


**Background:** In 1985. McCarty *et al.* [1] described patients (pts) with an abrupt beginning of bilateral synovitis, predominantly affecting the tendon sheaths of the hand and dorsal pitting edema. The syndrome was therefore named „Remitting Seronegative Symmetrical Synovitis with Pitting Edema", in short, RS3PE. Further magnetic resonance imaging (MRI) and ultrasound imaging (US) studies showed extensor tendosynovitis edema of the peritendinous and subcutaneous soft tissue. There is a male predominance (2:1) and elderly pts are mainly affected. The serological workup in the majority of these patients showed negativity for rheumatoid factor. An association could be demonstrated with polymyalgia rheumatica (PMR), seronegative rheumatoid arthritis (RA) and many other rheumatic diseases [2]. Paraneoplastic RS3PE has also been described and lately two case reports were published of RS3PE after nivolumab. Common to all cases is a dramatic response to corticosteroids and an overall good prognosis [1–5].

**Objectives:** In sepsis, various mechanisms contribute to endothelial injury and capillary leakage. High volume fluid resuscitation often leads to the formation of generalized edema. De-resuscitation by means of diuretics or renal replacement therapy is a major challenge after the initial phase. Persisting peripheral edema despite negative volume balance should raise suspicion for co-existing problems like severe hypoalbuminemia, thrombosis or myxedema. By presenting two cases of persisting edema we want to draw attention to a rare differential diagnosis, RS3PE.

**Methods:** Informed consent was obtained from the legal substitute. Ultrasound studies were performed with a Philips (R) CX-50 with a linear probe.

**Case presentation 1:** A 76-year-old male patient was transferred our ICU. After vascular surgery he suffered septic multiple organ failure caused pneumonia (HAP). Previously known diagnoses were alcohol abuse and hypothyroidism. Despite de-resuscitation of persisting volume overload, bilateral edema of the hands persisted. Thromboses of the upper extremities were excluded, thyroid hormones were substituted and in normal range. Retrospectively, the diagnosis of pre-existing PMR was based on a family member reporting extreme bilateral painfulness in the shoulder area in the weeks before. There was a markedly increased blood sedimentation rate. Rheumatoid factor was unspecific, antibodies against cyclic citrullinated peptide (CCP) were negative. On corticosteroids, a rapid improvement of the edema and of PMR symptoms resulted.

**Case presentation 2:** A 66-year-old male with known history of RA was transferred to our department in septic multi--organ failure combined with hydropic decompensation caused by destructive mitral-valve endocarditis. A immunosuppressive RA therapy was paused. After de-resuscitation bilateral pitting edema of the hands persisted. As soon as it was feasible in the septic course of the endocarditis, low dose steroids showed a dramatic effect.

**Conclusions:** R3SPE is a rare differential diagnosis in edema of the upper extremities but should be considered in persisting pitting, bilateral edema refractory to de-resuscitation. Implications of diagnosis are possible associations with paraneoplastic or rheumatoid diseases and their complications, e.g. temporal arteritis in PMR. RS3PE might be an emerging syndrome as a possible side effects of new therapies.

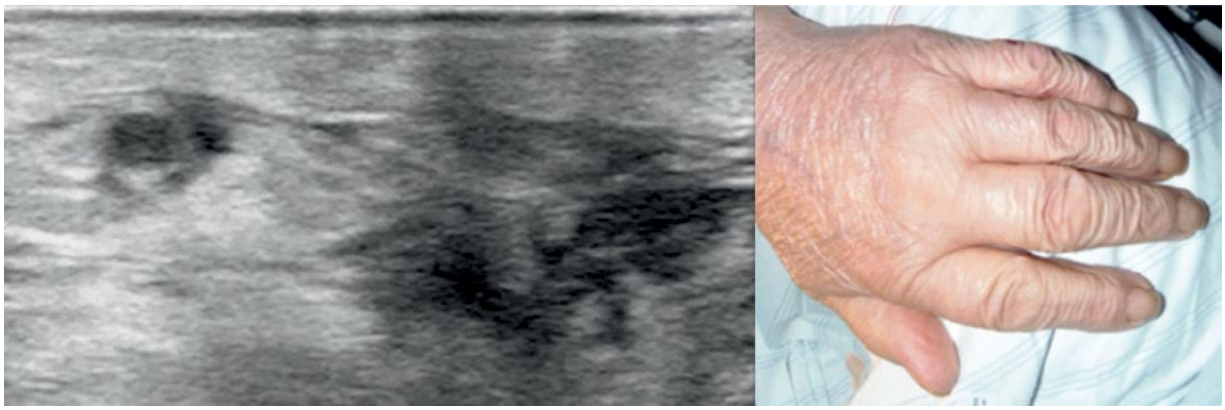

**Figure 1.** Ultrasound imaging of the dorsal hand prior to steroids of a pt (case 1) with PMR diagnosed retrospectively (top). Dramatic response on a short course steroid therapy with remaining folds (bottom)

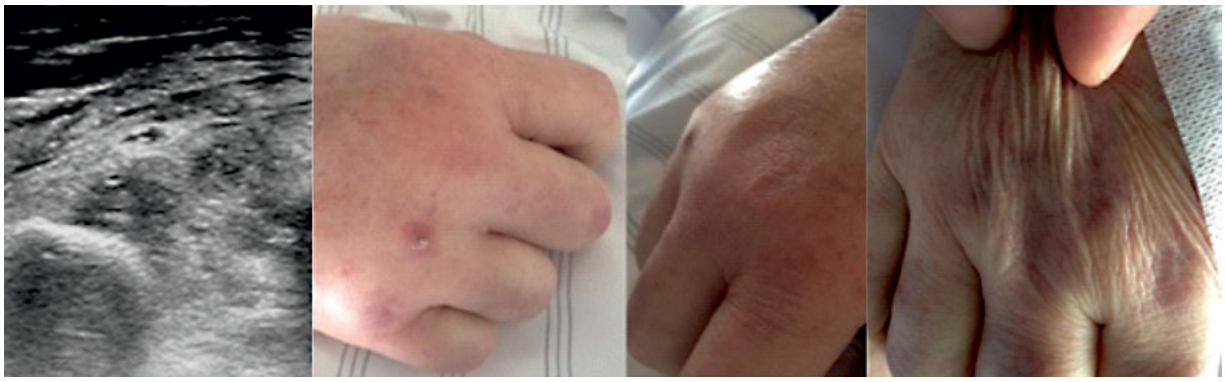

**Figure 2.** Pat. with „boxing glove edema" (Top left) and "pitting" edema (top middle). This pt. with known rheumatoid arthritis developed RS3PE under cessation of steroids and MTX because of mitral valve endocarditis. Dramatic response to a short course of low dose steroids

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## P028. A case of fatal disseminated mucormycosis infection in an HIV-patient on plasmapheresis for atypical hemolytic uremic syndrome

*Ine Gerard[1], Peter Rogiers[1], Marc Helbert[1], Sabine Declercq[2], Bart Gordts[3]*

[1]Department Intensive Care, Ziekenhuis Netwerk Antwerpen, ZNA Middelheim, Antwerp, Belgium

[2]Department Pathology, Ziekenhuis Netwerk Antwerpen, ZNA Middelheim, Antwerp, Belgium

[3]Department Microbiology, Ziekenhuis Netwerk Antwerpen, ZNA Middelheim, Antwerp, Belgium

Contact: ine-gerard@hotmail.com

**Background:** Mucormycosis is a rare but emerging yeast infection, mostly associated with hematological diseases and immunosuppression. It has a high mortality, especially when disseminated1 and diagnosis is still very challenging. Until now there are no specific recommendations for diagnosis and management.

**Clinical case:** We present a 39-year-old HIV-and HCV positive patient from Asian origin. He had recently been treated with plasmapheresis and high corticoid dosing for a case of atypical hemolytic uremic syndrome (aHUS)/ thrombotic micro-angiopathy of unknown etiology (HIV-related, antiretroviral therapy related?).

After an emergency appendectomy this patient was admitted on ICU because of a post-operative bleeding with need for massive transfusion. On ICU we diagnosed a recidivating thrombocytopenia and hemolysis. A new series of plasmapheresis was started because of this new episode of aHUS. After an initial recovery he deteriorated again with once more signs of hemolysis. During new plasmapheresis he showed signs of infection with fever, high inflammatory parameters, and bilateral diffuse pulmonary infiltrations on chest X-ray and chest CT-scan. Broncho-alveolar lavage (BAL) showed a positive antigen for Aspergillus and concomitant infection with Pneumocystis carinii. He showed a Cytomegalovirus reactivation as well. Intensive antifungal treatment was started (consecutively Echinocandins, Voriconazol and Amphotericin B) combined with antibacterial treatment, but this therapy was challenged by recidivating hemolysis and interactions of anti-fungal therapy. Despite this treatment there was an evolution to severe respiratory insufficiency with need for elective endotracheal intubation and ventilation. Even under lung-protective ventilation he deteriorated to a very difficult ventilation. New CT-scan showed slightly evolving bilateral pulmonary infiltrations but also infiltrations in various abdominal organs. Due to the combination of persisting kidney failure and hemolysis/thrombocytopenia patient underwent a kidney biopsy which showed infiltration with fungi. We planned a diagnostic open lung biopsy but our patient died due to a rapidly evolving sepsis. Postmortem autopsy showed multi-organ angio-invasive mucormycosis (heart, lungs, stomach, spleen and kidneys) with extended necrosis in all those organs. This postmortem diagnosis explained why all our therapies failed. Due to multi-organ invasion a necessary surgical debridement would not have been possible and antifungal treatment alone wouldn't have been enough.

**Conclusions:** We showed a case of complicated HIV-infection with atypical HUS who had multiple opportunistic infections after necessary plasmapheresis. Although intensive therapy with almost all available antifungal therapies our patient died due to a disseminated mucormycosis infection with multi--organ invasion. This case shows the diagnostic difficulties of this condition (BAL, 2 times, and kidney biopsy failed to reveal this diagnosis although infection of this organs). Even if diagnosed, therapy for mucormycosis is very challenging [1, 2]. Especially in multi-organ invasion it tends to fail due to impossibility of necessary concomitant surgical debridement [3, 4]. This disseminated mucormycosis is rare [5, 6] but emerging in our population of HIV patients, diabetics and patients on immunosuppression. Invasion of stomach and spleen are barely described in literature as well as infiltration of the heart, what makes this case more special. As mucormycosis is emerging in our population we probably should think about this diagnosis earlier in our differential diagnosis when competing with a high-risk patient with untreatable sepsis.This case also shows the value of postmortem autopsy to reveal undiagnosed causes of death. Although all are diagnostic testing possibilities we still fail to diagnose some major conditions. So, especially in patients with HIV or immunosuppression we advise postmortem autopsy to confirm assumed infections and the spread in different organs.

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## P029. Effect of perioperative fluid therapy on blood osmolality in patients undergoing elective orthopaedic surgery


*Paulina Iwaniuk[1], Hubert Kolano[2], Ziemowit Rzecki[1], Edyta Wilczyńska[1], Daniel Pietrzak[1], Małgorzata Barud[1], Jacek Gagała[3], Dorota Siwicka-Gieroba[1], Wojciech Dąbrowski[1]*

[1]Department of Anaesthesiology and Intensive Therapy Medical University of Lublin, Poland,

[2]Regional Hospital in Nisko, Poland

[3]Department of Orthopaedic and Traumatology Medical University of Lublin, Poland

Contact: paulina.pawlik89@gmail.com


**Background:** Plasma osmolality is an important determinant for fluid shift across the capillary wall. A decrease in plasma osmolality leads to tissue edema, which impairs tissue perfusion. Perioperative fluid infusion may affect the blood osmolality, because theoretical fluid osmolality is different that real [1]. Several studies have documented that crystalloids infusion affects plasma osmolality whereas colloid fluids are iso-oncotic [2].

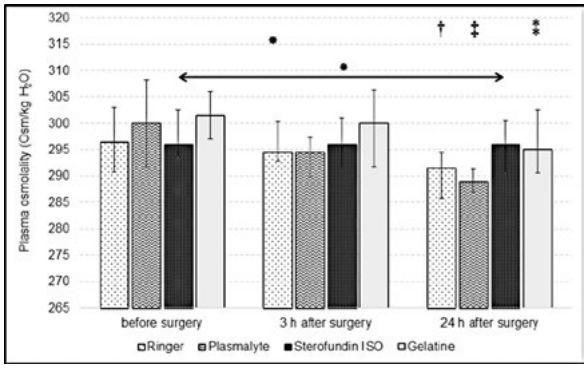


**Figure 1.** Changes in plasma osmolality in patients undergoing elective orthopaedic surgery treated with solution Ringer, Plasmalyte®, Sterofundin ISO and Gelatine; *$P < 0.05$ — differences between plasma osmolality before surgery and 24 hours after surgery; †, ‡ and ⁑$P < 0.05$ — differences in plasma osmolality between groups: R and S, P and S and P and G, respectively

**Objectives:** The purpose of this study was to analyse the plasma osmolality in patients treated with crystalloids or gelatine infusions.

**Methods:** Adult patients undergoing elective knee arthroplasty surgery under spinal anaesthesia were enrolled. Patients with complicated perioperative period and/or those, who required massive fluid resuscitation following perioperative bleeding were excluded. Plasma osmolality was measured just before surgery (A — baseline), 3 hours after surgery (B) and 24 hours after surgery (C). Patients were divided into four equal groups (n = 20): R — patients receiving Ringer solution, P — Plasmalyte®, S-Sterofundin ISO and G — Gelatins. All fluids were administered at the dose 10–15 mL $kg^{-1}$ body weight.

**Results:** 80 patients (33 female and 47 male) aged 34––84 (mean 63 ± 12) were studied. The baseline osmolality was comparable in all patients. Plasma osmolality decreased in group R and P at time point C ($P < 0.01$. respectively), whereas was practically unchanged in group S and G. At time point C we noted significant differences in plasma osmolality between groups R and S ($P < 0.05$), P and S ($P < 0.05$) and P and G ($P < 0.05$) (Fig. 1).

**Conclusions:** Some crystalloids infusion, such as Ringer solution or Plasmalyte®, decreases plasma osmolality whereas Sterofundin ISO infusion does not affect it. Gelatine infusion does not affect plasma osmolality.

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## PO30. Effect of fluid therapy on body water content in patients undergoing elective orthopaedic surgery

*Paulina Iwaniuk[1], Hubert Kolano[2], Dorota Siwicka-Gieroba[1], Ziemowit Rzecki[1], Edyta Wilczyńska[1], Małgorzata Barud[1], Jacek Gągała[3], Wojciech Dąbrowski[1]*

[1]Department of Anaesthesiology and Intensive Therapy Medical University of Lublin, Poland

[2]Regional Hospital in Nisko, Poland

[3]Department of Orthopaedic and Traumatology Medical University of Lublin, Poland

Contact: paulina.pawlik89@gmail.com

**Background:** Fluid therapy is frequently used for correction of perioperative haemodynamic disorders in patients undergoing surgery under spinal anaesthesia. Unfortunately, an inappropriate fluid administration may result in tissue edema leading to severe postoperative complications [1, 2].

**Objectives:** The aim of this study was to compare the effect of perioperative crystalloids infusion vs. gelatine infusion on body water content in orthopaedic patients.

**Methods:** Adult patients undergoing elective knee arthroplasty surgery under spinal anaesthesia were enrolled. Patients with complicated perioperative period and/or those, who required massive fluid resuscitation following perioperative bleeding were excluded. Whole body bioimpedance was used for volume excess (VE), total body water (TBW), extracellular body water (ECW) and intracellular body water (ICW) measurement. All variables were measured just before surgery (A), just after surgery (B) and 3. 6 and 24 hours after surgery (C, D and E, respectively). Patients were divided into four groups: R — patients receiving Ringer solution, P — Plasmalyte®, S — Sterofundin ISO and G — Gelatins. All fluids were administered at the dose 10–15 mL $kg^{-1}$ body weight during surgery.

**Results:** 75 patients (27 female and 38 male) aged 34––84 (mean 62 ± 12) were studied. VE increased in group R, P and S at time points B ($P < 0.05$), C ($P < 0.01$), D ($P < 0.01$) and E ($P < 0.01$). Similarly, ECW increased in groups R, P and S at time points B, C, D and E ($P < 0.001$). Gelatine infusion did not affect VE, TBW, ECW and ICW. There were significant differences in VE between group R and G at time points C and E ($P < 0.05$) and between group P and G at time points C, D and E ($P < 0.05$). Additionally, TBW and ICW were significantly higher in group R than G at time point C ($P < 0.05$).

**Conclusions:** Perioperative crystalloids infusion increases total body water, particularly in extravascular space. Use of gelatine does not affect body water homeostasis and seems to be safe in patients undergoing elective orthopaedic surgery under spinal anaesthesia.

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## P031. Effect of fluid therapy on blood coagulation parameters in patients undergoing elective orthopaedic surgery

*Hubert Kolano[1], Paulina Iwaniuk[2], Dorota Siwicka-Gieroba[2], Ziemowit Rzecki[2], Edyta Wilczyńska[2], Małgorzata Barud[2], Jacek Gagala[3], Wojciech Dabrowski[2]*

[1]Regional Hospital in Nisko, Poland

[2]Department of Anaesthesiology and Intensive Therapy Medical University of Lublin, Poland

[3]Department of Orthopaedic and Traumatology Medical University of Lublin, Poland

Contact: hkolano@poczta.onet.pl

**Background:** Perioperative fluids infusion may affect blood coagulation increasing a risk of perioperative bleeding. This effect results from perioperative blood dilution, transient decrease in plasma factor VII and von Willebrand concentrations or impaired platelet reactivity [1]. These disorders are strongly dependent on kind of fluid and infused volume. Previous study showed a higher decrease in coagulation competence in patients receiving hydroxyethyl starches than in patients treated with crystalloids [2].

**Objectives:** The aim of this study was to analyse the effect of fluid infusion on popular coagulation variables in patients undergoing orthopaedic surgery. Methods: Adult patients undergoing elective knee arthroplasty under spinal anaesthesia were enrolled. Patients with complicated perioperative period and/or those, who required massive fluid resuscitation following perioperative bleeding were excluded. Active partial thromboplastin time (APTT), prothrombin time and international normalized ration (INR) were assessed for measurement at the three time points: A — a day before surgery (baseline), 3 hours after surgery and 24 hours after surgery. Patients were divided into four equal groups (n = 20): R — patients receiving Ringer solution, P — Plasmalyte®, S — Sterofundin ISO and G — Gelatins. All fluids were administered at the dose 10–15 mL $kg^{-1}$ body weight.

**Results:** 80 patients (33 female and 47 male) aged 34–84 (mean 63 ± 12) were studied. In group R: APTT increased at time points C, PT and INR increased at time points B and C. Similar changes were noted in group P (Table 1). In group S, PT and INR increased at time points B and C. In group G, APTT, PT and INR increased at time points B and C (Table 1). There were significant differences between groups: R and S in APTT ($P < 0.01$), PT and INR ($P < 0.05$) at time points C, P and S in PT ($P < 0.01$) and INR ($P < 0.05$) at time points C as well as R and G, and P and G in PT at time points B ($P < 0.05$).

**Conclusions:** Crystalloids infusion prolongs coagulation times. Disorders in coagulation associate with both crystalloids and gelatine infusion.

**Table 1.** Changes in coagulation variables in patients undergoing elective knee arthroplasty (median [quartile 1 and 3]). Time points: A — a day before surgery (baseline), B — 3 hours after surgery completion, 24 hours after surgery completion; * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$ — comparison with baseline (Wilcoxon test)

| | APTT | | |
|---|---|---|---|
| | **A** | **B** | **C** |
| Group R | 29.5 [27.8; 31.3] | 28.4* [26.2; 31.6] | 30.3 [27.8; 33.4] |
| Group P | 27 [26.2; 30.7] | 26.6* [24; 29.6] | 29.3 [26.2; 31.8] |
| Group S | 27.6 [25.8; 27.7] | 26.8 [25.5; 28] | 27.2 [26.1; 31.8] |
| Group G | 27.5 [26.3; 28.6] | 28.9* [27.1; 30.7] | 28.7** [27.3; 31.6] |
| | **PT** | | |
| | **A** | **B** | **C** |
| Group R | 11.2 [10.9; 11.7] | 12.2*** [11.8; 12.6] | 12.8*** [12.2; 13.3] |
| Group P | 10.9 [10.7; 11.5] | 12.1*** [11.5; 12.6] | 12.3*** [12.1; 13] |
| Group S | 11.5 [10.9; 12] | 12.4*** [11.9; 12.9] | 13.4*** [13; 13.9] |
| Group G | 11.2 [10.9; 11.8] | 12.7*** [12.3; 13.2] | 13.4*** [12.5; 14] |
| | **INR** | | |
| | **A** | **B** | **C** |
| Group R | 1.03 [0.98; 1.05] | 1.1** [1.06; 1.13] | 1.15*** [1.1; 1.2] |
| Group P | 0.99 [0.96; 1.04] | 1.09*** [1.02; 1.12] | 1.11*** [1.07; 1.18] |
| Group S | 1.04 [0.98; 1.07] | 1.1*** [1.06; 1.16] | 1.19*** [1.15; 1.24] |
| Group G | 1 [0.97; 1.1] | 1.14*** [1.09; 1.17] | 1.21*** [1.14; 1.25] |

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## P032. Comparative effects of fluid resuscitation on lung and heart oxidative injury in a rat model of hemorrhagic shock

*Kubra Vardar, Ugur Aksu*

Department of Biology, Science Faculty, Istanbul University, Istanbul, Turkey

Contact: ugur_aksu@hotmail.com

**Background:** Although fluid resuscitation therapy is the first step of treatment for hemorrhagic shock, there is still debate on the different outcome for each organ.

**Objectives:** In the present study, we aimed to compare the oxidative effects of unbalanced resuscitation fluids for lungs and heart in a rat hemorrhagic shock model.

**Methods:** Anesthetized and spontaneously breathing rats were randomly assigned to four groups (n = 6/group): (1) time control; (2) hemorrhagic shock control; (3) hemorrhagic shock followed by unbalanced crystalloid resuscitation (0.9% NaCl); and (4) hemorrhagic shock followed by unbalanced colloid resuscitation (6% hydroxyethyl starch (HES). Hemorrhagic shock was induced by withdrawing blood from the femoral artery until mean arterial pressure (MAP) was reduced to 30–40 mm Hg. One hour later, animals were resuscitated with resuscitation fluids until a target MAP of 80 mm Hg was reached throughout one hour. Major lipid peroxidation product as malondialdehyde (MDA) levels in both lungs and heart were measured by spectrophotometric determination following experimental procedure.

**Results:** The main findings of our study were that: (1) Hemorrhagic shock increased MDA levels in lung tissues but not in heart tissues. (2) While both colloid and crystalloid resuscitation suppressed MDA levels in lung tissues (3) lipid peroxidation was further increased by crystalloid resuscitation in heart tissues.

**Conclusions:** Lungs seem to be early effected organ than heart during hemorrhagic shock, and crystalloid resuscitation could start a stress that is not already present. Hence organ based fluid resuscitation should be taken into consideration.

## P033. Furosemide and albumin for diuresis of edema (FADE): a parallel-group, blinded, randomized controlled pilot trial

*Simon Oczkowski[1, 2], Lisa Klotz[2], Ian Mazzetti[3], Fayez Alshamsi[4], Mei Lin Chen[5], Gary Foster[6, 7], Maureen Meade[1, 2, 6], Cindy Hamielec[1, 2]*

[1]Division of Critical Care Medicine, Department of Medicine, McMaster University, Hamilton, Canada

[2]Department of Critical Care, Hamilton Health Sciences, Hamilton Canada

[3]Schulich School of Medicine and Dentistry, Western University, Windsor, Canada

[4]Department of Internal Medicine, College of Medicine and health Sciences, United Arab Emirates University, Al Ain, UAE

[5]Department of Health Sciences Honours, Faculty of Health Sciences, McMaster University, Hamilton, Canada

[6]Department of Health Research Methods, Evidence, and Impact, McMaster University, Hamilton, Canada

[7]St. Joseph's Healthcare Hamilton Research Institute, Statistics Unit, Hamilton, Canada

Contact: oczkowsj@mcmaster.ca

**Background:** Fluid overload is associated with morbidity and mortality in critically ill patients. Adding hyperoncotic albumin to standard treatment with diuretics may improve diuresis and facilitate liberation from mechanical ventilation.

**Objectives:** We conducted a pilot study to assess the feasibility of a definitive randomized controlled trial testing the effectiveness of hyperoncotic albumin as an adjunct to diuretics in critically ill adults.

**Methods:** At two medical/neurotrauma ICUs in Canada, we randomized hemodynamically stable, hypoalbuminemic adults, judged to require diuresis, to receive either 25% albumin or 0.9% saline placebo, 100 mL twice daily for a total of six doses, within 2 hours of prescribed furosemide. Patients, physicians, and research staff were blinded. We specified five feasibility criteria for moving on to a larger trial: enrollment of 50% of eligible patients, and at least one patient per week; provision of the first dose of study treatment within 2 hours of diuretics in 85% of patients; completion of study regimen in 80% of patients; and avoidance of open label 25% albumin in 85% of patients.

**Results:** From September 2014 to October 2016 we randomized 85% of eligible patients (24 albumin, 21 placebo). Due to slow recruitment (0.42 patients/week), we stopped the trial short of our target 50 patients. 84% (95%CI 0.73, 0.96) of patients received study treatment within 2 hours of the first furosemide dose, 69% (95%CI 0.54, 0.80) received the complete study regimen, and 20% received open–label albumin (95%CI 0.11, 0.34). The albumin group had a greater increase in serum albumin (MD 5.94 g $L^{-1}$, 95%CI [1.44, 6.89], $P = 0.0047$) and colloid osmotic pressure (MD 3.13 mm Hg, 95%CI [1.96, 4.31], $P < 0.001$), but both groups had similar changes in urine output (MD –422 mL, 95%CI [–1062, 218],

$P = 0.20$) and fluid balance (MD 147 mL 95% CI [–767, 1061], $P = 0.75$). Clinical outcome data included ventilator free days (median [Q1, Q3] days, 4.0 [0.0, 23.5] v. 13.0 [0.0, 21.0]), length of ICU stay (median [Q1, Q3] days, 18.25 [11.3, 38.0] v. 16.6 [11.2, 26.2]) and 30-day mortality (6/24 v. 2/21).

**Conclusions:** The current study design was infeasible with respect to rate of recruitment, timely and complete administration of study treatment, and avoidance of open-label 25% albumin. With modifications to address these challenges, this pilot study can inform the protocol for a successful definitive trial.

**Trial registration:** Clinicaltrials.gov NCT02055872; ISRCTN 70191881.

**Funding:** Hamilton Health Sciences New Investigator Fund, Dr. Clive Davis.

**Acknowledgements:** Dr. Oczkowski is supported by a Canadian Critical Care Trials Group Fellowship Award, and a career award from the Department of Medicine, McMaster University.

## P035. Bilirubin, an early outcome marker in tricuspid surgery

*Brecht Calle[1], Koen De Decker[1], Frank Van Praet[2], Filip Casselman[2]*

[1]Department of Anesthesia and Intensive Care Medicine, Onze Lieve Vrouw hospital, Aalst, Belgium

[2]Department of Cardiovascular Surgery, Onze Lieve Vrouw Hospital, Aalst, Belgium

Contact: brechtcalle@icloud.com

**Background:** Bilirubin, as a marker of backward failure and/or congestion, is well-studied in the therapy in right ventricular failure or in the field of mechanical circulatory support. The relevance of (even minor) postoperative bilirubin elevations after surgery of the tricuspid valve is less clear.

**Objectives:** Therefore, we investigated the bilirubin levels of all patients admitted to our intensive care unit (ICU) after tricuspid surgery and correlated them with outcome.

**Methods:** The bilirubin levels of 100 patients undergoing tricuspid valve surgery between 2013 and 2016. were retrospectively analyzed, regardless of concomitant surgical procedures. For each patient, the highest recorded bilirubin during their ICU stay, the Peak bilirubin level (PBL), and the timing of PBL were retrieved from the files. Patients were divided into 3 groups according to PBL: Normal PBL (≤ 1 mg $dL^{-1}$), moderate rise in PBL (> 1 mg $dL^{-1}$ and ≤ 5 mg $dL^{-1}$), and high rise in PBL (> 5 mg $dL^{-1}$). We then compared the following outcome parameters: length of ICU stay (ICU-LOS), Hospital Length of stay (Hos-LOS), and hospital mortality.

**Results:** ICU-LOS and Hos-LOS where clearly prolonged with increasing PBL (Fig. 1), while Hos-LOS was significantly longer ($P = 0.012$) for the moderate PBL group (24.8 days + SD) compared to the normal PBL group (14.8 days + SD). Interestingly, the average value of, only 1.8 mg $dL^{-1}$ in the group with moderate PBL rise, seems relevant (Fig. 2). Overall hospital mortality was 6% but increased to 65% in the high

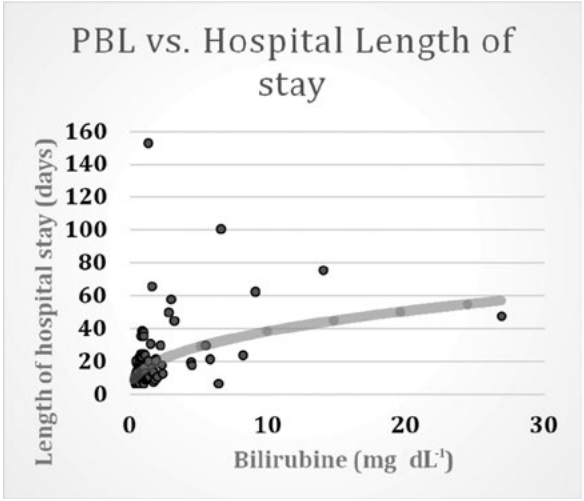


**Figure 1.** Peak bilirubin level vs. hospital length of stay

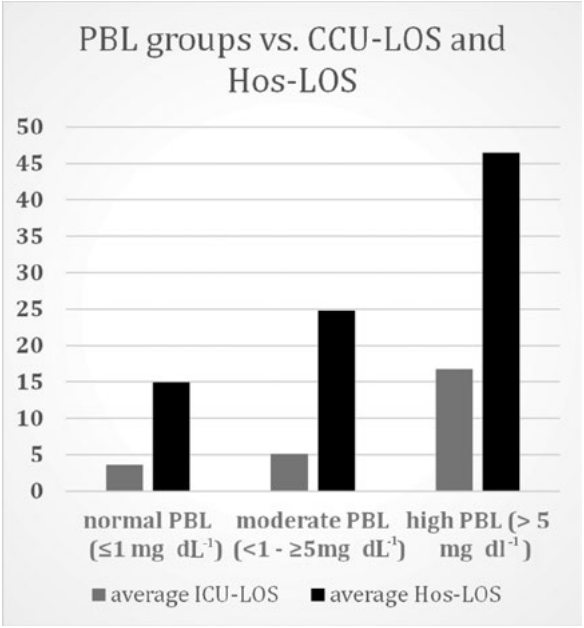


**Figure 2.** Peak bilirubin levels groups in relation to CCU and hospital length of stay

**Table 1**

| | normal PBL (≤ 1 mg $dL^{-1}$) | moderate PBL (< 1 – ≥ 5 mg $dL^{-1}$) | high PBL (> 5 mg $dL^{-1}$) |
|---|---|---|---|
| average (h) | 29.4 | 54.4 | 249.9 |
| Median (h) | 16.5 | 40 | 186 |

PBL group. As shown in Table 1, the time to reach PBL in the normal, moderate and high PBL group was 16.5h (+ SD), 40h (+SD) and 189h (+ SD) respectively. Which is rather early in the ICU stay, at least in the normal and moderate group.

**Conclusions:** In patients with tricuspid repair or replacement even a small rise in postoperative bilirubin can indicate a prolonged length of stay in the hospital. As the PBL is reached within 48 hours, bilirubin could serve as a low cost, easily available predictor in the postoperative management of patients undergoing tricuspid valve surgery.

## P037. Effect of dilution with different fluids on blood coagulation

*Grzegorz Wilhelm[1], Dorota Siwicka-Gieroba[1], Magdalena Bielacz[2], Hubert Kolano[3], Ziemowit Rzecki[1], Wojciech Dabrowski[1]*

[1]Department of Anaesthesiology and Intensive Therapy Medical University of Lublin, Poland

[2]Institute of Tourism and Recreation, State Vocational College of Szymon Szymonowicz, Zamosc, Poland

[3]Regional Hospital in Nisko, Poland

Contact: dsiw@wp.pl

**Background:** Perioperative blood dilution may affect blood coagulation increasing risk of perioperative bleeding. Some experimental studies have documented significant increase in active partial thromboplastin time (APTT), prothrombin time (PT) and international normalized ration (INR) following hydroxyethyl starch (HES) and normal saline infusion [1]. In vitro studies have showed significant disorders in APTT and PT following blood dilution with normal saline and HES to 35–45% [2]. Unfortunately the effect of blood dilution with balanced crystalloids and gelatin on coagulation times (APTT and PT) has not been thoroughly investigated.

**Objectives:** The aim of this study was to analyse an in vitro effect of isovolaemic blood dilution on coagulation variables.

**Methods:** Blood samples from 30 healthy voluntaries at the volume of 10 mL were diluted with crystalloid solution (Sterifundin® ISO, Braun), gelatin (Gelaspan®, Braun), and hydroxyethyl starch (Tetraspan®, Braun). According to degree of dilution, samples were randomized using a concealed envelope method into three equal groups: diluted to 25%, 35 and 45% (n = 10). APTT, PT and international normalized ration INR were assessed in samples just before dilution (baseline) and after dilution.

**Results:** The baseline values of APTT, PT and INR were similar in all groups. PT and INR increased following 25%, 35% and 45% blood dilution with crystalloids ($P < 0.01$), whereas APTT increased following 25% blood dilution with gelatine ($P < 0.05$). Longer PT and INR were noted in samples diluted to 35% with crystalloids than hydroxyethyl starch ($P < 0.01$), and samples diluted to 45% with crystalloids than gelatin ($P < 0.01$). Longer APTT was noted in samples diluted to 35% and 45% with gelatin than crystalloids and hydroxyethyl starch ($P < 0.01$). Increasing blood dilution prolongs PT and INR independently of type of solutions, whereas gelatin significantly drawn APTT out only in samples diluted to 45% (0.001).

**Conclusions:** Blood dilution prolongs coagulation times. In vitro, crystalloids disturb coagulation times more spectacularly than gelatin and hydroxyethyl starch in diluted samples. The greatest changes in PT and INR caused blood dilution to 25%.

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## P038. Septic shock as a complication of heart surgery successfully treated with cytosorb: a case report

*Miodrag Golubovic, Jovan Rajic, Natasa Gocic-Peric, Andrej Preveden, Stamenko Susak, Aleksandar Redzek, Ksenija Babovic-Stanic*

Institute for Cardiovascular Diseases of Vojvodina, Clinic for Cardiovascular Surgery, Sremska Kamenica, Serbia

Contact: a.preveden@gmail.com

**Case report:** In this abstract we present a case of a forty--eight-year-old man who was admitted to hospital because of anterior wall STEMI. Urgent coronary angiography showed occlusion of the left anterior descending artery. Primary percutaneous coronary intervention was performed with an implantation of a stent in the occluded artery. During the extraction of the stent's balloon catheter it got disconnected and remained stuck in the left main coronary artery. Despite many attempts, it couldn't be removed, so an urgent surgery was indicated. Successful extraction of the balloon, as well as coronary artery bypass to the left anterior descending artery was performed in the general anesthesia with the use of extracorporeal circulation. Immediate postoperative course went by without any problems. During later postoperative period the patient became febrile with elevated inflammatory markers, which was followed by development of global respiratory insufficiency. Chest x-ray showed signs of bilateral bronchopneumonia. The patient was intubated and mechanically ventilated, blood samples were sent to microbiology, followed by an initiation

of empiric antibiotic therapy. Despite undertaken measures inflammatory markers kept on rising and septic shock was developed, so stimulation with inotropes and vasopressors had to be initiated. The patient developed multiorgan failure, so the decision was made to do continuous veno-venous hemodiafiltration with the addition of the CytoSorb filter to remove inflammatory cytokines from the circulation. This led to significant recovery and hemodynamic stabilization. Blood samples previously sent to microbiology turned out positive (*Acinetobacter species*), so the antibiotic therapy was changed. Inflammatory markers gradually fell down and there was a significant improvement on chest x-ray, so the patient was extubated and slowly started rehabilitation. The patient was released from hospital in a good general condition after 34 days of hospitalization.

**Conclusions:** Primary percutaneous coronary intervention is a vital procedure in patients with STEMI, but has potentially lethal complications that require an urgent surgical intervention. Continuous veno-venous hemodiafiltration with the addition of the CytoSorb filter has a significant role in treating septic patients. SIRS after cardiac surgery with the use of extracorporeal circulation complicated with an infection in the postoperative period is an ideal situation for the use of CytoSorb, but has to be initiated in the right time.

## P039. Effect of rapid increase in intra-abdominal pressure on pleth variability index in healthy women undergoing gynaecological laparoscopy

*Małgorzata Barud[1], Ziemowit Rzecki[1], Magdalena Bielacz[2], Hanna Brzozowska[1], Paulina Iwaniuk[1], Daniel Pietrzak[1], Wojciech Dabrowski[1]*

[1]Department of Anaesthesiology and Intensive Therapy Medical University of Lublin, Poland

[2]State School of Higher Education, Zamosc, Poland

Contact: gosiekbar@wp.pl

**Background:** Increase in intra-abdominal pressure (IAP) impairs circulatory system via depression of cardiac function. An increase in IAP under 12 mm Hg (called intra-abdominal hypertension), may result from abdominal trauma, massive fluid resuscitation, pregnancy and pneumoperitoneum. Rapid increase in IAP elevates diaphragm and presses abdominal vessels reducing circulating blood volume, which may affect blood pressure and increase pulse variability. Pleth variability index (PVI) is a novel parameter presenting dynamic changes in peripheral perfusion index (PI) during comparable respiratory cycles [1]. Several authors have documented usefulness of PVI in early hypovolaemia detection [1, 2]. However, an increase in IAP and subsequent decrease in blood return from the limb and abdomen may affect PVI.

**Objectives:** The purpose of this study was to analyze the changes in PVI in patients undergoing gynecological laparoscopy.

**Methods:** Adult women undergoing elective laparoscopy with IAH = 15 mm Hg, under general anaesthesia were enrolled. After tracheal intubation, mechanical ventilation with the mixture of air and oxygen (inspired oxygen concentration — 40%) was provided. All the patients were ventilated using intermittent positive pressure ventilation (IPPV) with tidal volume of 5–6 mL $kg^{-1}$ body wt and respiratory rate, which was adjusted to maintain normocapnia, controlled by capnography. PVI was monitored using Masimo Root monitor (Irvine, Ca, USA). Heart rate (HR), mean arterial pressure (MAP) and PVI were analysed in four time points: A — just after anaesthesia induction, before surgery (baseline), B — 5 min after induction of IAH, C — during IAH in Trendelenburg position, D — just after surgery, before completion of anaesthesia. All patients received crystalloids infusion at the dose of 10 mL $kg^{-1}$ body weight during anaesthesia. Half of this dose was infused immediately after anaesthesia induction.

**Results:** 40 women aged 22–48 (mean 35 ± 5) were studied. Median baseline value of PVI, HR and MAP were 10 [8; 12], 88 $min^{-1}$ [69; 100. quartile 1 and 3. respectively] and 85.3 mm Hg [79; 97]. HR increased at time point B, MAP decreased at time point B, and PVI increased at time points B and C ($P < 0.001$). An increase in PVI (ΔPVI = PVI at time points B-PVI at time points A) correlated with ΔMAP ($P < 0.01$, $r = 0.48$).

**Conclusions:** A rapid induction of IAH increase value PVI. Changes in PVI correspond with changes in MAP.

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## P040. Early postoperative follow up and management of patients with chronic renal failure after coronary surgery

*Natasa Gocic-Peric, Andrej Preveden, Miodrag Golubovic, Ksenija Babovic-Stanic, Jovan Rajic, Stamenko Susak*

Institute for cardiovascular diseases of Vojvodina, Clinic for cardiovascular surgery, Sremska Kamenica, Serbia
Contact: a.preveden@gmail.com

**Background:** There is a high risk of mortality in patients who undergo coronary surgery and have chronic renal failure (CRF) stage 5. The influence of CRF stages 2–4 is still not enough explored.

**Objectives:** The aim of this study is to compare the outcomes after coronary surgery in patients with different stages of CRF.

**Methods:** Retrospective study included 34 patients with a diagnosis of CRF stages 2–5, who underwent coronary surgery in the Institute for cardiovascular diseases of Vojvodina in the period from 1.1.2015–31.12.2015. There were 13/34 (38.23%) patients with CRF stage 4 and 5. There were 3/34 (8.8%) patients with CRF stage 5 that were on a chronic dialysis program.

Statistical analysis was performed using SPSS Statistics version 16 (SPSS Inc, Chicago, USA). The data was displayed in tables and diagrams, statistical significance was determined at the level of $P < 0.05$. Acquired data was processed with standard statistical tests.

**Results:** Out of 10 patients who had CRF stage 4, two (20%) required postoperative continuous veno-venous hemodiafiltration. There was no significant difference between the groups of dialysed and non-dialysed patients with CRF stage 4 in terms of gender, age, creatinine clearance, ejection fraction, use of inotropes, vasopressors and diuretics and the duration of extracorporeal circulation. However, the difference in mean fluid balance was significant ($P = 0.035$). The mean value of fluid balance in patients with CRF stage 4 who were not dialysed was 767.5 ± 790.87, and in patients who were dialysed 2725 ± 1803.12. None of the patients with CRF stages 2 and 3 were dialysed after surgery. There were no deaths.

**Conclusions:** Worsening of the CRF after surgical intervention that required postoperative hemodiafiltration is in connection with fluid balance.

**Key words:** chronic renal failure, coronary surgery, hemodiafiltration

## P041. Effect of hyperosmotic therapy on extravascular lung water index in patients treated for severe traumatic brain injury

*Ziemowit Rzecki[1], Dorota Siwicka-Gieroba[1], Paulina Iwaniuk[1], Magdalena Bielacz[2], Grzegorz Wilhelm[1], Daniel Pietrzak[1], Małgorzata Barud[1], Wojciech Dabrowski[1]*

1Department of Anaesthesiology and Intensive Therapy Medical University of Lublin, Poland
2State School of Higher Education, Zamosc, Poland
Contact: dsiw@wp.pl

**Background:** Osmotic therapy is routinely used in patients after traumatic brain injury (TBI). Mannitol, the most popular hyperosmotic fluid in Poland, intensifies extraction of water, Na+ and other electrolytes via osmotic diuresis [1]. Additionally, mannitol reduces extracellular lung water content in rats with cerebral ischaemia [2]. Unfortunately, an effect of increasing plasma osmolality on extracellular lung water has not been estimated in patients treated for severe TBI.

**Objectives:** The aim of this study was to analyze an effect of osmotic therapy with mannitol on extravascular lung water index (ELWI) and pulmonary vascular permeability index (PVPI) in TBI patients.

**Methods:** Adult patients with GCS < 8, treated for isolated TBI were enrolled. Immediately after the admission to the ICU, all patients received hyperosmotic therapy with 15% mannitol at the dose 0.5–1 g $kg^{-1}$ body weight per day connected with loop diuretics. This treatment was discontinued in patients with osmolality higher than 310 mOsm $kg^{-1}$ $H_2O$. All patients were monitored using EV 1000 platform (Edwards Lifesciences, USA) for ELWI and PVPI measurement. Changes in ELWI and PVPI were compared with plasma osmolality immediately after the admission into ICU (baseline) and 24, 48, 72 and 96 hours after the admission. Studied variables were analysed in survivors (group S) and non-survivors (group N–S).

**Results:** 32 patients (13 female and 19 male) aged 22–94 (mean 49 ± 19) were studied, 12 patients died. In all participants, median value of baseline plasma osmolality, ELWI and PVPI were 281 mOsm $kg^{-1}$ [275; 286-quartile 1 and 3 respectively], 7.5 mL $kg^{-1}$ [6; 11.5], and 1.8 [1.5; 2], and were comparable in groups S and N–S. Mannitol administration increased plasma osmolality from 24$^{th}$ hour to the end of observation time ($P < 0.001$). ELWI decreased at 72 and 96 hours in group S ($P < 0.01$), whereas was unchangeable in group N–S. In both groups PVPI increased in 24 hours of treatment ($P < 0.05$) than decreased only in group S ($P < 0.01$). There were significant differences between group S and N–S 48, 72 and 96 hours in ELWI and PVPI ($P < 0.01$).

**Conclusions:** Osmotic therapy reduces ELWI and PVPI only in patients, who survive TBI.

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## P042. High dose colistin combined with continuous veno-venous hemofiltration for treatment of multidrug resistant gram-negative infection in critically ill patients

*An Verdoodt A[1], Patrick M. Honoré[2], Ives Hubloue[1], Herbert Spapen[2]*

[1]Department of Emergency Medicine, Universitair Ziekenhuis Brussel, Brussels, Belgium

[2]Department of Intensive Care Medicine, Universitair Ziekenhuis Brussel, Brussels, Belgium

Contact: An.Verdoodt@uzbrussel.be

**Background:** Gram-negative (GN) infections susceptible only to colistin (COL) are emerging in critically ill patients. Pharmacological studies suggest that a higher COL dose (i.e. a 9 MIU loading dose followed by a maintenance dose as high as 15 MIU daily) is needed to ensure microbiological and clinical cure. However, such high dose may enhance COL-related renal toxicity [1]. Since COL is effectively removed from the blood by continuous veno-venous hemofiltration (CVVH), in particular when membranes with high adsorptive capacity are used, this technique may allow to administer high COL doses without inducing or enhancing nephrotoxicity.

**Objectives:** To assess safety and clinical/microbiological efficacy of high-dose COL treatment under "prophylactic" CVVH.

**Methods:** Prospective observational cohort study in adult ICU patients with GN infections only susceptible to COL. All patients received COL (colistimethate sodium, Colistineb™) as monotherapy or in combination with meropenem ± amikacin. COL was administered as a 9MIU loading dose followed by 3 × 4.5 MIU daily. CVVH was performed under citrate anticoagulation at a dose of 35 mL $kg^{-1}h^{-1}$ using a highly adsorptive AN69 ST filter with 1.5 $m^{-2}$ surface area. Clinical and microbiological efficacy were assessed at the end of therapy. Clinical efficacy was defined as favourable (clinical improvement) or failure (persistent or progressive infection). Microbiological response was defined as eradication (negative cultures), presumed eradication (clinical efficacy but no microbiological data) or failure (pathogen persistence). Results were expressed as means ± SD or (range). In survivors, serum creatinine was evaluated before and at the end of therapy and at hospital discharge.

**Results:** 16 patients (10 males, age 57 ± 15 years) were consecutively included. APACHE II score was 26 ± 10. *Pneumonia* was present in 14 and urosepsis in 2 patients. Causative pathogens were *P. aeruginosa* (n = 8), *K. pneumoniae* (n = 6) and *Enterobacter species* (n = 2). COL MICs (for 14 pathogens) ranged from 0.03 to 3 mg $L^{-1}$. COL was given as monotherapy in 5 subjects. Patients received COL + CVVH therapy for 13 (6–27) days. Length of ICU stay was 48 (13–128) days. A favourable clinical response was obtained in 14 (88%) patients. Accordingly, microbiological eradication was complete in 10. presumed in 4 and absent in 2 subjects. Seven (45%) patients survived. Serum creatinine (n = 6) at the predefined time points was 2.12 ± 1.52; 1.59 ± 0.96; and 0.91 ± 0.29 mg $dL^{-1}$, respectively. One patient required intermittent dialysis at ICU discharge.

**Conclusions:** In patients with multidrug-resistant GN infections, CVVH using an highly adsorptive membrane may represent a valuable option to enable safe and effective high-dose COL treatment.

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## P043. Validation of severity-of-illness scores in critically ill obstetric patients: a multicenter cohort study

*Jose Rojas-Suarez[1], Rafael Padron[2], Francisco Salcedo[2], Rogelio Mendez[2], Carmelo Dueñas[1], Cesar Mendivil[2], Juan Montes[1], Angel Paternina[3]*

[1]Department of Intensive Care Medicine, Universidad de Cartagena, Cartagena, Colombia

[2]Department of Obstetrics, Universidad de Cartagena, Cartagena, Colombia

[3]Department of Epidemiology, Hospital GRICIO, Universidad de Cartagena, Cartagena, Colombia

Contact: joseantonio.rojas.suarez@gmail.com

**Background:** Obstetrical critical care patients are at an increased risk of dying. Despite the development of clinical prediction models for the general population, pregnant or postpartum women were excluded from these development studies, and the usefulness of previous scores to predict mortality is still questioned due to physiological changes of pregnancy [1, 2]. Data of a previous study by our group established that MPM0–II was a better predictor of death than the other mortality prediction scores [3]. However, this was a retrospective database in a single center.

**Objectives:** The aim of this study was to perform external validation of Mortality Probability Model-II (MPM-II), Mortality Probability Model-III (MPM-III), Simplified Acute Physiology Score-2 (SAPS-2), and Simplified Acute Physio-

**Table 1.** Discrimination and Calibration of Mortality Probability Model II, Mortality Probability Model III, Simplified Acute Physiology Score 2 and Simplified Acute Physiology Score 3 to Predict Mortality in Obstetric Critical Care

| Score | Number of admissions | Deaths | | AUC (95% CI) | Mortality ratio (95% CI) | Test of Hosmer-Lemeshow |
|---|---|---|---|---|---|---|
| | n | Observed | Expected by the score | | | (*P*-value) |
| MPM-II | 2.101 | 100 | 121 | 0.862 (0.821–0.902) | 0.83 (0.67–1.01) | < 0.001 |
| MPM-III | 2.101 | 100 | 322 | 0.884 (0.844–0.923) | 0.31 (0.25–0.38) | < 0.001 |
| SAPS-2 | 1.039 | 40 | 241 | 0.872 (0.808–0.936) | 0.17 (0.12–0.23) | < 0.001 |
| SAPS-3 | 1.111 | 48 | 115 | 0.898 (0.855–0.941) | 0.42 (0.31–0.55) | < 0.001 |

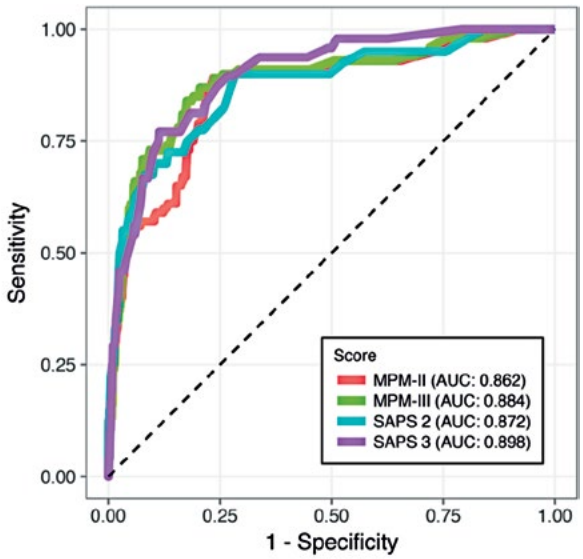


**Figure 1.** Discrimination of Mortality Probability Model (MPM0)-II, MPM0-III, Simplified Acute Physiology Score (SAPS) 2 and SAPS 3 in obstetric critical care patients. AUC = Area under receiver operator characteristic

logy Score-3 (SAPS-3) in a multicenter cohort of obstetric critical care patients.

**Methods:** We recruited women from six intensive care units from Colombia, South America in a retrospective and prospective cohort study. We started prospective data collection in January 2016 and ended in July 2017. Retrospective data collection varied by center, from 2006 onwards. We calculated the probability to die according to the four scores, and assessed in the cohort discrimination (through area under the curve, AUC) and calibration (test of Hosmer-Lemeshow and mortality ratio). A *P*-value under 0.05 was considered significant.

**Results:** We recruited 2.115 women admitted to critical care in all centers. Mean age of the cohort was 26.2 years (95%CI, 25.9–26.5). A total of 100 deaths occurred in the cohort during the study period resulting in a mortality rate of 4.7%. Area under the curve was 0.862 (95%CI, 0.821–0.902) for the $MPM_0$-II model, 0.884 (95%CI, 0.844–0.923) for $MPM_0$-III, 0.872 (95%CI, 0.808–0.936) for SAPS-2, and 0.898 (95%CI, 0.855–0.941) for SAPS-3 with the South American equation. All models except MPM0-II overestimated mortality. $MPM_0$-II model was the only model with a non-significant mortality ratio (0.83; 95%CI, 0.67–1.01; $P = 0.057$). The test of Hosmer-Lemeshow was significant for all models.

**Conclusions:** This large study shows similar results to our previous assessments of models to predict death in obstetrical critical care women. MPM0-II is the model that most accurately predicts mortality in obstetrical critical care patients.

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## P044. Effects of totally non-invasive guided perioperative fluid optimization for enhanced recovery after surgery in major abdominal surgery patients

*Chompunut Nethan[1], Sratwadee Lorsomradee[2], Niyom Cheepcharoenrat[3], Suraphong Lorsomradee[2]*

[1]Division of Anesthesiology, Yasothorn hospital, Yasothorn province

[2]Department of Anesthesiology, Chiang Mai University Hospital, Thailand

[3]Division of General Surgery, Yasothorn hospital, Yasothorn province

Contact: slorsomr@gmail.com

**Background:** Routine non-invasive monitoring of the signs and symptoms of perioperative hydration can be

identified by follow the changes in heart rate and blood pressure, urine output or other basic evaluation. However, during operation, there are several factors that interfere these basic signs and symptoms, such as the depth of anesthesia, blood loss or the intensity of painful surgical stimuli [1]. Perioperative fluid therapy guided by only clinical evaluation and traditional routine non-invasive monitoring may lead into insufficient or excessive volume administration which may interfere with the normal physiology of organ perfusion [2–4] or increase the risk of anastomotic leakage; delay the return of postoperative bowel function and prolong duration of hospital stay [5]. Thus, patients undergoing moderate to high risk surgery require high fidelity and more reliable parameter to guide fluid responsiveness. As a result, the trend has been changed into the perioperative goal-directed therapy (PGDT) [6–10] which maintains the specific Frank-Starling curve of each individualized patient by using the flow parameters of cardiac output and dynamic parameters from heart-lung interaction, such as stroke volume variation (SVV), pulse pressure variation (PPV), pleth variability index (PVI), predicting fluid responsiveness during mechanical ventilation [11–13]. Zimmerman *et al.* [14] showed that non-invasive pleth variability index (PVI) predicts fluid responsiveness as accurately as does the invasive stroke volume variation. In addition, The noninvasive method for estimated continuous cardiac output (esCCO) measurement uses a technique involving determination of the pulse wave transit time (PWTT), which consists of a pre-ejection period, pulse wave transit time through the artery, and pulse wave transit time through the peripheral arteries [15]. Based on the relationship between PWTT and stroke volume, the noninvasive device provides esCCO measurements using the traditional routine non-invasive electrocardiogram (ECG), pulse oximeter wave, and non-invasive blood pressure. Thus, it may be a useful technique for optimizing perioperative treatment.

**Objectives:** We hypothesized that perioperative fluid optimization with totally non-invasive hemodynamic monitoring of PVI and esCCO might enhance the recovery after surgery in major abdominal surgery patients. Therefore, the primary objective of this study was to compare the return of gastrointestinal function between non-invasive guided perioperative goal-directed therapy and traditional fluid therapy in major abdominal surgery patients, and the secondary objective was to compare the cost of treatment and the length of stay in the hospital between the two treatment groups.

**Methods:** After the study was approved by the local Institutional Review Board (Yasothorn Provincial Health Office: IRB No. HE6003 Dated 28 April 2017), and approved for Thai clinical trial registry (TCTR20170515001 Dated 15 May 2017), written informed consent was obtained from each patient enrolled. One hundred elective major abdominal surgery patients were prospective included in the study. Inclusion criteria were adult patients undergoing elective open major abdominal surgery with estimated blood loss > 500 mL, expected operative time > 60 min, age more than 18 years. Exclusion criteria were patients who refusal of consent, undergoing gynecological surgery, trauma, sepsis, respiratory failure, acute renal failure, cardiac arrhythmia, heart failure, thrombocytopenia or coagulopathy. Patients were screened for eligibility by a member of the research team. Patients meeting inclusion criteria were randomized and allocated to receive different perioperative hemodynamic management regimens by sequence from Randomization.com (21,936). Control group (n = 50) received traditional fluid therapy based on the discretion of individual anesthesiologists on the clinical and Holliday-Segar nomogram. PGDT group (n = 50) received perioperative goal directed therapy (PGDT) protocol based on non-invasive guided intravenous fluid and inotropic support to maintain pleth variability index (PVI) less than 20% (Root Masimo, USA) and estimated continuous cardiac index (esCCI) > 2.5 L min $m^{-2}$ (BSM–9101 Nihon Kohden, Tokyo, Japan) (Figs 1, 2).

**Results:** Patient characteristics were no significant difference among the groups in any of the variables. The returning of the bowel sound and the starting of soft diet therapy was significantly faster in the PGDT group ($P < 0.001$, $P < 0.001$. respectively). The overall cost of treatment was significantly lower ($P = 0.023$) and the length of stay in the hospital was significantly shorter in the PGDT group ($P = 0.003$). However, the changes in blood lactate level immediately after surgery of both groups were not different.

**Discussion:** Perioperative fluid optimization with totally non-invasive hemodynamic monitoring of PVI and esCCO enhance the recovery after surgery in major abdominal surgery patients. This study demonstrated the faster return

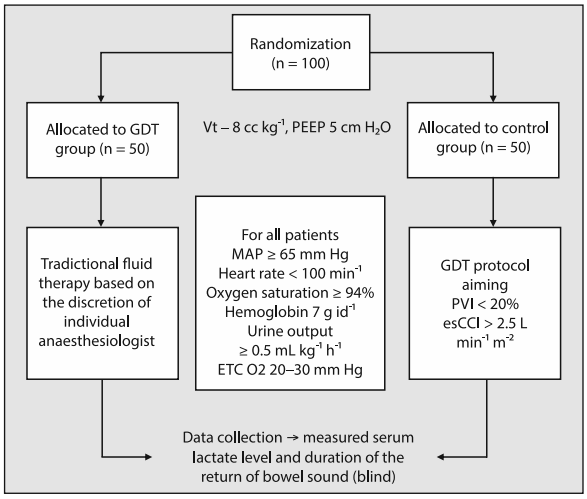


**Figure 1.** Randomization

**Table 1.** Patient characteristics

| | Control (n = 50) | GDT (n = 50) | Significance |
|---|---|---|---|
| Male/Female | 23/27 | 28/22 | 0.073 |
| Age (yr) | 62.36 (± 14.60) | 57.26 (± 12.25) | 0.61 |
| Weight (kg) | 52.62 (± 13.38) | 54.8 (± 7.63) | 0.303 |
| Height (cm) | 156.58 (± 6.88) | 160.58 (± 6.07) | 0.377 |
| BMI (kg $m^{-2}$) | 21.35 (± 4.94) | 21.27 (± 2.82) | 0.927 |
| ASA classification | | | 0.816 |
| ASA 1 | 43 (86%) | 42 (84%) | |
| ASA 2 | 6 (13%) | 7 (14%) | |
| ASA 3 | 1 (2%) | 1 (2%) | |
| DM/non DM | 2/3 | 0/1 | 0.579 |
| Diagnosis | | | 0.871 |
| CA colon | 19 (38%) | 16 (32%) | |
| CA rectum | 11 (22%) | 11 (22%) | |
| CHCA | 4 (8%) | 11 (22%) | |
| Gut obstruction | 16 (32%) | 12 (24%) | |

**Table 2.** Operative time, perioperative fluid balance and study variable

| | Control (n = 50) | GDT (n = 50) | Significance |
|---|---|---|---|
| Operation time (hr) | 120.74 (± 96.09) | 115 (± 60.27) | 0.721 |
| Blood loss (mL) | 196.32 (± 195.86) | 297.20 (± 425.50) | 0.131 |
| IV type (0.9% NaCl) | 50 (100%) | 50 (100%) | 0.656 |
| IV fluid (mL) | 1.256.00 (± 1290.61) | 1.809 (± 1047.43) | 0.021* |
| delta lactate | 13.99 (± 11.97) | 12.95 (± 12.13) | 0.668 |
| Urine output (mL) | 70 (± 73.76) | 98.62 (± 68.87) | 0.048* |
| Return of bowel sound (hr) | 98.66 (± 33.37) | 67.40 (± 22.25) | 0.000* |
| Soft diet (hr) | 157.68 (± 46.62) | 110.18 (± 25.61) | 0.000* |
| Length of stay (day) | 12.90 (± 6.91) | 9.68 (± 2.88) | 0.003* |
| Cost of treatment (Baht) | 94.518.07 (± 75313.11) | 54.667.25 (± 23358.44) | 0.023* |

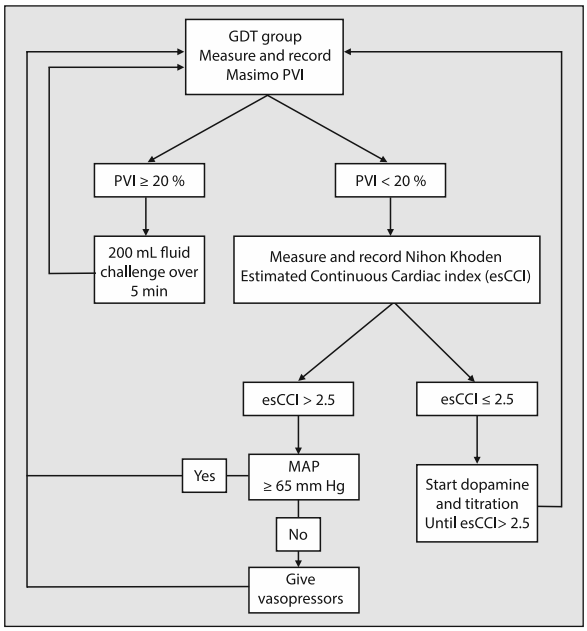


**Figure 2.** Goal-directed therapy (GDT)

of gastrointestinal function in the non-invasive guided perioperative goal-directed therapy compare to the traditional fluid therapy in major abdominal surgery patients, and the secondary objective was demonstrated the reduction of the cost of treatment and the length of stay in the hospital in the non-invasive guided perioperative goal-directed therapy compare to the traditional fluid therapy.

Traditional fluid therapy in the present study is perioperative fluid management by using clinical finding and static hemodynamic parameter guided, for example, HR, blood pressure, urine output or CVP. In the PGDT study group, the present study used the heart-lung interaction dynamic parameter as the hemodynamic target for predicting fluid responsiveness using the PVI number 20% because there was no obvious cut off value of PVI guidance (14–20% is the range of gray zone of fluid responders and non-responders). These simplified non-invasive PGDT study protocol in the present study has been demonstrated that whether the type of fluids therapy or blood components were control under the decision of individual anesthesiologists or not, the fluid

management under this totally non-invasive PGDT protocol is able to enhanced the recovery after surgery and reduced the cost of treatment and length of stay in the hospital after major abdominal surgery.

**Conclusions:** Totally non-invasive PVI and esCCI guided perioperative fluid optimization enhanced the recovery of postoperative gastrointestinal function and reduced the cost of treatment and length of stay in the hospital after major abdominal surgery.

**Key words:** enhanced recovery after surgery (ERAS), estimated continuous cardiac index (esCCI), length of stay in hospital, perioperative goal directed therapy (PGDT), pleth variability index (PVI).

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## P046. Catheter related deep vein thrombosis in pediatric intensive care patients

*Klaar Vergaelen[1], Viola Van Gorp[1], Koen Huysentruyt[2], Manu L.N.G. Malbrain[1]*

[1]Department of Intensive care, Universitair Ziekenhuis Brussel, Vrije Universiteit Brussel (VUB), Brussels, Belgium

[2]Department of Pediatric Gastroenterology, Universitair Ziekenhuis Brussel, Vrije Universiteit Brussel (VUB), Brussels, Belgium

Contact: klaar.vergaelen@uzbrussel.be

**Background:** Catheter-related deep venous thrombosis (CRDVT) is an emerging problem in pediatrics and affects up to 4–66% of children with a central venous catheter (CVC), depending on whether routine screening is applied [1, 2]. The presence of a CVC seems to be the predominant risk factor and accounts for > 85% of DVT in children [2, 3]. Universally accepted prevention guidelines for CRDVT are lacking for critically ill children. An understanding of the occurrence and major risk factors of CRDVT could be a first step in identifying those children that would benefit from thromboprophylaxis after CVC placement.

**Table 1.** Characteristics of patients with/without deep venous thrombosis

| Patient caracteristics Median (Q1–Q3) | DVT | No DVT | *P* -value |
|---|---|---|---|
| Age | 1.1 (0.3–2.5) | 2.9 (0.8–7.8) | 0.014 |
| Length of stay PICU | 16.6 (9.7–29.5) | 7.0 (4.0–14.0) | < 0.001 |
| Duration mechanical ventilation | 11.0 (2.3–16.5) | 0 (0–5.0) | < 0.001 |
| Duration CVC in place | 7.5 (6.0–10.0) | 6.0 (3.0–10.0) | 0.016 |

**Objectives:** The aim of this study was to establish the incidence rate and risk factors for the development of CRDVT in critically ill pediatric patients.

**Methods:** Retrospective, single center cross-sectional study including children and adolescents (0–18 years) with CVC, hospitalized on the paediatric intensive care department (PICU) between 2013 and 2017. The primary outcome was the occurrence of CRDVT, as confirmed by echo Doppler. The secondary outcomes were possible risk factors for CRDVT. Differences between categorical and continuous variables were analyzed using $\chi 2$ and Mann-Whitney U testing respectively. A $P$-value < 0.05 was considered significant.

**Results:** From a total of 1360 patients, 264 patients (51.5% male) had a CVC placement. Median and interquartile range (Q1;Q3) age was 2.47 (0.7–7.5) years and the median (Q1;Q3) duration of PICU stay was 8 (4;16) days. The site of CVC placement was femoral for 171 (64.8%) patients, subclavian for 74 (28.0%) and jugular for 19 (7.2%) patients. Deep venous thrombosis was detected in 30 (11.3%) of cases. Significant risk factors ($P < 0.05$) for the development of CRDVT were female gender, femoral placement of the CVC, presence of sepsis, ARDS, mechanical ventilation, pre-existent neurological impairment and the administration of total parenteral nutrition. Hospitalization due to trauma ($P = 0.7$) or surgery ($P = 0.6$) were not associated with increased risk for CRDVT. Children with a CRDVT had a significantly younger age (1.1 years vs. 2.9 years; $P = 0.014$), longer duration of PICU stay (16.6 days vs. 7 days; $P < 0.001$), longer duration of mechanical ventilation (11 days vs. 0; $P < 0.001$) and longer time span in which the CVC was in place (7.5 days vs. 6 days; $P < 0.016$).

**Conclusions:** In our study one in every ten children with a CVC placement had a CRDVT, which is consistent with previously reported findings. We identified multiple clinical risk factors which could help in the selection of patients in need of routine screening and possible thromboprophylaxis.

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## P047. Assessment of arterial dynamic elastance as a function variable of arterial load, derived from both non-invasive and invasive haemodynamic variables

*Tina Maes[1, 2], Jasper Wylleman[1], Roxane Cool[3], Michel Vervoort[4], Jan Poelaert[1, 5]*

[1]Department of Anaesthesiology and Perioperative Medicine, Acute and Chronic Pain Therapy, UZ Brussel, Vrije Universiteit Brussel, (VUB), Brussels, Belgium

[2]Intensive Care Unit, UZ Brussel, Vrije Universiteit Brussel (VUB), Brussels, Belgium

[3]Department of Medical School, Vrije Universiteit Brussel (VUB), Brussels, Belgium

[4]Department of Biotechnology, UZ Brussel, Brussels, Belgium

[5]Faculty of Medicine and Pharmacy, Vrije Universiteit Brussel (VUB), Brussels, Belgium

Contact: tina.maes@uzbrussel.be

**Background:** Intraoperative assessment of the cardiovascular status comprise cardiac output, determined by left ventricular preload, contractility, afterload and heart rate. Various haemodynamic monitors have been introduced in anesthesia and ICU practice, providing cardiac output either non-invasively or invasively. The combined use of arterial pressure monitoring with these devices provides insight not only in cardiac output but offers bedside assessment of most determinants of cardiovascular function. Both pulse pressure variation (PPV) and stroke volume variation (SVV) have been described as dynamic descriptors of fluid responsiveness, a measure to optimize preloading conditions if haemodynamics show signals of insufficient perfusion [1].

**Objectives:** The aim is to determine Eadyn as a functional measure of arterial load, in conjunction with other actual afterload indices, derived from both invasive arterial pressure tracing and non-invasive signals, such as non-invasive cardiac output obtained by bio-reactance [2].

**Methods:** Eleven patients, who needed a continuous arterial pressure monitoring and scheduled for major surgery, were included. Traditional hemodynamic monitoring (ECG, $SaO_2$, non-invasive blood pressure) and non-invasive wired patches (connected to a Cheetah® cardiac output monitor) were installed. A computer link between a Philips monitor and the Cheetah monitor was used to obtain selected curves in a digital format for post-intervention processing. After induction of anesthesia and before surgery, the following data were registered during 5 min.: ECG, invasive arterial pressure tracing, cardiac output and PPV and SVV (Cheetah monitor), $SaO_2$ tracing, arterial pressure tracing. Cheetah calculates a mean SVV over 30 seconds. When SVV > 15%, the operation Table was put in Trendelenburg position. Statistical analysis was performed using Medcalc software (v. 15. Mariakerke, Belgium). Numerical data were expressed as mean values ± standard deviation (SD). Comparison between groups was made using ANOVA for multiple measures. A *P*-value of 0.05 was considered significant.

**Results:** Pulse pressure variation and stroke volume variation were not statistical significant parameters for fluid responsiveness, probably due to the low number of participants. In neutral position, PPV is 8.0 ± 4.4 and in Trendelenburg 5.7 ± 4.0 ($P = 0.44$). When back in neutral position PPV is 9.6 ± 6.5 ($P = 0.26$). A statistical power analysis ($1–\beta = 0.8$. $\alpha = 0.05$) suggests inclusion of 53 patients. The SVV in neutral position is 11.6 ± 3.8 and in Trendelenburg position 10.6 ± 3.9 ($P = 0.82$). Back in neutral position, SVV is 11.3 ± 3.7 ($P = 1.0$). The cardiac index (CI) was statistical significant in both situations. In neutral position the CI is 2670 ± 577 and in Trendelenburg 2839 ± 520 ($P = 0.01$). When back in neutral position the CI is 2647 ± 575 ($P = 0.003$). Eadyn is not significant in both position changes. In neutral position Eadyn is 0.77 ± 0.51 and in Trendelenburg position 0.67 ± 0.60 ($P = 1.00$). Back in neutral position Eadyn is 0.89 ± 0.62 ($P = 1.00$).

**Conclusion:** Pulse pressure variation and stroke volume variation can be used for fluid responsiveness. Our study shows that the cardiac index is statistical significant for fluid responsiveness. More patients need to be included to reach statistical power. Also, Eadyn is not significant for fluid responsiveness in our study. Nevertheless, Eadyn can give useful information for perioperative management, like ventriculo-arterial coupling [3]. Further investigation is needed to elucidate the additional impact on daily management of critically ill patients.

**Key words:** Eadyn; PPV; SVV

**Table 1.** Hemodynamic values in the 3 positions

| | Neutral position (1), mean and SD | Trendelenburg position (2), mean and SD | Back toneutral position (3), mean and SD | *P*-value (1–2) | *P*-value (2–3) |
|---|---|---|---|---|---|
| PPV | 8.0 ± 4.4 | 5.7 ± 4.0 | 9.6 ± 6.5 | 0.4373 | 0.2644 |
| SVV | 11.6 ± 3.8 | 10.6 ± 3.9 | 11.3 ± 3.7 | 0.8211 | 1.0000 |
| SVR | 1150 ± 269 | 1178 ± 325 | 1114 ± 242 | 0.7101 | 0.3049 |
| EA | 1.24 ± 0.35 | 1.30 ± 0.46 | 1.21 ± 0.31 | 0.6993 | 0.3930 |
| CI | 2670 ± 577 | 2839 ± 520 | 2647 ± 575 | 0.0136 | 0.0026 |
| Eadyn | 0.77 ± 0.51 | 0.67 ± 0.60 | 0.89 ± 0.62 | 1.0000 | 1.0000 |

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## P048. Survey on hemodynamic management of severe sepsis and septic shock: evaluation on monitoring, treatment goals and preferred regimen of care in sepsis and septic shock

*Delphine De Smet, Sven Adam, Marilyn Gilleman, Hazim Noori, Simon Tierens, Niels Peyls, Manu L.N.G. Malbrain*

Intensive Care Unit, University Hospital Brussels (UZB), Jette, Belgium

Faculty of Medicine and Pharmacy, Free University Brussels (VUB), Belgium

Contact: delphine-de-smet-1@hotmail.com

**Backgound:** Severe sepsis and septic shock are major health problems, causing increased morbidity and mortality. A correct and timely management is paramount to improve outcome.

**Objectives:** Our goal is to compare the overall approach to the patient with severe sepsis/septic shock with standard practice according to the SSC guidelines 2016.

**Methods:** In an online four-headed multiple-choice questionnaire we assessed the hemodynamic management of patients with severe sepsis and septic shock among 326 participants (Link to Survey on Hemodynamic management of severe sepsis and shock: http://www.tfaforms.com/257527).

**Results:** The study consists of 326 participants. 75.8% of the participants were an intensivist. In our survey, the minimal monitoring for handling a severe sepsis/septic shock according to the participants were $SPO_2$. Lactate, electrocardiogram (ECG) monitoring and measurement of invasive blood pressure. Around 6% of the interrogated population always used hemodynamic monitoring in contrast to 14.3% of the participants who never used hemodynamic monitoring. In our survey, 89.7% of the responders performed early adequate fluid resuscitation, and 72.2% of the interrogated physicians determined fluid responsiveness before starting fluid loading. Functional hemodynamic monitoring with stroke volume variation (SVV) in 27% and pulse pressure variation (PPV) in 25% were the most frequently used predictors of fluid responsiveness. Around 48.4% of the interrogated persons used a passive leg raising test to evaluate fluid responsiveness, 40% used a fluid challenge. The main triggers to start fluid loading were mean arterial blood pressure (MAP) and lactate levels (Table 1). According to these respondents, fluid responsiveness was assessed by an increase in the MAP to > 65 mm Hg (19.8%), followed by a decrease in lactate to < 2.5 mmol $L^{-1}$. Transpulmonary thermodilution with $PiCCO_2$ (Getinge, Germany) and echocardiography (either transthoracic or transesophageal) were the most frequently used devices to measure cardiac output. Late goal-directed fluid removal was considered as an important issue by 75.8% of the responders. Lactated Ringer's solution, other balanced crystalloid solution, and normal saline were the most frequently used initial resuscitation fluid (respectively 30.6%, 23.8%, and 21%). The vasopressor of choice was norepinephrine in 91.7% of the participants, and 63.5% of the physicians chose dobutamine as inotropic of preference.

**Conclusions:** In this observational questionnaire, we investigated the use of hemodynamic monitoring and preferred treatment strategies in patients with severe sepsis and septic shock. The results of this survey showed good adherence to the latest SSC guidelines concerning initial fluid resuscitation, inotropic agents and preferred use of vasopressor. In this study, however, we noticed a rather limited use of monitoring functional hemodynamics and cardiac output. The explanation for this limited use remains unclear to us as by definition cardiac output should be included in the diagnosis and management of patients with severe sepsis and septic shock. As the use of dynamic variables and the passive leg raising test combined with monitoring of cardiac output is suggested in the latest guidelines, more educational efforts are needed to increase adherence to the SSC guidelines on routine monitoring of cardiac output. Hence, potentially improving the strategy for correct fluid therapy and overall outcome.

**Table 1.** Triggers to start and stop fluid loading (mean ± SD)

| Parameter | Trigger to start | Trigger to stop | *P*-value |
|---|---|---|---|
| MAP (mm Hg) | 62.2 ± 5.7 | 70 ± 8.3 | 0.000 |
| SAP (mm Hg) | 90.4 ± 8.4 | 105.9 ± 16.7 | 0.000 |
| CVP (mm Hg) | 7.6 ± 8.9 | 11.7 ± 3.1 | 0.000 |
| PCWP (mm Hg) | 9.5 ± 4.6 | 16.5 ± 9.3 | 0.000 |
| CI (L $min^{-1}$ $m^{-2}$) | 2.2 ± 0.5 | 3 ± 1 | 0.000 |
| SVV (%) | 13.5 ± 4.4 | 10.8 ± 4.6 | 0.000 |
| GEDVI (mL $m^{-2}$) | 549.5 ± 220.9 | 775.1 ± 179.8 | 0.000 |
| EVLWI (mL $PBW^{-1}$) | 7.9 ± 4.7 | 10.8 ± 3.7 | 0.003 |
| LVEDAI ($cm^{-2}$ $m^{-2}$) | 13.5 ± 13.3 | 143.1 ± 312.8 | 0.863 |
| $ScvO_2$ (%) | 64.5 ± 6.9 | 69.2 ± 7.7 | 0.000 |
| $SvO_2$ (%) | 63.3 ± 7.4 | 68.1 ± 11.2 | 0.000 |
| Lactate (mmol $L^{-1}$) | 3.1 ± 1.8 | 2.2 ± 0.9 | 0.000 |

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## P049. Results of a survey on fluid management and hemodynamic monitoring

*Marilyn Gilleman, Sven Adam, Delphine De Smet, Simon Tierens, Hazim Noori, Niels Peyls, Manu L.N.G. Malbrain*

Department of Intensive Care, University Hospital Brussels (UZB), Laarbeeklaan 101. 1090 Jette, Belgium

Faculty of Medicine and Pharmacy, Free University of Brussels (VUB), Brussels, Belgium

Contact: Marilyn.Gilleman@uzbrussel.be

**Background:** Adequate IV fluid administration and appropriate hemodynamic monitoring are essential elements in the treatment of ICU patients [1]. Inappropriate fluid administration can contribute to morbidity and mortality, hence the importance of good fluid management [2]. There is a lot of controversy and on-going debate about the type, dose and timing of fluids for each individual patient. Fluids should be seen as any other kind of drugs, with a specific dose and timing of administration [1, 2]. To help us in determining the right dose of fluid many bedside hemodynamic monitoring systems have become available. It is the task of every critical care physician to choose the right monitoring system for the right patient in order to be able to give the right fluid at the right time, hence contributing to a better long-term outcome [1]. Until today there is no ideal strategy and the choice of fluids and monitoring systems largely depends on regional and clinician's preferences.

**Objectives:** This survey was designed to analyse the current practice in hemodynamic monitoring and choice of fluids among critical care physicians attending the previous International Fluid Academy Days (IFAD) meetings (2014–2015) and those preparing for the present 2017 meeting.

**Methods:** An online survey (accessible via http://www.tfa-forms.com/355045) was conducted with the participants of the 4th and 5th IFAD held in Antwerp (Belgium) at the end of November 2014 and 2015 respectively, as well as attendants preparing for the 6th IFAD (Nov 2017), assessing their views on hemodynamic monitoring and fluid choices in the daily practice. The survey was conducted before and after the meeting and consisted of 32 multiple choice questions, 8 dealing with monitoring issues and 13 assessing fluid choices. Personal additions and comments were possible after each question. The other questions provided information about country of residence, baseline medical specialty, level of education and years of experience in the ICU, type of hospital and types of patients treated on their ward.

**Results:** A total of 608 surveys were received. Three hundred and fifty-six of the participants reported being an intensivist and 153 not being one. The baseline specialties varied between anaesthesiology (47.2%), internal medicine (16.4%), emergency medicine (4.3%), surgery (3%), paediatrics (2.6%) and 'other' (10.2%). Most of the responders resided in Europe, 13% of them in Belgium, 6.5% in the Netherlands, 6.9% in Spain, 6.3% in the UK, 4.7% in France, 3.9% in Germany, and 3.3% in Italy. Regarding the level of education, 61.9% of the responders answered being qualified specialists, 16.7% were head of ICU, 16.1% residents and 5.3% 'other'. Forty-three-point two percent had more than 10 years of experience while 6.3% had no experience in ICU. Most of the responders (55%) worked in an academic hospital, treating mainly medical and surgical patients. When asked about the minimal

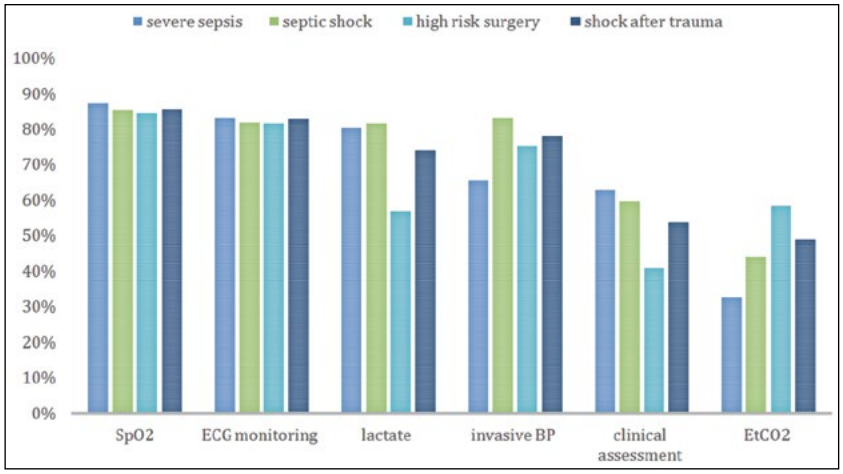


**Figure 1.** Preferences for minimal monitoring tools in different clinical settings

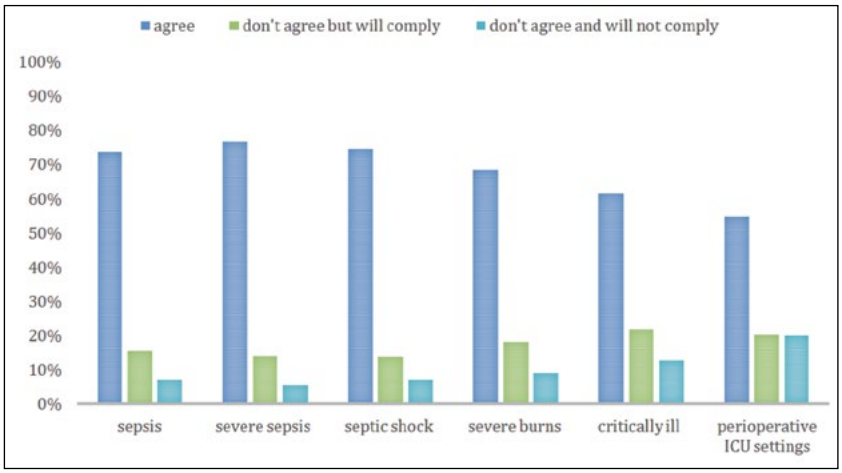


**Figure 2.** Responders' opinion on PRAC guidelines advising against the use of HES in different clinical conditions

monitoring for handling a patient with severe sepsis 87.2% replied $SpO_2$ monitoring, 83.1% ECG monitoring, 80.1% lactate, 65.5% invasive BP and 62.7% clinical assessment. For the minimal monitoring when handling a patient with septic shock most of the responders tended towards the same monitoring tools as in severe septic patients, with 85.3% responding $SpO_2$, 81.5% lactate, 83.1% invasive BP and 81.9% ECG monitoring. Fifty-nine-point five percent also reported clinical assessment of fluid responsiveness as an important tool. For monitoring patients after high risk surgery, the answers were similar to those in septic patients, with the addition of end tidal $CO_2$ being important for 58.4% of the responders. The same trends were found for the minimal monitoring needed when handling patients with shock after trauma. The results are summarised in Figure 1. The preferred index for assessing fluid responsiveness was passive leg raising, as indicated by 58.4% of the participants, followed by stroke volume variation (48.7%) and pulse pressure variation (46.7%). Thirty six percent also considered inferior vena cava collapsibility index as an important tool in assessing fluid responsiveness. The preferred surrogates for tissue oxygenation were lactate (56.4%), intermittent $ScvO_2$ (17.9%) and intermittent $SvO_2$ (7.5%). For assessing hepatosplanchnic perfusion 66.8% of the responders indicated lactate as being the preferred assessment tool and 27.5% considered intra-abdominal pressure (IAP). When evaluating the choice of fluids, one of the questions considered the clinical relevance of hyperchloremic metabolic acidosis. Forty-five-point six percent considered it being an independent risk factor for acute kidney injury, 36.7% found it to be an independent risk factor of mortality while 10.8% did not think of it as being a clinical relevant problem. Next, responders were asked about their opinion on the PRAC guidelines advising against the use of hydroxyethyl starches (HES) in the following conditions: sepsis, severe sepsis, septic shock, severe burns, critically ill and perioperative ICU setting (Fig. 2). In the setting of sepsis 73.7% agreed, 15.5% did not agree but will comply while 7.1% did not agree and will not comply. The same trends were seen in the condition of severe sepsis, with 76.8% agreeing, 13.9% not agreeing but complying and 5.5% not agreeing nor complying. In septic shock 74.5% agreed, 13.8% did not agree but will comply, 7.1% did not agree and will not comply. In the condition of severe burns 68.4% agreed not to use HES, 18.1% did not agree but will comply while 9.0% did not agree and will not comply. For the critically ill 61.5% agreed, 21.8% did not but will comply and 12.8% did not agree nor would comply. Finally, in the condition of perioperative ICU setting only 54.6% agreed against the use of HES, 20.2% did not agree but will comply and 20% did not agree and would not comply. When asked if giving a balanced crystalloid with a potassium concentration of 5 mEq $L^{-1}$ should be avoided in patients with a creatinine clearance less than 25 mL $min^{-1}$, 30.8% of the responders disagreed, 27.1% would probably avoid it, 25% probably not and 15.1% would avoid it and was in favour of using normal saline instead. In the use of hyperoncotic human albumin 20% in patients with traumatic brain injury, 28.9% of the responders considered it being a problem, 26.3% answered it probably being a problem, 25.7% probably not being a problem and 15.9% did not think of it as being a problem.

Next, the responders were asked about their primary choice of fluids for an episode of hypotension with tissue hypoperfusion in a fluid responsive patient with severe sepsis with a normal chest X-ray and $FiO_2$ of 40% (Fig. 3). Seventy eight percent would choose a balanced crystalloid, 13.9% chose for normal saline, 2% for gelatines, 1.6% for hyperoncotic human albumin 20% and 1.4% for starches. The same question was then asked with the adjustment of the chest X-ray showing bilateral infiltrates and the $FiO_2$ being 100%.

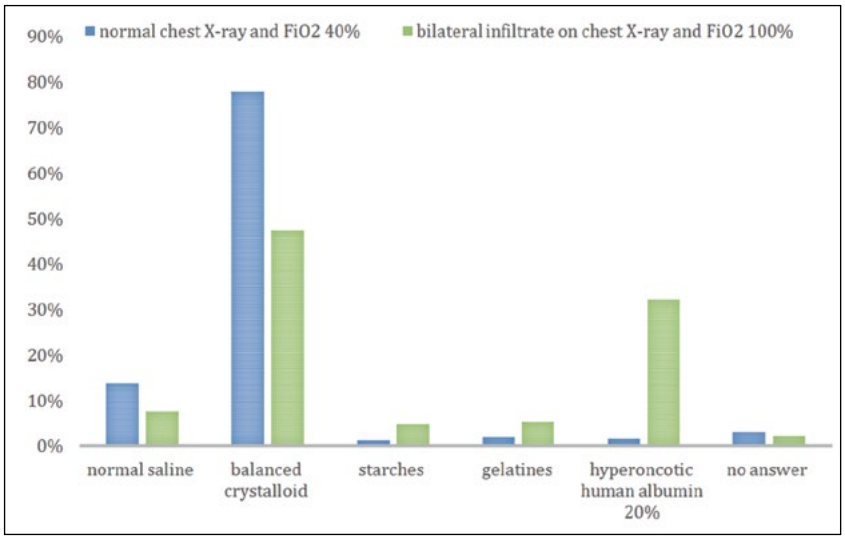


**Figure 3.** Responders' primary choice of fluids for an episode of hypotension with tissue hypoperfusion in a fluid responsive patient with severe sepsis when his/her maintenance requirements are fully covered by enteral nutrition with a) a normal chest X-ray and $FiO_2$ 40% and b) bilateral infiltrates on chest X-ray and $FiO_2$ 100%

In that case only 47.5% of the responders chose balanced crystalloids, while 32.2% chose hyperoncotic human albumin 20%, 7.7% normal saline, 5.3% gelatines and 4.91% preferred starches. The primary choice of fluids for an episode of hypotension with tissue hypoperfusion during trauma surgery when no blood is available was balanced crystalloids in 50.9%, while 18.7% preferred starches, 11% normal saline, 11% gelatines and 5.9% would use hyperoncotic human albumin 20%. Lastly, the responders were asked if they would (continue to) use 'normal' saline as a resuscitation fluid after the results of the SPLIT trial showing no difference in outcome between saline vs. Plasma-lyte. Thirty-three-point six percent of the responders answered yes, 19.8% no and 29.5% answered never to use saline as resuscitation fluid.

**Conclusions:** This survey evaluated the choices in fluid management and minimal monitoring in the daily ICU practice among the participants of the 4th and 5th IFAD and those preparing for the 6th IFAD. We can conclude that there is an overall preference for the use of balanced crystalloids in the setting of sepsis and septic shock, with colloids being less used, except in the perioperative and trauma setting where they are still being used in some cases. There is an increased awareness about the negative effects of hyperchloremic metabolic acidosis in causing acute kidney injury and increased mortality. As for the monitoring tools in the ICU there is an overall consensus in the use of at least $SpO_2$, lactate, ECG monitoring, invasive BP monitoring and clinical assessment of the patient in combination with assessment of fluid responsiveness. Further education is needed and as suggested by the NICE guidelines, every ICU should have a fluid guideline and in analogy to antibiotic stewardship, fluid stewardship should gain its place in every ICU.

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## P050. Can body anthropomorphy predict intraabdominal hypertension in critically ill patients?

*Hazim Noori, Simon Tierens, Delphine De Smet, Niels Peyls, Marilyn Gilleman, Sven Adam, Manu L.N.G. Malbrain*

Department of Intensive Care, University Hospital Brussels (UZB), Jette, Belgium

Faculty of Medicine and Pharmacy, Brussels Free University (VUB), Brussels, Belgium

Contact: hazimarak2@hotmail.com

**Background:** Previous studies showed a correlation between intraabdominal pressure (IAP) and body anthropomorphic data like sagittal abdominal diameter and body mass index (BMI) [1, 2]. The abdominal compartment society has listed a number of risk factors for intra-abdominal hypertension (IAH). Traditional risk factors or related to decreased abdominal wall compliance, increased intraluminal contents, increased intra-abdominal contents or fluid resuscitation. While obesity has been associated with IAH, little is known of the predictive power of other anthropomorphic parameters [3, 4].

**Objectives:** The aim of this study is to examine possible relations between other body parameters and baseline IAP

in critically ill mechanically ventilated patients. Furthermore, this study will also compare gastric versus bladder pressure measurements. Finally, to determine which anthropomorphic parameters are closely and independently associated with the presence or not of IAH.

**Methods:** Prospective study in 96 mechanically-ventilated patients equipped with a Foley bladder catheter connected to a FoleyManometer (Holtech Medical, Charlottenlund, Denmark) to measure intrabladder pressure (IBP) and a Ci-MON balloon-tipped nasogastric probe that records endexpiratory (IAPee), endinspiratory (IAPei) and mean IAP (IAP) (Pulsion Medical Systems, Maquet Getinge Group, Feldkrichen, Germany). Intraabdominal-hypertension (IAH) is defined as an IBP or IAPee above 12 mm Hg and ΔIAP is defined as IAPee-IAPei. Comparison of bladder (IBP) and gastric (IGP) pressure measurements was done with Pearson correlation and Bland and Altman analysis. The following body anthropomorphic parameters were measured: distances (ear-xiphoid, ear-nose, xiphoid-pubis, and ribcage-crista), diameters (rib cage, umbilical, waist, and hip), circumference (rib cage, abdominal, waist, and hip), height (patient, rib cage, hip, and sagittal abdominal diameter). Furthermore, a simulation model was developed with Datastories (www.datastories.com) in order to identify independent anthropomorphic and other parameters (out of a total of 28) able to predict IBP and the presence of IAH. We created and challenged 66,537 predictive models to deeply learn which metrics are necessary and sufficient to predict IBP or IAH.

**Results:** SAPS-II was 55.4 ± 12.9; APACHE-II 26.4 ± 9.6, SOFA 11.3 ± 5.2; age 57.5 ± 13.9; height 174 ± 9 cm; weight 85 ± 20; BMI 27.9 ± 7. The patients with IAH (n = 55) had higher BMI (29 ± 8 vs. 26 ± 4. $P = 0.02$). The ΔIAP was significantly higher in IAH: 5 ± 1 vs. 3 ± 1 mm Hg ($P < 0.0001$). We found a positive correlation between IAP and ΔIAP, suggesting a lower abdominal wall compliance (Cab) the higher the IAP: ΔIAP = 0.3 × IAP + 0.1 ($P < 0.001$. R2 = 0.579). The following body parameters were significantly higher in patients with IAH: IAPmean (15 ± 3 vs. 9 ± 2 mm Hg), umbilical diameter (43 ± 7 vs. 40 ± 5 cm, $P = 0.02$), abdominal perimeter (121 ± 17 vs. 108 ± 11 cm, $P < 0.0001$), waist circumference (107 ± 14 vs. 100 ± 11 cm, $P = 0.01$), the convex xiphoid to pubis distance (40 ± 7 vs. 35 ± 5 cm, $P < 0.0001$), rib cage height (24 ± 3 vs. 21 ± 4. $P = 0.0001$), sagittal abdominal diameter (28 ± 4 vs. 21 ± 4 cm, $P < 0.0001$). Patients with IAH had higher alveolar plateau pressures (29 ± 5 vs. 25 ± 5 cm $H_2O$, $P = 0.0002$) and higher PEEP (10 ± 3 vs. 8 ± 3 cm $H_2O$, $P = 0.04$). Patients with IAH had lower abdominal compliance, defined as ΔTV/ ΔIAP (137 ± 55 vs. 222 ± 85. $P < 0.0001$). Significant differences were observed between men and women. There was a significant Pearson correlation between IBP and IGP (IBP = 1.04 × IGP + 1.1 mm Hg, R2 = 0.91, $P < 0.0001$). Bland and Altman analysis comparing IGP and IBP at endexpiration showed a mean bias of 1.6 ± 1.1 mm Hg. The limits of agreement were small from –0.7 to 3.9 mm Hg resulting in a percentage error of 26%. After deep learning creating and challenging 66,537 models with Datastories, we discovered that 3 metrics were sufficient to predict IBP at Pearson correlation of 0.745 (R2 = 0.56). These drivers are the difference between the convex and horizontal xiphoid to pubis distance (importance: 37%), the sagittal abdominal diameter (SAD, importance: 4%), and the abdominal compliance (Cab, importance: 58%), all together their importance sum up to 100%. There were 55 patients with IAH and after deep learning we discovered that 1 metric is sufficient to predict IAH at Pearson correlation of 0.89 (R2 = 0.79), namely the difference between the convex and horizontal xiphoid to pubis distance. With a difference of 10 cm or more the model was able to predict a 90% chance for IAH presence.

**Conclusion:** Patients with IAH have increased waist and abdominal perimeter, convex xiphoid-to-pubis distance, rib cage height, and sagittal abdominal diameter. Female patients have significantly different body measurements. High IAP is related to ΔIAP and low Cab. Deep learning identified 3 independent factors able to predict IBP with 74.4% accuracy: SAD, Cab and the difference between the convex and horizontal xiphoid to pubis distance. Deep learning also identified 1 independent factor to predict the presence of IAH with 89% accuracy: difference between the convex and horizontal xiphoid to pubis distance. Body anthropomorphy plays an important role in the abdominal wall compliance and the way the patient's IAP behaves in relation to increased intraabdominal volume. In our patient sample, we found a good correlation between IGP and IBP when measured at endexpiration in supine position.

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## P051. Assessment of fluid overload in ICU patients: prognostic value of bioelectrical impedance analysis

*Simon Tierens, Hazim Noori, Marilyn Gilleman, Sven Adam, Delphine De Smet, Niels Peyls, Manu L.N.G. Malbrain*

Department of Intensive Care, University Hospital Brussels (UZB), Jette, Belgium

Faculty of Medicine and Pharmacy, Brussels Free University (VUB), Brussels, Belgium

Contact: simon.tierens@gmail.com

**Background:** Aggressive fluid resuscitation is a lifesaving aspect in the initial goal-directed management of critically ill intensive care unit (ICU) patients with shock. However, recent data suggests a independent significant correlation between fluid overload and mortality, after correction for disease severity. Therefore, administration of fluid should be tailored to an individual level [1]. As such, objective and timely assessment of hydration status is warranted, as clinical observations are mostly inaccurate. In the search for a gold standard assessment of hydration status in the ICU, several techniques have been developed, some with proven value, such as transpulmonary dye– or thermodilution techniques and to a lesser extent pulmonary artery catheterization. The non-invasive analysis of body fluid composition with bio-electrical impedance analysis (BIA) may provide additional prognostic information. Recent data showed its superior value over the classic daily fluid balance for prognostication [1–3]. The relative conservative use of fluid therapy has already been demonstrated to improve lung function in ARDS. In patients with septic shock, fluid balance is also directly related to mortality rates [4, 5]. Therefore, fluid stewardship seems mandatory, as both aggressive and restrictive fluid administration may be indicated. BIA offers a simple method to guide these therapeutic goals and determination of 'ideal body weight' since fluid excess is difficult to assess in ICU patients [3].

**Objectives:** The aim of this study is to assess the prognostic value of fluid overload (FO) in the first week of ICU-stay, defined as 5% increment in volume excess (VE) divided by initial body weight. Furthermore, a post hoc analysis will be performed with respect to the prognostic value of total body water (TBW), intra- and extracellular water (resp. ICW, ECW), ECW/ICW ratio, VE, fat free mass (FFM), resting metabolic rate (RMR) and malnutrition index. Finally, a survival curve will be created for the cohort with fluid overload (FO+) and the group of patients without fluid overload (FO–).

**Methods:** A retrospective analysis of data of 101 ICU patients was performed in whom BIA measurements were performed during the first week of their stay (on day 5.1 ± 2). Measurements were obtained via whole-body BIA using the BioScan 920-II multi-frequency analyzer (Maltron International, Essex, United Kingdom). As per manufacturer's instructions, electrodes were placed on the wrist and on the ankle and bioelectrical impedance was measured at 4 frequencies of 5. 50. 100 and 200 kHz in the complete supine position. Statistical analysis was performed via Excel with the 2-tailed unpaired student's t-test. Mortality rates were noted for patients and assessed in relation to the presence of fluid overload.

**Results:** Demographic and anthropomorphic data: Patients with fluid overload (FO+, n = 49) had similar demographic characteristics in comparison to patients without fluid overload (FO–, n = 52): they did not differ significantly with regard to age (respectively 63.2 ± 14.3 vs. 63.7 ± 16.7 years; $P$ = 0.88), gender (34.7% vs. 34.6% female; $P$ = 0.68), height (171 ± 9.8 vs. 172 ± 8.8 cm; $P$ = 0.65), weight (82.2 ± 21.1 vs. 81.3 ± 19.0 kg; $P$ = 0.83) and body mass index or BMI (28.1 ± 7.0 vs. 27.6 ± 6.5 kg $m^{-2}$; $P$ = 0.68).

Severity of illness: On admission, FO+patients had comparable severity of illness in comparison to FO-patients, as neither APACHE II (resp. 23.1 ± 8.4 vs. 23.6 ± 9.4; $P$ = 0.80), SAPS II (55.6 ± 21.1vs 54.6 ± 18.3; $P$ = 0.80), nor SOFA score (11.9 ± 12.9 vs. 10.1 ± 6.9; $P$ = 0.37) could demonstrate a statistical significant difference.

Fluid balance, volume excess and distribution in body compartiments: As expected, FO+patients had a higher cumulative fluid balance during their ICU stay (8.8 ± 7.0 vs. 5.5 ± 5.4 L; $P$ = 0.009) which was reflected in derived parameters such as VE (9.9 ± 6.5 vs. 1.5 ± 1.5 L; $P$ < 0.001) and TBW% (63.0 ± 9.5 vs. 52.8 ± 8.1%; $P$ < 0.001). Importantly, the reported fluid accumulation seemed strictly confined to the extracellular compartment, as no significant difference in absolute water content of the intracellular compartment could be demonstrated (23.9 ± 5.1 vs. 22.5 ± 4.1 L; $P$ = 0.148). In contrast, the extracellular compartment was largely expanded in FO+patients (27.0 ± 7.3 vs. 19.6 ± 3.7 L; $P$ < 0.001), as illustrated in Figure 1. This is reflected in the ECW/ICW ratio as an inverse relation of relative body fluid distribution is observed in FO+ vs. FO– patients (1.1 ± 0.2 vs. 0.9 ± 0.1; $P$ < 0.001), with a normal ECW/ICW ratio usually below 0.9. Also, a slightly higher intra-abdominal pressure was observed in FO+ patients (14.1 ± 3.1 vs. 12.3 ± 4.5; $P$ = 0.05).

Biochemical analysis: Not unexpectedly and probably related to dilution and leakage to the interstitial space, a significant difference was found for albumin levels in FO+ patients in comparison to FO– patients (23.0 ± 3.2 mg dL-1 vs. 25.9 ± 6.5 mg $dL^{-1}$; $P$ = 0.007). In contrast, other biochemical measurements (i.e. hematocrit, total protein, potassium, sodium, glucose, urea and creatinine) did not differ between groups (Table 1).

Nutritional status and calorimetrical analysis: patient with fluid overload had higher RMR (1708 ± 309 vs. 1589 ± 249 kcal; $P$ = 0.04), but comparable amount of muscle, protein,

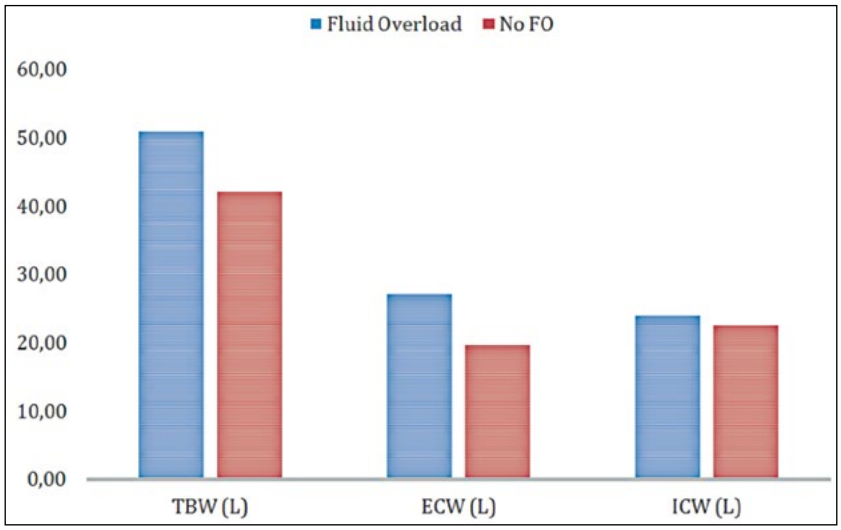


**Figure 1.** Fluid distribution in compartiments, expressed in liters (absolute value) for ICU patients with or without fluid overload. Note the strict accumulation in the extracellular compartment versus the comparable amount of fluid in the intracellular compartment

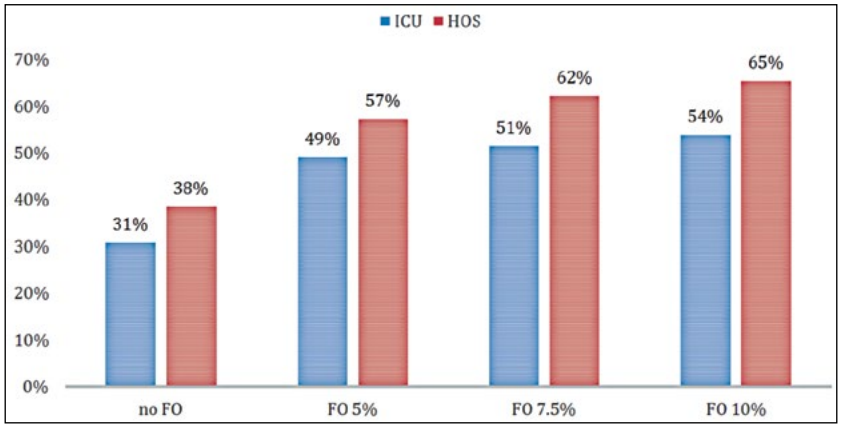


**Figure 2.** ICU and hospital mortality rates in relation to the amount of fluid overload. Expressed as a percentage volume excess increase from the initial body weight, categorized as no fluid overload (no FO), 5% fluid overload (FO 5%), 7.5% fluid overload (FO 7.5%) and 10% fluid overload (FO 10%)

**Table 1.** Biochemical characteristics of ICU patients with and without fluid overload

| | Fluid overload above 5% | No fluid overload | *P*-value |
|---|---|---|---|
| Hct (%) | 28.4 ± 5.8 | 29.30 ± 5.9 | 0.4263 |
| Tot Protein (mg $dL^{-1}$) | 49.00 ± 7.1 | 50.20 ± 9.8 | 0.4802 |
| Albumin (mg $dL^{-1}$) | 23.00 ± 3.2 | 25.90 ± 6.5 | 0.007 |
| CRP (mg $dL^{-1}$) | 179.80 ± 113.5 | 149.60 ± 111 | 0.1886 |
| Urea (mg $dL^{-1}$) | 71.70 ± 47.7 | 67.60 ± 50.2 | 0.6566 |
| Measured osmolality (mmol $L^{-1}$) | 300.40 ± 14.5 | 295.60 ± 21 | 0.3259 |
| Glucose (mg $dL^{-1}$) | 145.30 ± 60.2 | 140.40 ± 41.3 | 0.6444 |
| Na (mmol $L^{-1}$) | 143.70 ± 6.7 | 141.20 ± 8.9 | 0.1155 |
| K (mmol $L^{-1}$) | 4.10 ± 0.5 | 4.30 ± 0.7 | 0.1532 |
| Creatinin (mg $dL^{-1}$) | 1.40 ± 0.9 | 1.30 ± 1.1 | 0.9402 |
| RMR (kcal) | 1708.00 ± 309 | 1588.60 ± 249 | 0.04 |
| Protein (kg) | 12.70 ± 2.7 | 12.40 ± 2.4 | 0.5241 |
| Mineral (kg) | 4.60 ± 0.9 | 4.50 ± 0.8 | 0.4643 |
| Muscle (kg) | 27.70 ± 6.5 | 27.30 ± 6.0 | 0.7176 |
| TBCa (g) | 1151.90 ± 229 | 1139.40 ± 218 | 0.7833 |
| Glycogen (g) | 510.80 ± 105 | 508.50 ± 100 | 0.9116 |
| Malnutrition Index | 1 ± 0.2 | 0.8 ± 0.1 | < 0.0001 |

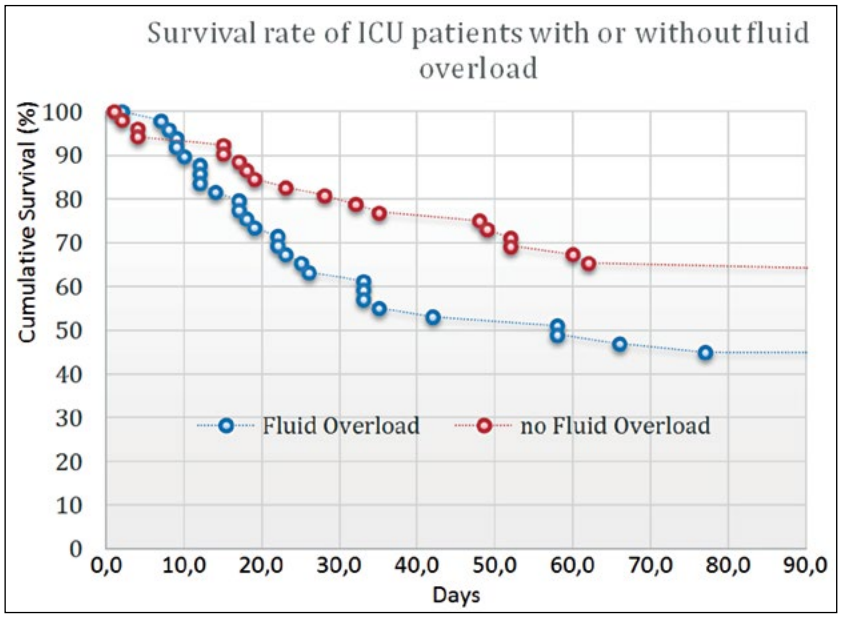


**Figure 3.** Kaplan-Meier survival curve of ICU patients, dichotomized by the presence or absence of 5% fluid overload according to BIA analysis (measurement of volume excess)

bone mass and glycogen deposits (Table 1). Also, the FO+ group were more likely to be undernourished, compatible with a higher malnutrition index (60.0 ± 7.1 vs. 54.7 ± 7.3; $P < 0.001$).

ICU and hospital mortality rates in comparison to amount of fluid overload: patients were categorized according their amount of fluid overload and ICU and hospital mortality rates were calculated. The presence of no, 5%, 7.5% and 10% fluid overload was directly related to increased mortality rates (respectively 31%, 49%, 51% and 52% ICU-mortality rate). The same pattern was found in hospital mortality rate (respesctively 38%, 49%, 51% and 54%, Fig. 2).

Longitudinal mortality rates of FO+ patients vs. FO– patients: A Kaplan-Meier survival curve was constrcuted for the ICU cohort, which was dichotomized based on the presence or absence of 5% FO in the first week of their ICU stay. Interestingly, the presence of FO was associated with a higher survival during the first week but after approximately 1 week it was associated to an increased mortality rate, persisting over time (Fig. 3).

**Conclusions:** BIA analysis allows insight in body water composition in critically ill patients and may help the clinician to guide fluid resuscitation and deresuscitation. In this study, we observed an important accumulation of fluid (above 5% of initial body weight) in about half of the ICU patients, and this fluid overload was predominantly confined to ECW. Furthermore, a higher mortality rate in ICU patients with FO was observed. FO seems a new and independent prognostic factor, as neither APACHE II, nor SOFA nor SAPS II significantly differed on admission between survivors and non-survivors. The absolute extent of FO (5%, 7.5% vs. 10%) only had a marginal additive negative effect on mortality suggesting that 5% FO measured with VE by BIA seems to have a relatively good predictive value. Further research is needed to confirm these data prospectively and to evaluate whether BIA-guided deresuscitation in the subacute phase may improve mortality.

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## P052. Cerebral thrombosis in neonates and children: an overview of clinical relevant treatment protocols

*Viola Van Gorp[1], Klaar Vergaelen[1], Gerlant van Berlaer[1], Elisabeth De Waele[2], Manu L.N.G. Malbrain[2]*

[1]Pediatric Critical Care Department

[2]Critical Care Department, Universitair Ziekenhuis Brussel, Brussels, Belgium

Contact: viola.vangorp@hotmail.com

**Background:** Although very rare, thrombotic events and ischemic stroke during childhood are marked with significant morbidity and mortality.

**Objectives:** After reporting and discussing two cases, we reviewed the literature.

**Methods:** Report of 2 cases and review of the relevant PubMed literature [1–14].

**Results:** Ischemic stroke in children occurs less frequently (0.6–7.9/100,000/year) than in adults (2.8/100,000/year). Etiology includes cardiac abnormalities, inborn or acquired thrombotic diseases including inflammatory or non-inflammatory vasculopathy. Laboratory testing for underlying coagulation disorders is essential. In our two cases lupus anticoagulans, VIIIc deficiency, anticardiolipin, antithombin III, protein C and S, mutations of factor V Leiden, prothrombin gene expression, MTHFR, and anti-Xa were all normal in both patients, but they both suffered from hyperlipidemia. Methylene tetrahydrofolate reductase (MTHFR) is the rate-limiting enzyme in the methyl cycle, and it is encoded by the MTHFR gene. Two of the most studied genetic defects are MTHFR C677T and MTHFR A1298C. With regard to diagnostic imaging, MRI and angiography have been forwarded as the gold standard. We provide a relevant overview of current available treatment protocols. Most of the time, unfractionated heparin therapy is monitored by means of APTT and anti-Xa measurements. In children APTT and anti-Xa do not correlate well as previously shown in literature. Later during the course therapy can be changed to low molecular weight heparin and oral vitamin K antagonists or acetylsalicylic acid. In our setting, and under the above lsited treatment plan, both patients did recover well. By means of two cases, etiology, clinical features, imaging, therapy, practical protocols, possible complications and follow up are discussed.

**Conclusions:** Ischemic–thrombotic incidents in children are extremely rare, but morbidity and mortality rates are high. Screening for underlying hypercoagyulopathy should be performed. For therapeutic monitoring, anti-Xa has been proven superior over APTT measurements.

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## P053. The Neglected parameter: adequacy of intraabdominal pressure monitoring

*José Carlos Bonilla-Perez[1], Josep M. Garcia-Alamino[2], Israel Alberto-Rodríguez[1], Joaquín Felipe-Vargas[1], Juan Pablo González-Toledo[1]*

[1]Intensive Care Unit. Hospital Universitario Ntra Sra de Candelaria, Tenerife, Spain

[2]Clinical Department Southern Europe. ConvaTec, Barcelona, Spain

Contact: JoseMaria.GarciaAlamino@convatec.com

**Background:** Critically ill patients have an increased risk of developing intra-abdominal hypertension (IAH), either due to complicated admissions after surgery or due to associated rsik factors during their stay in the intensive care unit. It has been shown in many studies that the prevalence of IAH in this population is increased [1]. However, the monitoring of this parameter is still somewhat neglected [2].

**Objectives:** The objective of this study is to quantify the rate of monitoring of IAP (intra-abdominal pressure) in patients at risk for IAH.

**Methods:** Prospective observational study in the period June–December 2016. In total 150 patients were analyzed in an ICU with 26 symmetrical boxes. During this period, a review of the clinical records was made daily and box by box is s the presence of risk factors for IAH was noted, according to the WSACS guidelines (the Abdominal Compartment Society). Apart from this proactive search, the doctor was consulted on the suitability of measuring the IAP in those patients who met the WSACS criteria when this parameter was not being monitored.

**Results:** A total of 150 patients were included and the rate of IAP monitoring grouping all risk factors was only 17.3%. For the different risk factors the monitoring rate was as follows: in case of a semi-recumbent position (15.8%), acute respiratory failure (22.5%), severe sepsis (33.3%), polytrauma (40%), presence of ascites (100%) and abdominal surgery (100%).

**Conclusions:** Despite the high prevalence of IAH in the critically ill population, the growing evidence and recommendations for IAP monitoring and the increasing awareness of this problem in our unit we still observe a low overall IAP monitoring rate especially in some clear indications such as sepsis. These data has lead to specific actions to improve adherence to WSACS guidelines: joint sessions between surgeons and ICU physicians will be organized, as well as specific teaching sessions for nurses and allied health care personnel with regard to indications for and correct measurement of IAP.

**Key words:** intra-abdominal hypertension, critical care, intensive care units, monitoring

**Conflict of interest:** Yes, the presenter works for the Clinical Department Southern Europe. ConvaTec, Barcelona, Spain.

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## P054. Percutaneous closure of pulmonary arteriovenous malformation in the left inferior lobe in a fifteen-year-old female with hemoptysis and cardiac arrest secondary to hypoxemia

*Celine Perceval[1], Viola Van Gorp[2], Hans Nieboer[3], Anne Malfroot[1], Manu L.N.G. Malbrain[2]*

[1]Department of pediatrics, Universitair Ziekenhuis Brussel, Brussels, Belgium

[2]Critical Care Department, Universitair Ziekenhuis Brussel, Brussels, Belgium

[3]Department of Radiology, Universitair Ziekenhuis Brussel, Brussels, Belgium

Contact: celine.perceval@uzbrussel.be

**Background:** Pulmonary arteriovenous malformations (PAVMs) are abnormal communications between the pulmonary arteries and veins, which result in a right-to-left shunt with resultant hypoxemia, depending on the size and number of lesions. The paradoxical emboli as a result of compromised filtration of the pulmonary capillary bed can lead to severe complications like brain abscess, transient cerebral ischemia and stroke. Although rare, hemoptysis and hemothorax resulting from intrabronchial or intrapleural rupture respectively can cause life-threatening situations. The congenital form appears in 2 variants: capillary telangiectasia which is usually associated with Hereditary Hemorrhagic Telangiectasia (HHT) also called the Rendu-Osler-Weber (ROW) syndrome; the other form is a cavernous hemangioma supplied by one or more dilated tortuous vessels of the pulmonary artery. Secondary or acquired PAVMs can be caused by trauma, infection, heart surgery, long-standing hepatic cirrhosis, amyloidosis, metastatic carcinoma, cystic fibrosis and mitral stenosis.

**Objectives:** To describes a case of PAVM in a 15-year old girl leading to cardiac arrest followed by a review of the relevant literature [1–15].

**Case presentation:** A 15-year-old girl of Moroccan descent presented with severe and massive hemoptysis accompanied with loss of consciousness. This episode was preceded by a sudden loss of strength with motoric failure of both arms.

Brain MRI and an EEG were both normal. A CT angiography of the thorax showed a consolidation in the left inferior lobe (Fig. 1). There was no clear evidence of a vascular lesion. Further workup included: a gastroscopy and a bronchoscopy. Gastroscopy was normal. Bronchoscopy showed a bulging of the posterolateral tracheal wall, suggestive for a bleeding polyp, the left inferior lobe tissue was inflamed and filled with some blood. A second bronchoscopy two days later visualized no tracheal lesion and there were no anatomical abnormalities. Coagulation screening was nor-

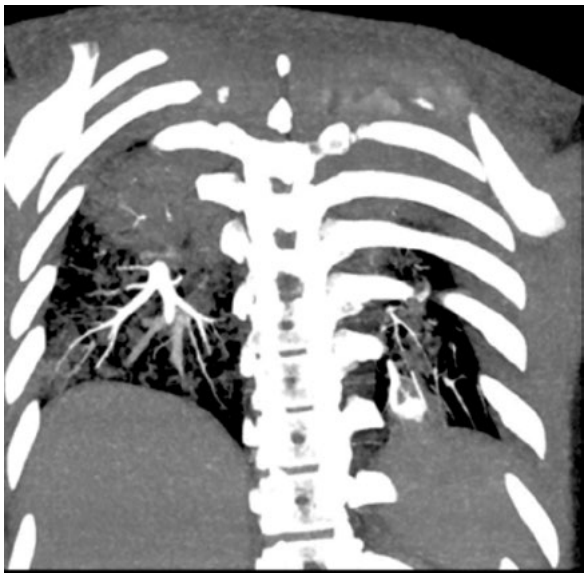

**Figure 1.** Sagittal CT image showing consolidation left lower and right upper lobe

mal. Additional investigations revealed positive serology for Mycoplasma. Inflammation caused by an acute Mycoplasma infection was thought to be the reason for the bleeding. She was treated with clarithromycin during two weeks. The evolution was favorable, with no more hemoptysis during hospitalization nor need for supplementary oxygen, and she could return home after 8 days.Two months later, the girl presented with a sudden loss of consciousness during physical activity. It started with coughing up blood and afterwards she fell down unconscious. The emergency team found her in a non-responsive state without pulse. CPR was started. The ECG showed ventricular fibrillation and an asynchronic shock was administered with recovery of normal rhythm and return of circulation. The patient was intubated and transported to the hospital for further stabilization. MRI angiogram of the brain revealed no cerebral vascular abnormalities. CT angiography of the thorax showed a focal extravasation of contrast in the left inferior lobe, indicative of a vascular malformation of pulmonary origin and a consolidations of the inferior segments of both lungs, most likely as a result of chronic seeping of blood. The next day a percutaneous angiography was performed which confirmed the arteriovenous malformation in the basal segments of the lower lobe of the left lung. The lesion was coiled successfully (Fig. 2). Heparin was administered during the procedure to minimize the risk of embolism. She stayed for 3 days on ICU before admission to the pediatric unit. A MRI angiogram of the brain and CT angiography for cerebral vascular malformations were negative. Further course of hospitalization was uncomplicated and the patient was able to return home after 9 days. Further questioning

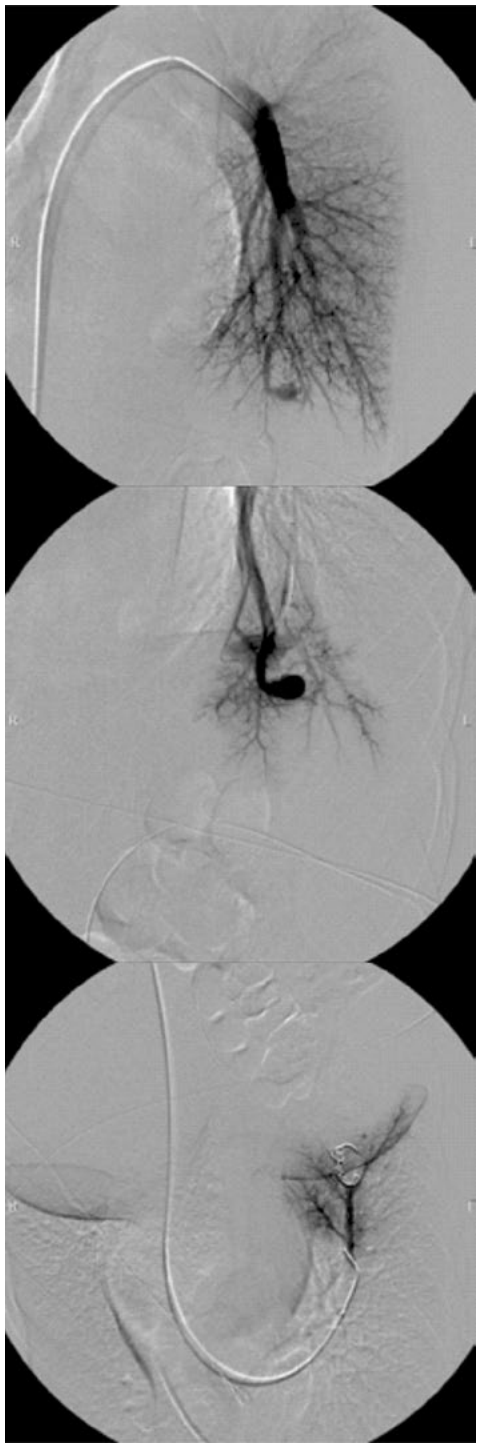

**Figure 2.** Angiography with successful coiling of AV malformation

revealed a combination of loss of power and sensibility of her right arm the day before the incident, which had lasted for about five minutes and spontaneously resolved. There were no other associated symptoms. In fact, this loss of power did occur about once a week since the first episode of hemoptysis, always with sudden onset and spontaneous resolution after a few minutes. Family history was negative:

no sudden death, no coagulopathy, no cerebral incidents or other diseases.

Genetic testing did not show mutations in ENG, SMAD4, ALK1 (= ACVLR1) and GDF2. Micro-array was normal. Therefore is Hereditary Hemorrhagic Telangiectasia (Rendu-Osler-Weber syndrome) unlikely as underlying diagnosis.

**Conclusions:** Although PAVM may no longer be classified as an extremely rare disease, its prevalence in the pediatric population is rare. Even in children with PAVM it may go unnoticed until well into adulthood. It is, however, an important clinical entity which can lead to significant morbidity and mortality. Diagnosis can be made by cardiac ultrasound with microbubbles or CT angiography. treatment by percutaneous angiographic intervention.

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## P055. A simple tool to guide intra--abdominal pressure monitoring


*Vincenzo Pedace[1], Giovanna Michela Pace[2], Andrea Del Grande[3], Valerio Di Nardo[4], Mauro Scimmi[5], Josep M. Garcia-Alamino[6]*

[1]Clinical Department Italy. ConvaTec, Rome, Italy
[2]Infermiera, Gruppo Operatorio, AV 2 Asur Marche, Jesi (AN), Italy
[3]Infermiere, Rianimazione, A.O. di Terni (TR), Italy
[4]Infermiere, Rianimazione, A.O. di Terni (TR), Italy
[5]Coordinatore, Rianimazione, A. O. di Terni (TR), Italy
[6]Clinical Department Southern Europe. ConvaTec, Barcelona, Spain
Contact: JoseMaria.GarciaAlamino@convatec.com


**Background:** The WSACS (the Abdominal Compartment Society) guidelines advise monitoring of IAP in patients with risk factors for the development of intra-abdominal hypertension. The different consensus documents on prevention and management of intra-abdominal hypertension recommend monitoring this parameter every 4–6 hours [1]. However, to the best of our knowledge there are no validated useful record formats.

**Objectives:** The objective of this study is to develop and validate the use of a simple tool to follow the evolution of IAP values in critical ill patients.

**Methods:** Prospective observational study during the period September–December 2016. The spreadsheet (tool) was distributed in paper format in a total of 92 intensive care units. The tool contains 2 sections: the first section records the patient's IAH risk factors. The presence of risk factors for IAH was noted, according to the WSACS guidelines [1]. In the second section, the intra-abdominal pressure values of each patient are recorded every 4–6 hours. All data were entered anonymously.

**Results:** A total of 143 spreadsheets were collected, we discarded 35 spreadsheets due to lack of information. Finally, a total of 108 spreadsheets were analyzed. The most prevalent risk factors were sepsis 22 (29%), obesity 18 (24%), PEEP > 10 (14%), infection or intraabdominal abscess 7 (9%), high APACHE-II or SOFA score (8%), other 12 (16%). The mean of daily IAP measurements was 5. A total of 75 patients (81%) had IAP values > 12 mm Hg. Based on the results obtained in 42 (56%) a specific treatment or intervention was started to ldecrease IAP, however only 22 (29%) received one of the measures proposed in the WSACS consensus document. In 6 (8%) a surgical decompression was performed, and 5 (7%) patients died.

**Conclusions:** The use of this tool shows that there is a high number of patients with intra-abdominal pressure values > 12 mm Hg, or this intra-abdominal hypertension. However, this percentage seems very high compared to the data that can be found in the literature [2]. The use of this tool seems very useful to observe the trend in IAP and degree

of intra-abdominal hypertension. At the moment, we are developing a new version of the spreadsheet where the patient's position and the amount of fluid resuscitation received will be included. This is a useful nursing tool to perform the registration and monitoring of IAP. The possibility of integrating the tool with an electronic patient data system is currently under evaluation.

**Key words:** intra-abdominal hypertension, critical care, intensive care unit, monitoring

**Conflict of interest:** Yes, the presenter works for the Clinical Department Southern Europe. ConvaTec, Barcelona, Spain.

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## P056. Social media in critical care: conference hashtags, a time-limited entity

*Ifor Capel[1], Adrian Wong[1], Matthew Rowland[1, 2], Olesegun Olusanya[3], Manu L.N.G. Malbrain[4]*

[1]Oxford University Hospitals NHS Foundation Trust, UK
[2]Kadoorie Centre for Critical Care Research, University of Oxford, UK
[3]North Hampshire Hospitals NHS Trust, UK
[4]Brussels University Hospital, Belgium
Contact: avkwong@mac.com

**Background:** Twitter is a microblogging site, founded in 2006, where users interact with a social network through creating or sharing posts of 140 characters or fewer. These posts may contain hashtags, which allow the aggregation of tweets to topics. Twitter has been used for some years to amplify the reach of scientific conferences, with growing success. Tweets can be labelled with the conference hashtag, such that people unconnected on Twitter, may join and participate in a broader discussion of themes or subjects stimulated by the conference-both locally and from a distance. Despite the increasing use of Twitter at critical care conferences, there remains considerable debate as to its impact and ability to generate meaningful discussions beyond the duration of the conference itself.

**Objectives:** To analyse differences in hashtags and impressions (measure of impact) used at critical care conference between 2015 and 2016. The conference of the main critical care societies (SCCM, ESICM and ICS) as well as the more established/prominent ones (SMACC) were chosen for analysis.

**Methods:** Six critical care conferences were identified, covering the regions of the USA (Critical Care Conference), Europe (LIVES, ISICEM), UK (ICSSOA), Belgium (IFAD) and the international Social Media and Critical Care (SMACC) movement. Data analytics were obtained using the Symplur platform, an established tool to analyse Twitter traffic.

**Results:** There has been an increase in the number of tweets across all conference between 2015 (27,000) and 2016 (46,000) (Figs 1, 2). The SMACC conferences remain the most popular and active with impressions exceeding the combined total of all the other critical care conference for that year. It is very notable that the frequency of the conference hashtags being used drops off exponentially after the conference itself; to the point that a week after the conference, there is almost no mention of it. The only exception to this is once again the SMACC conferences. This may be due to the fact that their organisers are much more active on social media and the fact that educational material from the conference is released in a more controlled fashion.

**Conclusion:** The use of twitter and conference hashtags has increased amongst critical care conferences. The use of conference hashtags is not sustained and drops off dra-

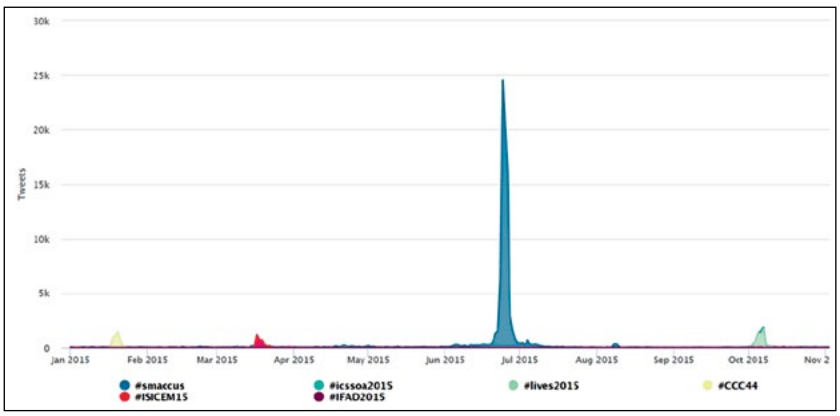


**Figure 1.** Twitter analytics for critical care conferences in 2015

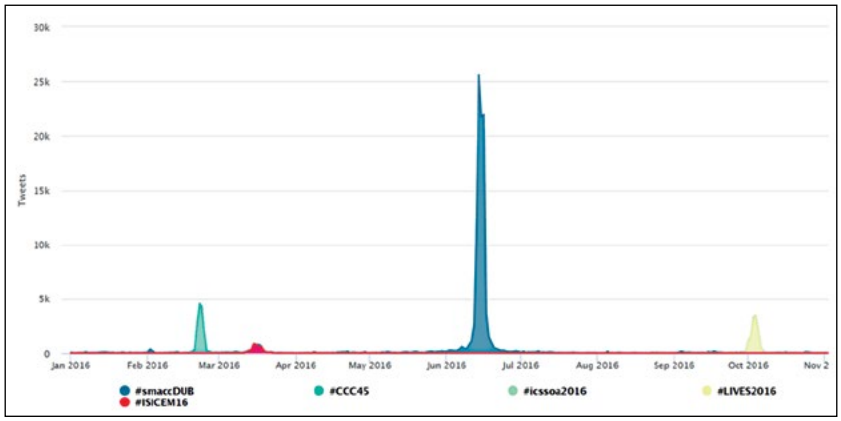


**Figure 2.** Twitter analytics for critical care conferences in 2016

matically after the event itself. In order to prolong their use and presence, conference organisers should consider the controlled release of educational material as part of their overall social media strategy.

## P057. Can $ECCO_2R$ be the rising sun for respiratory failure?

*Adriaan Sablon, Rita Jacobs, Marc Diltoer, Joris Troubleyn, Manu L.N.G. Malbrain*

Intensive Care Unit, University Hospital Brussels (UZB), Jette, Belgium
Faculty of Medicine and Pharmacie, Vrije Universiteit Brussel (VUB), Brussels, Belgium
Contact: adri.sablon@gmail.com

**Background:** Extracorporeal carbon dioxide removal ($ECCO_2R$) devices have been proposed as an adjunctive therapy in patients with acute exacerbations of chronic obstructive pulmonary disease (AECOPD) to avoid intubation or reduce the length of invasive ventilation [1–3]. In acute respiratory distress syndrome (ARDS) patients it is used to allow ultra-protective ventilation. In cases of severe ARDS, veno-venous extracorporeal membrane oxygenation (VV-ECMO) proves to be a life-sustaining rescue strategy; however, complications associated with VV-ECMO are common and potentially life-threatening [1–3].
**Objectives:** We performed a single-center retrospective observational study where we investigated the benefits of $ECCO_2R$, complications encountered and mortality. We were also interested to know for patients who have contraindications for VV-ECMO if they could benefit from an $ECCO_2R$.
**Methods:** We performed a single-center retrospective observational cohort analysis in a tertiary University Intensive Care Unit (ICU). Over a 34-month period, 59 patients were treated with arterio-venous (AV)-$ECCO_2R$ for ARDS or AECOPD. We used a Novalung® iLA Membrane Ventilator (Xenios, Heilbronn, Germany) which is a pumpless device.
**Results:** In total, 59 subjects were analyzed. In the ARDS group 35 patients were included, consisting of 16 male and 19 female patients with a mean age of 57 years (54–59) and a mean APACHE score of 25 (23–27). In the AECOPD group 24 patients were included, consisting of 12 male, and 12 female patients with a mean age of 64 years (63–65) and a mean APACHE score of 24 (21–27). Mortality for patients treated with AV-$ECCO_2R$ for ARDS or AECOPD was respectively 48.6% and 40.9%. In the ARDS group the mean duration of ventilation during $ECCO_2R$ was 5.7 days (5.1–6.3), the mean length of ICU and hospital stay was 23.9 days (20.9––26.8) and 44.1 days (37.5–50.9) respectively. Mean arterial blood pH obtained at initiation of $ECCO_2R$ treatment was 7.2 mm Hg (7.04–7.36) and 7.36 mm Hg (7.22–7.50) at termination of $ECCO_2R$ therapy. Mean PaCO2 value was 65.8 mm Hg (63.3–68.4) at initiation of $ECCO_2R$ therapy and 48.1 mm Hg (46–50.2) at termination of the $ECCO_2R$ treatment.
In the AECOPD group the mean duration of ventilation during $ECCO_2R$ was 2.4 days (1.8–3.0), the mean length of ICU and hospital stay was 10.8 days (9.2–12.4) and 23.2 days (19.9–26.5) respectively. Mean arterial blood pH obtained at initiation of $ECCO_2R$ treatment was 7.24 (7.22–7.26) and 7.42 (7.41–7.43) at termination of $ECCO_2R$ therapy. Mean $PaCO_2$ value was 80.3 mm Hg (77.0–83.6) at initiation of $ECCO_2R$ therapy and 56 mm Hg (53.3–58.7) at termination of the $ECCO_2R$ treatment. Complications due to AV-$ECCO_2R$ had no significant impact upon outcome in both groups.
**Conclusions:** $ECCO_2R$ is a feasible, rapidly evolving technology and is an efficient treatment that allows lung protective ventilation. However, evidence for a mortality benefit with $ECCO_2R$ is lacking and complications are frequent. Well-designed adequately powered randomized controlled trials (RCTs) are required to better elucidate risk-benefit balance.

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## P058. Social media in critical care: variation across professional groups

*Ifor Capel[1], Adrian Wong[1], Matthew Rowland[1, 2], Olesegun Olusanya[3], Manu L.N.G. Malbrain[4]*

[1]Oxford University Hospitals NHS Foundation Trust, UK
[2]Kadoorie Centre for Critical Care Research, University of Oxford, UK
[3]North Hampshire Hospitals NHS Trust, UK
[4]Brussels University Hospital, Belgium
Contact: avkwong@mac.com

**Background:** Social media allows for the rapid, effective dissemination of information between an individual and their followers. Twitter, an online social media platform, allows the individual to disseminate information in the form of "tweets" of 140 characters or less. In health education, this allows educators to rapidly disseminate information in public to a wide and varied audience. The use of social media has become increasingly common in medical practice leading to formation of specific committees to tackle this area in professional bodies and conferences. As a multidisciplinary specialty, it is important that such online discussion is reflective of real-world discussions and reflects the views of the team.

**Objectives:** To analyse the twitter traffic of the main critical care conference in 2015. 2016 and 2017 and identify the proportion of tweets attributable to the various professional groups.

**Methods:** Thirteen critical care conferences were identified, covering the regions of the USA, Europe, UK, Belgium and the international Social Media and Critical Care (SMACC) movement. Data analytics were obtained using the Symplur platform, an established tool to analyse Twitter traffic.

**Results:** There has been a dramatic increase in the number of tweets at critical care conference between 2015 and 2017. The peak of activity for the particular conference hashtags occurs during the conference itself. Analysis of the tweets across professional groups reveals that they were predominantly from physicians. The contribution of other healthcare professionals including nursing colleagues was on average below 10% of the total. Their contribution at European-based conferences was particularly low.

**Conclusion:** Despite being an integral part of the critical care team, non-doctors are not as proportionately involved in the twitter conversations during conferences. The reasons for this are probably multifactorial including culture, educational funding to attend conferences, embracing technology etc. Hence, online conversations such as those on Twitter may not reflect the opinions of the entire multidisciplinary team.

**Table 1.** Tweet contributions of doctors and healthcare professionals at various Critical Care Conferences between 2015 and 2017

| Conference | Doctor Stakeholder% | HCP Stakeholder% |
|---|---|---|
| LIVES 2014 | 32 | 2 |
| LIVES 2015 | 39.8 | 3.9 |
| LIVES 2016 | 57 | 6.5 |
| CCC 44 | 41.1 | 9.3 |
| CCC 45 | 56.1 | 14 |
| CCC 46 | 59.5 | 9 |
| SMACCUS | 75.6 | 8.4 |
| SMACCDUB | 83.8 | 3.6 |
| DASSMACC | 77.9 | 6.2 |
| ICSSOA15 | 64.1 | 7.8 |
| ICSSOA16 | 68.6 | 7.6 |
| IFAD2015 | 47.2 | 0 |

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# INVITED ABSTRACTS — LEARNING OBJECTIVES

## I001. Landiolol in atrial fibrillation in intensive care

*Martin Balik*

Department of Anesthesiology and Intensive Care, 1st Faculty of Medicine, Charles University and General University Hospital, Prague, Czechia, EU

**Learning objectives:** Amongst the general ICU population, the supraventricular arrhythmias are associated with worse short and long term prognosis. Besides improving oxygenation, preload and electrolyte corrections, the mainstay of treatment is represented by amiodarone preferred for its lower cardiodepressant side effect compared to other agents and an electric cardioversion. Amiodarone carries potential significant side effects. More than 50% of patients with heart failure in the ICU show a diastolic heart failure, often associating with a rhythm disorder. The reported benefits of betablockers in the critically ill [1, 2] could be related to the extension of diastolic filling time, improvement of LV diastolic function and arrhythmia management. The antiarrhyhmic efficacy of betablockers and the betablocker derivative propafenon could be higher in the absence of contraindications compared to the efficacy of the most frequently administered amiodarone [2].

**Background:** A new ultra-short beta-blocker with a half-life of only 4 minutes and a high beta-1 selectivity is landiolol which has been used for treatment and prevention of atrial fibrillation. Landiolol has also been shown to be well tolerated in the critically ill for its limited negative inotropic effect and minimal impact on blood pressure [3–5]. The use of low doses (5–10 mcg $kg^{-1}min^{-1}$) of landiolol is usually sufficient for cardioversion of AF compared to controls. In sinus tachycardia landiolol may prevent occurence of arrhythmias in a lower dose (3–5 mcg $kg^{-1}min^{-1}$) [3]. Additional benefits might be related to the regulation of inflammatory response and blunting of the adrenergic pathway.

**Discussion:** Beta-blockers are potential option to manage a supraventricular arrhythmia, both for prevention and treatment. A beta-blockade withdrawal syndrome is a risk factor for atrial fibrillation. Likewise, the administration of a betablocker should consider chronic beta-blockade status. Protecting the heart under stress conditions requires to reduce unnecessary load of catecholamines and stimulation of their receptors. Studies show that using well titratable betablockers esmolol and landiolol might be safe in those patients who parallely require a vasopressor for hypotension. There was no report of bronchospasm when using titrated betablockers in patients with atrial fibrillation [6]. Limiting systemic adrenergic activation may be beneficial however, may be also detrimental in improperly monitored patients with compromised heart function. Also in heart rate below 100 $min^{-1}$ the infusion of betablocker might result in cardiac output inadequate to systemic oxygen demand in a critical status.

**Take home messages:** The combination of ECG and echocardiography allows to indicate antiarrhythmics with the exclusion of a more cardiodepressant medication in severe LV dysfunction and also to correct preload when attempting to cardiovert to sinus rhythm. A hypercontractile ventricle or dynamic LVOT obstruction may rather, after correction of preload, indicate betablocker therapy. Echocardiography helps also to decide whether to cardiovert a patient with unknown arrhythmia history. A finding of a significantly dilated left atrium or valvular disorder may associate with chronic AF. In the absence of echocardiography the ECG findings of a structural heart disease like, for example, low R waves in precordial leads, profound ischaemic changes or atrioventricular blockade would contraindicate propafenon or a betablocker. A known history of severe LV dysfunction would exclude other antiarrhythmic than amiodarone too.

**Conflict of interest:** none.

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## I002. Hemodynamic monitoring; beyond accuracy and precision

*Christiaan Boerma*

Department of Anesthesiology and Intensive Care, Amsterdam, The Netherlands

**Learning objectives:** To become aware of non-device specific elements in the chain of events from monitoring to improvement in outcome.

**Background:** The existing literature on hemodynamic monitoring is somewhat limited to the issues of adequacy and precision and in essence device-oriented. However, in order the make hemodynamic monitoring successful from a clinical perspective, many more issues are involved.

**Discussion:** In order to implement a form of hemodynamic monitoring a comprehensive strategy needs to be developed. This includes careful selection of patient groups, eligible for the specific type of measurement. Furthermore, timing and sample rate are of importance; essential changes in hemodynamic may be missed if the window of opportunity is not set appropriately. In addition, human behaviour of medical personnel comes into play. This extends beyond a common implementation plan, which is usually limited to education of practical and theoretical aspects. The main question at hand is: do we perform according to our own expectations. There is growing evidence that this may not be the case. Humans act according to bounded rationality, seeking solutions good enough for the situation at hand, but could be optimised. It helps us to 'solve' complex problems that we do not fully understand. But it limits us in our ability to accept new concepts to the extent that we are prepared to change our behaviour. A recent Europe-wide survey among ICU staff reveals that doctors and nurses administer fluids, regardless of the data from their self-chosen type of hemodynamic monitoring [1]. In such setting it is hard understand how hemodynamic monitoring could contribute to improvement in patient outcome.

**Take home messages:** Correct measurement, correct interpretation and correct application all need to be addressed in order to turn hemodynamic monitoring into a clinically relevant tool. In addition, a thorough check is needed to answer the question: does ICU staff behave as anticipated, according to rational principles; or does irrational behaviour prevent successful implementation?

**Conflict of interest:** none.

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## I003. Optimizing blood pressure and organ perfusion with vasopressors and fluids

*Daniel Chappell*

Department of Anesthesiology, University Hospital Munich, Munich, Germany

**Learning objectives:** Apart from maintaining normovolemia in the individual fluid compartments, perioperative infusion therapy supports both blood pressure and tissue perfusion. Crystalloids and colloids have different distribution areas and should be used according to their individual indication. Additional vasoactive agents should be considered to support organ blood flow, oxygenation and to optimize patient outcome. A prerequisite is to carefully evaluate a patient's volume status before initiation of hemodynamic stabilization. In acute intravascular hypovolemia colloids seem to be more effective than crystalloids, avoiding fluid overload with subsequent tissue and organ edema. A (too) early treatment with vasopressors in this situation to increase blood pressure might impair microcirculatory blood flow. A rational infusion protocol combining the advantages of each substance whilst minimizing side effects seems warranted to maintain normovolemia, oxygen supply and organ function.

**Background:** Fluid and volume management remains a frequently discussed issue in anaesthesia and intensive care. In the past years there have been more drug-centred discussions around the ideal composition and total amount of intravenous fluids in general. Evidence is quite clear that balanced solutions should be preferred over saline-based solutions and both hypo- and hypervolemia increase morbidity and complication rates in our patients. Therefore, normovolemia of all fluid compartments should be the target in the perioperative situation. In the perioperative patient this means a replacement of ongoing fluid losses from the extracellular space with 1–2 mL $kg^{-1}h^{-1}$ plus measured urine output using isotonic crystalloids. In case of larger blood losses a replacement with isooncotic colloids seems advantageous as they directly target the intravascular compartment. This so-called goal-directed approach should be performed in major surgery and high-risk patients using devices measuring dynamic preload parameters. Infusing only crystalloids to replace blood losses cause intravascular hypovolemia or occult hypovolemia, without changes of surrogate parameters such as blood pressure or heart rate

but with reduced splanchnic and microcirculatory perfusion. Using vasopressors in such patients can further impair microcirculatory blood flow by reducing the proportion of perfused vessels and the heterogenity of blood flow.

**Discussion:** Meanwhile the focus has moved on to distinguish between different patient groups. Cardiopulmonary healthy patients going into elective surgery are supposed to primarily be normovolemic, if not overly fasted or received aggressive bowel preparation. Moreover they have a functioning vascular barrier and intact fluid compartments. They are mainly endangered by acute perioperative bleeding. Our goal is to maintain their steady state and hemostasis by distinguishing between a crystalloids for maintainance and the care for cardiac preload with a combination of low-dose vasopressors and iso-oncotic colloids. Critically ill patients, by contrast, are often systemically inflamed, suffering from imbalances affecting not only cardiac preload but with an impaired vascular barrier functioning. Large amounts of colloids in these patients, after initial stabilisation, have shown to have negative effects on patient outcome. But as with every drug not only the amount but also timing and context play a decisive role. With an impaired barrier and capillary leakage colloids have a reduced volume effect and are shifted in large quantities towards tissue. In patients requiring fluid resuscitation the indication for a colloid should be limited to the early initial stabilization phase.

**Take home message:** Patients with renal impairment or an impaired vascular barrier function should be primarily treated with crystalloids supplemented with small amounts of human albumin if indicated to limit fluid overload.

## I004. Perioperative fluid management

*Wojciech Dabrowski*

Department of Anaesthesiology and Intensive Therapy Medical University of Lublin, Poland

**Learning objectives:** To understand the importance of perioperative fluid management and hemodynamic management. To understand the different types of fluid therapy. To learn about different hemodynamic monitoring tools and goal-directed therapy.

**Background:** Fluid administration plays a crucial role in perioperative treatment and is a core concept in the management of the perioperative period. Its purpose is to maintain adequate oxygen delivery through restoration effectively circulating blood volume and correction of blood pressure. However, an appropriate perioperative hemodynamic management should be based on sufficient fluid infusion for correction of the volume deficit as well as vasopressors or vasodilators administration for the correction of vascular tome and inotropic support for correction of cardiac insufficiency. Type of fluid and its volume strongly affect organ function. Fluid composition is not fully similar to plasma. Physiologically, plasma mainly consists of water, proteins, organic acids, phosphates, sulphates and electrolytes, such as sodium, potassium, calcium, magnesium and chlorine whereas fluids generally consist of water and electrolytes. Hence, the presented fluids osmolality is only theoretical ("in vitro"), and real "in vivo" osmolality has to be calculated as a multiplication theoretical value of 0.926. Every hypotonic as well as hypertonic fluids may disturb plasma osmolality, which affects the capillary pressure and transcapillary flow. Given the revised Starling principle balanced crystalloids are superior to colloids and the use of plasma and plasma substitutes to achieve blood volume is not rational. Strong ions differences (SID) is another important parameter in perioperative appropriate fluid optimization. The best SID should range between 20–30, because SID higher than 40 leads to alkalosis while SID below 20 causes blood acidosis. Most of the fluids are buffered by anions including acetate, malate, lactate or citrate. Some of them are subtracts for Cori cycle. Citrate is also metabolized in the liver. However, it's the liver metabolism that can be disturb in patients with severe hepatic diseases. Disturbance in hepatic citrate metabolism leads to massive $Ca^{+2}$-citrate complexes accumulation. Moreover, massive fluid infusion buffered by citrate, which binds blood ionized calcium, affects blood coagulation which intensifies perioperative bleeding.

**Discussion:** The appropriate strategy for fluid administration is one of the most important treatments in the perioperative period. Although fluid therapy is essential for adequate tissue perfusion volume excess and positive perioperative fluid balance may induce iatrogenic hemodilution and impair cardiac, pulmonary, gastrointestinal and renal function contributing with prolonged recovery and worsen outcome. A lot of studies have suggested to limit fluid volume and have recommended goal directed therapy as a choice of perioperative fluid administration particularly in critically ill patients. Nevertheless, fluid therapy should be personalized and managed in accordance to haemodynamic variables. Currently pulse pressure variation (PPV), stroke volume variation (SVV), plethysmographic waveform variation (PWV) and pleth variability index (PVI) are recommended for intravascular volume control. Continuous monitoring of the mentioned dynamic variables can predict severe haemodynamic disorders and when fluid administration should be stopped. Interestingly, the interaction between PVI and continuous haemoglobin measurement significantly helped in the choice of fluid. Rapid increase in PVI with unchangeable haemoglobin level suggested to use

crystalloids or colloids, while a decrease in PVI associated with a decline haemoglobin level indicated blood transfusion. Secondarily, the interaction between PPV and SVV may be useful to identify patients with hypotension, who require vasopressor therapy.

**Take home message:** Finally, perioperative fluid therapy should be managed in accordance to patients' conditions and the kind of surgery. The Goal directed therapy is recommended for critically ill patients, however a strategy for fluid therapy should be personalised.

**Conflict of interest:** none.

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## I005. Renal recovery: does the choice of renal replacement therapy matter?


*De Geus Hilde*

Department of Intensive Care, Room H-619, Erasmus University Medical Center, Rotterdam, The Neherlands


**Learning objectives:** This lecture will provide insight information on the physiology of CRRT techniques. It will display the available evidence on convective versus diffusive clearance. And it will display the evidence to enable the audience to substantiate the statement that CVVH and CVVHD are interchangeable techniques to apply in the critically ill.

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## I006. The dangers of deresuscitation


*Jan De Waele*

Intensive Care Unit, University Hospital Ghent, Belgium


**Learning objectives:** Understand the negative effects of fluid overload and describe different phases in fluid management**.** List the methods for and side effects of fluid removal in critically ill patients**.** Safely apply fluid removal strategies in clinical practice

**Background:** Fluid overload is a common finding in critical care and has been associated with negative outcomes. In the SOSD approach de-escalation of fluid therapy is an important strategy

Restrictive fluid strategies have been demonstrated to have better outcomes although mortality advantages have not been confirmed.

**Discussion:** De-resuscitation refers to a restrictive approach to fluid administration in the de-escalation phase of fluid management. De-resuscitation as a term suggests a short--term intervention, and would arguably be the *reverse* of resuscitation, and as such, may cause confusion. The term fluid de-escalation may also not optimally reflect the goal of this phase and therefore fluid removal probably better reflects the key focus in this phase of fluid management.

Fluid removal in critically ill patients is currently receives little attention and may be used in patients who have been treated in the ICU for at least a few days. The goal of fluid removal is to prevent or treat the toxicity of fluid therapy, and is mostly relevant in patients with sepsis, major trauma, burns — situations where it is quite common to administer large volumes of fluid during the salvage/rescue and stabilisation faze.

Although the concept is intellectually attractive, there are limited data to support this approach and even fewer data on how to do this in practice. Obviously, safety should be the first concern, and depending on the intervention used, as well as the timing of and rate at which fluid is removed, complications may occur.

Continuous monitoring of fluid balance is a first and logical step — and should be done continuously, not at 24h intervals. The cumulative fluid balance should be monitored, and if indeed the fluid balance is markedly positive, and the

patient is suffering from the toxicity of fluid overload, fluid removal should be considered.

Secondly, hemodynamic stability is a prerequisite, but this is not easily defined. Often parameters of tissue perfusion used in the salvage and optimisation phase are used but these may not be perfect to guide fluid removal. Nevertheless, often used parameters include lactate, skin perfusion, CVP, urinary output, blood pressure but the optimal parameter to guide fluid removal is unknown. Regular re-evaluation — clinically and with biomarkers — is strongly recommended, and hemodynamic parameters such as SVV, PPV, ant others can also be considered.

Factors that will determine the method and rate include extent of fluid overload, organ dysfunction attributable to fluid overload, organ function including hemodynamic stability.

Fluid removal can be spontaneous in some patients, but this may be a lengthy process and therefore often may require either diuretics or ultrafiltration using extracorporeal techniques.

Complications of fluid removal are linked to the intervention used and can be either hemodynamic or metabolic. Hemodynamic compromise may include hypotension and hypovolemia. Metabolic complications can be related to the use of diuretics and may include electrolyte disorders and metabolic alkalosis; in patients who require RRT for fluid removal complications can be multiple.

In order to avoid complications fluid removal should be gradually increased, and regular re-evaluation is highly recommended. Clearly set goals are important but should be updated based on the response and the observed effect.

**Take home messages:**

- Fluid removal as important as fluid resuscitation — diuretics and RRT most used approaches
- Timing, dose and monitoring of fluid removal has been poorly described
- Side effects of fluid removal include hypotension and hypovolemia, and metabolic complications such as electrolyte disorders
- A rational approach uses a continuous therapy with pre-defined, individualized goals, with frequent re-evaluation of clinical and biochemical parameters

**Conflict of interest:** none.

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## I007. Why children are not small adults: the fluid perspective


*Els L.I.M. Duval*

Department of Pediatric Intensive Care, University Hospital Antwerp, Edegem, Belgium


**Learning objectives**: Knowledge of the (patho)physiology of water and electrolyte balance in growing childre. Learning how to use a structured approach to prescribe fluids in children. Tools to recognize dehydration and specify a rehydration plan. When to use fluid-bolus in the acute setting

**Background:** Fluid and electrolyte therapy is a basic component of the care of hospitalized children. Requirements are higher than those for adults for many reasons: children have a higher metabolic rate requiring a greater caloric expenditure, which translates into higher fluid requirements. Their higher body surface area to weight ratio and their higher respiratory rates, translate into relatively more insensible losses from the skin and respiratory tract respectively. It is thus not surprisingly that children are prone to water and electrolyte imbalances and that pediatric fluid therapy can be challenging. Prescribing fluids is as prescribing medications: it requires a thorough understanding of the changing requirements of growing children. Using a systematic approach organizing fluid therapy in maintenance, deficit and replacement with careful monitoring of the child's response, can make it manageable.

**Discussion:** Fluid and electrolytes required to replace daily losses and maintain an overall net balance of zero, are referred to as 'maintenance needs'. Historically daily water needs have been estimated based upon energy expenditure (Holliday-Segar: 1 kcal expended = 1 mL of fluid required). This method, preferred due to its ease of calculation, can be further simplified by estimating requirements in rate per hour ("4-2-1" method). Both methods however are based on assumptions in healthy children. Since most pediatric patients luckily have normal cardiac and renal function, they can cope for inherent errors by adjusting urinary output. Nevertheless these methods cannot account for the physiologic changes that occur in critically ill children which frequently have elevated fluid requirements due to their illness (fever, hypermetabolism, pain…) or therapy (e.g. ventilation), or disturbances in their physiologic responses (e.g. excess ADH secretion). Fluid and also electrolyte therapy must be adjusted based on these clinical circumstances.

Fluids lost prior to medical care are termed 'deficit'. This could be due to more chronic losses as in gastro-enteritis or DKA, or acute losses as in hypovolemia due to shock or trauma. Clinical signs usually correlate well with the degree of chronic dehydration, the most accurate one being the child's weight loss. Other signs are thirst, dry mucous membranes, sunken eyes and decreased urine output. Children with mild to moderate dehydration should be rehydrated orally even if diarrhea and vomiting continues. This could be done with commercially available oral rehydration solutions but also breastmilk. In severe dehydration it is important to distinguish between hypo-, iso- or hypernatremic dehydration since this influences the rate at which rehydration should be achieved. Following the child's weight is the simplest and most effective way to monitor fluid balance.

Although there are only minimal data to support it, aggressive fluid therapy remains the cornerstone in children with (septic) shock. Boluses (usually isotonic crystalloids) are used at a volume of 20 mL $kg^{-1}$ over 5–20 min or faster if needed, guided by clinical symptoms as prolonged capillary refill time, oliguria, metabolic acidosis or elevated arterial lactate. Recent reports question whether this strategy is ideal in resource limited areas. Early use of vasopressors whilst avoiding excessive fluid resuscitation might be a reasonable alternative approach.

Finally, 'replacement fluids' are defined as those given to meet ongoing losses, such as excessive vomiting or diarrhea, but also losses due to therapy such as CSF loss due to externalized shunts. Replacement fluids differ from deficit fluids in that they are ongoing.

**Take home messages:**

- Fluid needs are estimated in relation to energy expenditure that varies with weight
- No single solution provides maintenance water and electrolyte needs for all children
- Acute hypovolemia needs urgently correction with IV fluid bolus
- The choice and timing of rehydration therapy is dependent upon serum sodium.

**Conflict of interest**: none.

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## I008. Fluids in right heart failure


*Paul Elbers*

Department of Intensive Care Medicine, VU Medical Centre, Amsterdam, The Netherlands


**Learning objectives:** As right heart function can affect outcome in the critically ill patient, a thorough understanding of factors determining right heart performance in health and disease is pivotal for the critical care physician. This talk focuses on fluid therapy, which remains controversial in the setting of impending or overt right heart failure. Therefore, it is important to elucidate which patients are likely to benefit from fluid administration and for which patients fluid therapy would likely be harmful. Following a general discussion of right heart function and failure, we specifically focus on important causes of right heart failure in the critically ill, such as sepsis induced myocardial dysfunction, the acute respiratory distress syndrome, acute pulmonary embolism and the effects of positive pressure ventilation. In all cases, fluid therapy should always be cautiously administered with the right heart in mind, which calls for close multimodal monitoring.

## I009. Pros and cons of colloids in the operating room


*Robert G. Hahn*

Södertälje Hospital and Karolinska Institutet, Sweden


**Learning objectives:** Point out major differences in the kinetics of crystalloid and colloids, compare their adverse effects, and show how their behavior is affected by physiology.

**Background:** Colloid fluids are more effective plasma volume (PV) expanders than crystalloids and lack a distribution phase, which means that their effect is quite stable over time. Their half-life in plasma is 2-3 hours, which make them suitable for use during goal-directed fluid therapy. Their half-life may be affected by shedding of the endothelial glycocalyx layer, which is unlikely for crystalloids. By contrast, the kinetics of crystalloids is greatly affected by the arterial pressure, which does not seem to be the case for colloids.

Both crystalloids and colloids cause peripheral edema. The colloid edema develops slowly, cannot be adequately treated by diuretics, and is caused by capillary leakage of macromolecules that attract fluid to the interstitium. Crystalloids infused after a colloid are poorly excreted, and worsen the edema.

All colloid fluids have an allergic potential not shared by crystalloids. The incidence is about 1:500 and. Colloid fluids have a maximum dose, which is due to the risk of coagulopa-

thy due to dilution of the plasma proteins. Their potential to promote kidney injury in septic patients varies, but albumin is relatively safe.

**Discussion:** Colloid fluids should be considered when hemorrhage is large and the amount of crystalloid given may cause adverse effects (> 3–4 L) and erythrocyte transfusion has not yet come into play.

**Take home messages:**

- The allergic potential of colloids makes them unsuitable as first-line choice of resuscitation fluid in the operating room.
- Compared to crystalloids, the plasma volume expansion from of colloid fluids is greater and more stable over time, and their kinetics is less affected by physiology.
- Colloid fluid causes mild long-lasting edema and may promote kidney injury in septic patients.

**Conflict of interest:** none.

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## I010. The volume kinetic point of view

*Robert G. Hahn*

Södertälje Hospital and Karolinska Institutet, Sweden

**Learning objectives:** Explain how the effects of shedding of the endothelial glycocalyx layer on fluid kinetics can be studied in living human being. Show examples of results.

**Background:** Infusion fluids consist to nearly 100% of water, whereas the blood to 93% consists of water and hemoglobin. Therefore, hemodilution can be used as an index of the concentration of infusion fluid in the blood. This approach is used in volume kinetics, whereby data on the hemodilution over time is used to estimate the rates and distribution and elimination the infused fluid volumes. Moreover, population kinetic modeling can be used to study the influence of other parameters, such as the plasma concentrations of shedding products and cytokines, on these rate parameters. For shedding products, such as syndecan-1, the interesting covariance to explore is on $k_{12}$, which parameter governs the rate of fluid translocation from the plasma to the interstitial fluid space.

**Discussion:** Only unpublished studies on shedding and volume kinetics exist to date. One work from China included volume loading with Ringer´s lactate during surgery for inflammatory disease, i.e. appendicitis or cholecystitis (n = 40). Preliminary analysis did not disclose a higher value for *k*12 when the plasma concentration of syndecan-1 was on the high side. A study from Sweden comprised 15 volunteers and 15 postoperative patients (major abdominal surgery, about 4 hours) who received 3 mL $kg^{-1}$ of albumin 20% in the morning after the operation. No co-variance between shedding products and the fluid volume kinetics was found.

**Take home messages:**

- The distribution and elimination of infusion fluids can be calculated in living humans by using fluid volume kinetic analysis.
- So far, volume kinetic analysis have not been able to support that higher concentrations of shedding products are associated with faster distribution of Ringer´s lactate, or with altered kinetics of albumin 20%.
- No data exists of volume kinetics during states with very severe shedding.

**Conflict of interest:** none.

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## I011. Some gelatines are more equal than others

*Dirk G. Himpe*

Department of Anaesthesia, ZNA Middelheim, Antwerp, Belgium

**Learning objectives:** Introduced in 1915 gelatines stood the test of time and are still widely used, in spite of suspected toxicity [1]. According to Paracelsus poison is in everything, and the dosage makes it either a poison or a remedy. Hence, desirable effects by succinyl- and urea-cross-linked gelatines may occur on acid-base status, fluid balance and probably also on the glycocalix due, at least in part, to their albumin-like electrical charge, in contrast to other synthetic colloids. Therefore, even though large RCT's conducted in sepsis reached a dogmatic status of evidence at the moment, the non-inferiority of appropriately dosed gelatines has been corroborated in different settings and subgroups [2, 3].

**Background:** Because of implicit bias gelatine is considered the Cinderella among the synthetic colloids. Deprived from the good news on synthetic colloids at the time, distinctions from them (e.g. starches) are ignored when the bad news came and gelatines were tarred with the same brush. And, in spite of no evidence showing harm equal to what is seen with other colloids or beyond, it is suggested not to use gelatines anymore [4].

**Discussion:** Colloids in general may impair renal function and haemostasis. These are clearly dose-dependent phenomena not equally pronounced to the same extent and level for all (synthetic) colloids when doses increase. In vitro-induced coagulopathy by gelatine is significantly more reversible than by HES, with a balanced gelatine showing the best results [5]. As opposed to starch, both albumin and gelatine molecules carries net negative charges at physiological pH. Therefore, it can be hypothesized that the ability for interaction due to electrical charges offers clear benefits in specific situations such as cardio-pulmonary bypass [6]. However, not all beneficial effects can be attributed solely to electrical charges. Experiments with charged starch revealed complex interferences to exist between charges and the molecule's own nature, worsening coagulation effects by HES [7].

Furthermore, not all gelatines are equal either. While urea-linked gelatine has an equivalent molecular weight, the succinylated product is physically larger. This conformational change augment anionic charges attracting more ions, which increases osmotic power (Gibbs-Donnan effect). Poly-anionic colloids further participate as weak acids in the acid-base equilibrium as illustrated by the use of Stewart's quantitative approach [8]. This particular feature therewith facilitates the engineering of balanced carrier solutions by reducing the need of anions such as chloride to maintain electro-neutrality. It is also postulated that such charges preserve the glycocalix, representing an appealing mechanism to explain the observed protection by albumin in experimental studies [9]. Finally, effects of newer gelatines on kidney function are currently unclear but, if present, less pronounced than with starches [10]. One thing more: the potential for anaphylactic reactions is not equal for all gelatines [11]. In conclusion: since literature on gelatines is considered scarce and, according to some critics, studies are not well done, the GENIUS multicenter study was set up recently [12].

**Take home messages:**

- Like all colloids gelatines are also poisons to be administered by making trade-offs between benefit and harm, start and stop;
- Newer gelatines are electrically loaded: the higher the charge, the more pronounced their oncotic power and weak acid abilities in acid-base balancing;
- Contrary to gelatine, electrical charges on starch potentiates its detrimental effects on the coagulation;
- The allergic potential significantly differs between gelatine types;
- Effect of gelatine on kidney function is currently unclear: join the GENIUS study and give gelatine a chance!

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## I012. PK/PD in an era of multi-drug bacterial resistance: the example of colistin


*Patrick Honoré*

Department of Intensive Care Medicine, Universitair Ziekenhuis Brussel, Brussels, Belgium


**Learning objectives:** In multidrug resistant gram negative infections only suceptible to colistin, we are using high doses of colistin (as the MIC is high) under "prophylactic" continuous renal replacement therapy (CRRT). What is the concept of "Prophylactic CRRT" ? What are the elimination mechanisms of colistin during CRRT ? Which doses of colistin should we use during CRRT in order to be above the MIC.

**Background:** Colistin is a last-line antibiotic for treatment of multidrug-resistant Gram-negative bacterial infections in ICU patients. Colistin is generated from the inactive prodrug colistimethate sodium (CMS). Colistin at a loading dose of 9 MIU, followed by a maintenance dose of 13 to 15 MIU daily, is recommended to ensure adequate and safe treatment during CRRT.

**Discussion:** We performed Prospective an observational cohort study in adult intensive care unit (ICU) patients. Colistin treatment CMS (Colistineb™) 9 MIU loading dose, followed by 3 × 4.5 MIU daily. During continuous veno-venous hemofiltration (CVVH), CMS is eliminated by convection whereas colistin removal is determined by the adsorptive capacity of the dialysis membrane. We assessed safety, and clinical/microbiological efficacy of the recommended high-dose colistin treatment under "prophylactic" CVVH. *Study Design and Methods:* CVVH parameters: dose of 35 mL $kg^{-1}h^{-1}$, highly adsorptive AN69 ST membrane, 1.5 $m^{-2}$ surface area, regional citrate anticoagulation. Clinical and microbiological efficacy evaluated at end of the therapy. Serum creatinine evaluated before, at end of therapy, and at hospital discharge. *Outcome:* Favourable clinical response in 14 (88%) patients. Microbiological eradication: 10 complete,4 presumed, 2 no response. Seven (45%) patients survived. Serum creatinine (n = 6) at the predefined time points was 2.12 ± 1.52; 1.59 ± 0.96; and 0.91 ± 0.29 mg $dL^{-1}$, respectively. One patient required intermittent dialysis at ICU discharge.
**Take home messages:** In patients with multidrug-resistant Gram-negative infections, CVVH equipped with a highly adsorptive membrane represent a valuable option for safe and effective high-dose Colistin treatment.
Future studies could be designed: to compare evolution and outcome in patients with and without acute kidney injury treated with CVVH + high-dose Colistin and tto evaluate plasma Colistin levels obtained during CVVH + high-dose Colistin and relating them to outcome and toxicity. The doses of Colistin to be used during CVVH with adsorptive membranes (like AN69) should be a loading dose of 9 MIU, followed by a maintenance dose of 13 to 15 MIU daily. While using these doses with this CRRT protocol, no signs of colistin toxicity were observed.
**Conflict of interest:** none.

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## I013. De-resuscitation: dry enough? when to stop CVVH?

*Patrick Honoré*

Department of Intensive Care Medicine, Universitair Ziekenhuis Brussel, Brussels, Belgium

**Learning objectives:** Continuous veno-venous hemofiltration (CVVH) has been mostly consider in the process of resuscitation.We want to show that CVVH can be also a very powerful tool to eliminate Fluid Overload (FO). When to Stop CVVH and Avoid a too dry patient: Do we have good tools for assessing Fluid Overload ? Should we go for combined use of bioimpedance vector analysis (BIVA)and serum N-terminal pro-B-type natriuretic peptide (NT-proBNP) measurement to divide the patients in four groups regarding their fluid status. Should we use tricks to increase the effectiveness of CVVH regarding FO (Osmotic Tricks: Hypertonic Saline Solution (HSS) or Oncotic Tricks like concentrated 20% Albumin).
**Background:** Severe FO with an additional 10–15 kg of extravascular water is often present after a septic shock. De-Rescucitation with CVVH may be very effective but is probably not indicated in every patient.The level of De--Rescucitation has to be tapered to the patient 'condition'.
**Discussion:** In a recent study, Chen and co-workers did a combined approach with BIVA and NT-proBNP.They were able to classify their patients in four groups: NT-pro BNP which is produced by cardiomyocytes under stretching stress, reflects cardiac reaction to volume load and acts as a biomarker for diagnosis of heart failure . However,serum NT-pro BNP does not reflect tissue hydration status.Therefore, the differentiation of 'wet BNP' (induced by acute pressure or volume overload) from 'dry BNP'(baseline, euvolemic) has been suggested to improve assessment of fluid status in clinical practice.
Type 1: normal status, neither overhydration nor elevation of NT-pro BNP.
Type 2: no overhydration with abnormal NT-pro BNP levels.
Type 3: overhydration with normal NT-pro BNP levels.
Type 4: overhydration with abnormal NT-pro BNP levels.
This classification does allow the clinician to perform the best applied therapy to a single patient. For instance, in type 3 fluid status (manifested as normal NT-pro BNP and abnormal BIVA). These parameters may reflect fluid accumulation, but only in extravascular spaces, as usually observed in burn

and septic shock patients with capillary leakage syndrome caused by a systemic inflammatory response or a fluid shift caused by hypoalbuminemia. Under this condition, removal of excess fluid through CVVH should be performed only along with infusion of adequate colloids to shift fluid into vascular spaces. Also in type 2 fluid status (manifested as normal BIVA and abnormal NT-proBNP) may imply cardiac dysfunction but no fluid overload per se. In this situation, proper ultrafiltration by CVVH is essential to alleviate cardiac dysfunction, although over ultrafiltration should be avoided to prevent volume depletion and increased related mortality. It is expected that patients with late hemoconcentration would be type 4 fluid status, necessitating removal of fluid to improve related outcome, but that patients with early concentration likely have type 3 fluid status and thus, removal of fluid may result in volume depletion without any benefit to outcome. Therefore, water removal via CVVH ultrafiltration should be considerably aggressive only in patients with type 4 fluid status. Indeed for patients with type 4 fluid status before CVVH,and after CVVH intervention, improvement of either BIVA or NT-proBNP versus no improvement should confer lower mortality. In type 3 and type 4, concomitant use of albumin 20% and or HSS 3 or 6% may increase the removal of excess FO while avoiding hypovolemia. In any case, close monitoring of lactate combined with echocardiography and Pulse index Continuous Cardiac Output (PiCCO) to check on a regular basis, fluid removal responsiveness.

**Take home messages:**

- It is of major importance to classify these patients in order to know which therapy should be applied to an individual patient.
- The use of BIVA and NT-proBNP may allow to differentiate 4 types of patients under CVVH.
- Type 3 fluid status (manifested as normal NT-pro BNP and abnormal BIVA) and type 4 fluid status (overhydration with abnormal NT-pro BNP levels) will be the type of FO that would benefit most from CVVH in combination with albumin 20% and or HSS 3 or 6%.
- Monitoring of BIVA and NT-proBNP will tell us which of the patients would benefit the most of the therapy according to their fluid type (1 to 4).
- In any case, close monitoring of lactate combined with echocardiography and PiCCO to check on a regular basis, fluid removal responsiveness in order to avoid hypovolemia and related increased mortality.
- Future studies are currently designed to evaluate the respective value of albumin 20% versus HSS 3 or 6% in the context of De-Rescucitation while using CVVH.

**Conflict of interest:** none.

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## I014. Putting it all together: educational perspectives in point of care ultrasound


*Aidan Kingwill*

Senior clinical fellow, Point of Care Ultrasound, Adult Intensive Care, Oxford University Hospitals NHS Foundation Trust, Oxford, United Kingdom

aidan.kingwill@ouh.nhs.uk


**Learning objectives:** Understand current practices in POCUS education**.** Explore current challenges to POCUS accreditation. Future concepts which may enhance access to skills development

**Background:** Point of care ultrasound (POCUS) is seen by many as a natural progression of the clinical examination and is popular across many disciplines [1]. Although not conclusively proven, the benefit of employing POCUS in routine clinical practice seems intuitive. There is growing enthusiasm from around the world to include POCUS education modules at an undergraduate level [2] and this should speak of the premium which is currently placed on the ability to perform POCUS investigations. Lack of standardisation of educational endpoints remains an area of critique and obstacles to obtaining skills is an important deterrent for eager trainees.

**Discussion:** The Royal College of Radiologists in the United Kingdom has published comprehensive guidelines outlining their suggestions for ultrasound training of medical and surgical colleagues [3]. This has proven a useful document and should re-emphasise the importance of placing a ceiling on the capabilities of POCUS practitioners within a framework based on minimum skills acquired. POCUS investigations, by implication, require the lowest level of expertise according to these guidelines and should never aim to replace specialist ultrasound investigations [4]. This

document also outlines a suggested training pathway which combines the following elements: theoretical knowledge, practical training and revalidation. POCUS models around the world generally follow these principles with variance in terms of emphasis between these three elements [1]. There is currently no convincing evidence to guide a standardised approach to teaching. POCUS training is relatively well established within the post graduate medical training remit and emergency department colleagues led the way in this [5]. POCUS remains a useful tool and there is evidence to suggest that trainees still regard this as a vital skill to acquire. Increasingly, there is a drive to include POCUS training as part of the core skill set for disciplines such as intensive care and anaesthesia. The Core Ultrasound Skills in Intensive Care (CUSIC) program is the UK Intensive Care Society's answer to this cry and serves as a generic example of a postgraduate POCUS training program. Clear evidence explaining the requirements of such training platforms is lacking and the training requirements are largely based on expert opinion. Growing support for undergraduate POCUS training can no longer be ignored [2].

**Take home message:** Finally — we must ask ourselves whether the current educational paradigm around POCUS scanning could be prohibitive at all. Anecdotal reports from the UK suggest that there are a number of post graduate trainees who see the value in a POCUS skill set but are unable to train in this modality due to a program which appears difficult to access for them from the outset.

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## I015. Less is more: what is the best frequency of routine investigations?


*Ruth Kleinpell*

Phd, RN, FCCM, President of SCCM


**Learning objectives:** To discuss strategies for reducing unnecessary testing in critical care.

**Background:** Over-utilization of tests, treatments, and procedures is an important example of low value care that adds to the high cost of healthcare, and provides little to no benefit for patients. Although diagnostic testing, treatments and procedures may advance the time of diagnoses in selected critical care patients, they can increase the frequency of over-diagnosis and overtreatment in others. To combat this problem, the American Board of Internal Medicine Foundation developed the *Choosing Wisely®* campaign, tasking professional societies to develop lists of the top five medical services that should be questioned. The Critical Care Societies Collaborative (CCSC), which is comprised of the four major U.S. professional and scientific societies, participated by five critical care recommendations. They focused on not ordering diagnostic tests at regular intervals; limiting red blood cell transfusions in hemodynamically stable, non-bleeding patients with a hemoglobin greater than 7 mg $dL^{-1}$; not using parenteral nutrition in adequately nourished critically ill patients; not deeply sedating mechanically ventilated patients without a specific indication; and not continuing life support for patients at high risk for death. In order to assess critical care clinicians' awareness and use of the recommendations, a national survey was conducted with members of the CCSC.

**Discussion:** The survey was launched in November, 2016 with responses received through June, 2017. A total of 2,520 responses were received, Respondents familiar with the *Choosing Wisely®* recommendations (n = 1,273; 50.6%) reported varying degrees of implementation of the five CCSC recommendations at their organization. Some respondents identified that a specific quality improvement initiative was developed related to the recommendations (n = 468, 41.7%), or that a research initiative had been conducted (n = 156, 13.9%). Respondents identify variability in the degree to which clinicians adhere to the *Choosing Wisely®* recommendations with some reporting that only several or none of the recommendations have been implemented at their organizations.

**Take home messages:** The results of the survey identify the application of the *Choosing Wisely®* recommendations to clinical practice for critical care clinicians. Respondents identified a number of ways that the *Choosing Wisely®* recommendations have been integrated and care changes made. However, variability in the degree to which the recommendations are being applied was reported. Additional dissemination of strategies to reduce unnecessary testing in the ICU is needed.

## I016. Future ICU

*Erik Koomen*

Pediatric Intensive Care, Wilhelmina Children's Hospital, Utrecht, the Netherlands

**Learning objectives:** This lecture addresses the understanding of the needs to create the ICU of the Future with optimized use of data (Big Data).

**Background:** International recommendations and demands of our patients envision the future intensive care (ICU) to have single bed-space units with privacy and a healing environment for the patient. ICU care is getting more technical with monitoring, ventilation, dialysis, ECMO etc. This increase in technology comes at the cost of more and more data and more and more alarms for nurses and physicians. Information overload and alarm fatigue have become a serious threat to patient safety at our ICUs. In this presentation, I will address these problems and advocate a change in our thinking to solve them: risk analyses at an ICU should not stop at the technical safety of a device, but need to assess the entire chain of risks that might affect patient safety. This chain of risks consists of all possible negative effects of monitoring data and alarms on the work processes of an ICU, including the medical decisions and actions that are based on the information of the devices. This major change from solely technical safety of a device to clinical safety of the integration of data, information, decisions and actions requires clinicians, vendors and regulatory bodies to address such risk assessments together. A practical example of the ICU problem: in our adult ICU (30 single bed-space units) monitors are connected to a medical alarm system with pagers, from which the nurses receive 150,000 alarms per month — from the patient monitors, not including ventilators or infusion pumps. A practical example of a pediatric ward: At our pediatric oncology ward we tested the delays between patient monitors, connected to the medical alarm system (pager), and infusion pumps, not connected to the pager, and we found monitor alarms are addressed within 20 seconds, but infusion pump alarms are addressed in 3-4 minutes with a very flat patron.

**Discussion:** When the appropriately integrated and filtered patient information is delivered to the healthcare professional and its safety can be guaranteed, we can meet the demands of our patients: privacy and a quiet healing environment without compromising the clinical patient safety.

**Take home message:** To get to the Future ICU we need to understand:

- How nurses and physicians use information from devices in their decision making and actions.
- How we can provide nurses and physicians with the applied knowledge to understand the data measured from the patient correctly and more efficiently.
- How vendors can deliver their products and devices so that their vast knowledge of their product can be used to transform the enormous stream of data into information that can be shared to an IT platform.
- How such an IT platform can communicate the combined information and applied knowledge from vendors and their devices to healthcare professionals and to other vendors for further information integration and filtering.
- How mobile devices can help to make this information available.

**Conflict of interest:** The author is presenting in a sponsored meeting and is actively working to the Future ICU with a co-created consortium of B Braun, Getinge and Philips.

## I017. Do we need different monitoring tools in children?

*Joris Lemson*

Intensive Care Department, Radboud Medical Centre, Nijmegen, The Netherlands

**Learning objectives:** To gain insight into differences between adults and children with regard to fluid loading and hemodynamic monitoring.

**Background:** Like in adult ICU patients also critically ill children have a delicate balance between hypovolemia and hypervolemia. Unfortunately, is has been shown that fluid overload in children is a common phenomenon that might lead to prolonged ICU stay and even death. Unlike adults predicting fluid responsiveness in children is more difficult since well-known predicting parameters are less reliable. Even more, hemodynamic monitoring in children has many technical issues and can be cumbersome. Besides that, the pediatric market is not of commercial interest to all manufacturers.

**Discussion:** Since fluid therapy is still one of the cornerstones of PICU treatment there is a need for reliable cardiac output monitoring technologies. Moreover, like in the adult world, a different monitor that would actually provide information concerning not only fluid need but specifically oxygen consumption by various tissues is most wanted.

**Take home message:** Children are not small adults with regard to hemodynamic monitoring. We may need different tools.

## I018. The sesame-protocol

*Daniel A. Lichtenstein*

Medical ICU, Hospital Ambroise Paré, Boulogne (Paris-West university), France

**Learning objectives:** To show how a simple, holistic ultrasound system can help in the fast diagnosis of the cause of a cardiac arrest.

**Background:** The target is to find reversible causes as soon as possible. Ultrasound is a visual medicine, valuable if absolute simplicity is used, in this case where every second counts.

**Discussion of the SESAME-protocol:** This is a standardized approach using logic [1]. Shockable causes apart, and in a patient with a ventilation (mask, endotracheal tube...), a pneumothorax is first sought for, this is the Grade-1. If absent, Grade-2 looks for the lower femoral vein, which is found to be thrombosed in half cases of massive pulmonary embolism. If no thrombosis is found, the diagnosis is not excluded and the heart should be assessed. While going toward the heart, the probe stops at the abdomen for intra-peritoneal or intra-digestive massive fluids search, diagnosing hypovolemic arrest (Grade-3). If negative, and before assessing the heart, the pericardium is assessed (Grade-4). A pericardial effusion in a cardiac arrest is immediately withdrawn. If no pericardial effusion is found, the focus is done at the heart, hoping for an available cardiac window. Reversible causes are rarely found at this step (Grade-5). A right ventricle enlargment, if seen early, of interest if no DVT was found on Grade-2, favors the diagnosis of pulmonary embolism.

**Take home messages:** The most important for achieving this ultrafast protocol is a machine that is narrow (not especially laptop — ours 32-cm width), starts on rapidly (ours, 7 seconds), is simple (no button is touched during the first four steps, the settings being defined on ignition by default), has a unique, microconvex probe able to scan from 0,5 to 17 cm and to see a needle, i.e., to detect, and treat in the same step, pericardial effusions.

**Conflict of interest:** none.

**Reference:**

1. Lichtenstein D, Malbrain ML. Critical care ultrasound in cardiac arrest. Technological requirements for performing the SESAME-protocol--a holistic approach. Anaesthesiol Intensive Ther. 2015; 47(5): 471–481, doi: 10.5603/AIT.a2015.0072, indexed in Pubmed: 26578398.

## I019. Lung ultrasound in the critically ill (LUCI)

*Daniel A. Lichtenstein*

Medical ICU, Hospital Ambroise Paré, Boulogne (Paris-West university), France

**Learning objectives:** To present the suitable equipment, basic signs, and main applications of LUCI.

**Background:** LUCI is at best achieved using simple equipments. Regarding the equipment, see abstract on SESAME--protocol. The BLUE-points (three per lung) show the usual locations of the main disorders.

**Discussion of the Signs and applications:** The ten basic signs are the pleural line (bat sign), lung sliding (twinkling of the Merlin's space), the A-line (repetition of pleural line), pleural effusion (quad sign and sinusoid sign, regardless effusion tonality), lung consolidation (fractal sign if non translobar, lung sign if translobar), lung rockets (more than 2 B-lines per intercostal space), abolished lung sliding (with stratosphere sign) of pneumothorax among other causes, and lung point, ruling in pneumothorax. The applications are countless. Let us cite the BLUE-protocol, a fast protocol devoted to diagnose the cause of an acute respiratory failure among the usual causes, hemodynamic pulmonary edema, pneumonia, pulmonary embolism, COPD or asthma and pneumothorax [1]. Eight profiles associating signs and locations allow for an overall accuracy > 90%. In shock, the FALLS-protocol is proposed, after discounting of obstructive shock (pericardial tamponade, right ventricle dilatation suggestive of pulmonary embolism, pneumothorax) then cardiogenic shock (B-profile on lung ultrasound), for administrating fluids to the sole remaining diagnoses, hypovolemic and distributive shock). SESAME-protocol: read devoted abstract.

**Take home message:** The signs and applications of LUCI can be applied in the critically ill as well as more scheduled settings (nephrology, family medicine...), in skinny or bariatric patients, from neonates to elderly patients, from sophisticated ICUs to austere areas, without major adaptation.

**Conflict of interest:** none.

**Reference:**

1. Lichtenstein DA, Mezière GA. Relevance of lung ultrasound in the diagnosis of acute respiratory failure: the BLUE protocol. Chest. 2008; 134(1): 117–125, doi: 10.1378/chest.07-2800, indexed in Pubmed: 18403664.

## I020. Monitoring in sepsis and ards, how can ultrasound help?

*Daniel A. Lichtenstein*

Medical ICU, Hospital Ambroise Paré, Boulogne (Paris-West university), France

**Learning objectives:** Promptly diagnosing early stage of sepsis, including ARDS. Using ultrasound approach for monitoring sepsis and circulatory status.

**Background:** ARDS, usually an infectious disease, creates the conditions for a septic shock, i.e., an extreme emergency. Any help must be considered, especially the visual approach allowed by ultrasound.

**Discussion:** Diagnostic use: sonography in early management of sepsis (SIEMOS) is part of the FALLS-protocol ("round-FALLS-protocol"), at the step where fluid is indicated, after ruling out obstructive and cardiogenic shock. The FALLS-protocol is a fast protocol for diagnosing a shock, and including a noninvasive diagnosis of sepsis site [1]. For lung sepsis, the BLUE-protocol is used, as it describes four profiles typical of pneumonia (that is, most ARDS): the B'-profile, C-profile, A/B-profile, AVPLAPS-profile. The distribution and dynamics of B-lines allows for distinguishing, usually, ARDS from hemodynamic pulmonary edema. For abdominal sepsis, the FALLS-protocol uses from classical (liver abscesses etc, gallbladder or kidney sepsis) to more modern (diagnosis of GI tract sepsis, detection and safe puncture if needed of peritoneal purulent fluid, diagnosis of pneumoperitoneum). Therapeutic use: ultrasound allows monitoring of respiratory condition (e.g., by looking at the volume of lung consolidations during lung recruitment maneuvers or postural changes). For the circulatory status, usual tools (standard echocardiography) can be used. More modern options (simplified emergency cardiac sonography combined with lung ultrasound) can be associated: the FALLS-protocol. In the very early stage of sepstic shock, the FALLS-protocol has usually given the adequate fluid volume. During the later steps in the ICU, the FALLS-protocol must be combined with the usual tools used by the team for defining daily needs of fluids of this known septic shock.

**Take home message:** Critical holistic ultrasound must be considered as a tool allowing fast diagnosis of a sepsis site, but also a tool able to help in the hemodynamic assessment.

**Conflict of interest:** none.

**Reference:**

1. Lichtenstein D. The FALLS-protocol (2016). In: Lichtenstein D. ed. Lung ultrasound in the critically ill — the BLUE-protocol. Springer-Verlag, Berlin 2016: Berlin.

## I021. Assessing the right ventricle

*Yazine Mahjoub, M.D., Ph.D*

Intensive care Unit, Amiens-Picardy University Medical Center, France

**Learning objectives:** To fully understand right ventricular shape and anatomy. To understand interactions between right and left ventricle**.** To learn how to evaluate right ventricular function at the bedside using Doppler echocardiography.

**Background:** Evaluation of right ventricular function is of utmost importance in ICU as several clinical situations leads to RV dysfunction (pulmonary embolism, pericardial disease, post cardiac surgery, ARDS, myocardial infarction). Doppler echocardiography allows a comprehensive evaluation of the right ventricle. The aim of this presentation is to explain how to evaluate right ventricular function at the bedside in ICU.

**Discussion:** Right ventricular shape is complex and very different from the left ventricle'. The right ventricle has a truncated pyramid shape. Right and left ventricle interdependence is due to shared superficial myocardial fibers, septum and pericardium. RV can dilate easily under abnormal conditions but cannot easily adapt to acute increase in afterload. To the contrary to the left ventricle, ejection fraction is not appropriate for RV function evaluation.

For right heart evaluation by transthoracic echocardiography, selected views are necessary: parasternal long and short axis view, apical four chamber view and subcostal view. Acute core pulmonale is defined by an increased RV to LV end diastolic area ratio (more than 0.6) associated with an abnormal septum motion called "paradoxical septum". Time motion (TM) and Doppler tissue imaging(DTI) allow evaluation of the systolic function of the RV by analysis of its free wall. It has been shown in several studies that peak systolic velocity of the tricuspid annulus (S' wave) is an accurate parameter of RV systolic function. An S' value of 15.5 (± 2.6) cm $s^{-1}$ is considered as normal. RV myocardial performance index is a global index of RV function

Evaluation of the right ventricle function also needs the evaluation of the pulmonary artery pressure. Pulmonary artery systolic pressure is easily measured in the apical 4 chamber view by tricuspid regurgitation evaluation. Pulmonary acceleration time is a good predictor of increased pulmonary vascular resistances.

**Take home messages:**

- Epicardium is of utmost importance in RV-LV interaction.
- RV ejection fraction is not appropriate to evaluate RV function in ICU.
- Comprehensive analysis of right ventricular function needs.

- Measurement of RV to LV end diastolic area in the apical four chambers view.
- Evaluation of septal motion in parasternal short and/or long axis view.
- Evaluation of pulmonary hypertension.
- Evaluation of S' wave by DTI.

**Conflict of interest:** none.

## I022. Workshop on antibiotic stewardship

*Manu L.N.G. Malbrain*

ICU Director, University Hospital Brussels (UZB), Jette, Belgium
Faculty of Medicine and Pharmacy, Vrije Universiteit Brussel (VUB), Brussels, Belgium

**Learning** objective: This workshop will outline the basic pharmacokinetic and pharmacodynamic principles that underlie the need for individualized and personalized drug dosing.

**Background:** Antibiotics save lives and are essential for the practice of intensive care medicine. Adequate antibiotic treatment is closely related to outcome. However this is challenging in the critically ill, as their pharmacokinetic profile is markedly altered. Therefore, it is surprising that critical care physicians continue to rely on standard dosing regimens for every patient, regardless of the actual clinical situation. At present, therapeutic drug monitoring may be of help, but has major disadvantages, remains unavailable for most antibiotics and has produced mixed results. Antibiotic dosing regimens are usually based on data from healthy volunteers with normal physiology or non-critically ill patients. However, in critically ill hospitalized patients, pathophysiological changes may have profound effects on the primary determinants of the pharmacokinetics (PK) of hydrophilic antibiotics which are distributed to interstitial fluid and that are predominantly excreted via the kidneys (like β-lactams, aminoglycosides, glycopeptides). Extravascular volume expansion with fluid loading in the setting of capillary leak (poor source control) may alter their volume of distribution (Vd), while changes in renal function can significantly influence drug clearance (Cl). The β-lactams are the most commonly prescribed antibiotics in the critically ill. Since bacterial killing is considered time-dependent, the pharmacodynamic (PD) parameter of interest is the fraction of time that the free drug concentration exceeds a minimum inhibitory concentration (MIC tested *in vitro*) of the causative microorganism — the fT > MIC.

**References:**

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## I023. The role of social media and foam in critical care education

*Manu L.N.G. Malbrain*

ICU Director, University Hospital Brussels (UZB), Jette, Belgium
Faculty of Medicine and Pharmacy, Vrije Universiteit Brussel (VUB), Brussels, Belgium

**Learning objectives:** To learn about the different types of social media. To describe the anatomy of a Tweet. To explain the FOAM movement (Free Open Access Medical education). To define SMICC and SMACC (social media in and critical care). To understand whether or not social media can replace peer review. To describe the symplur healthcare hashtag project and the IFAD case study. To describe possible dangers.

**Background:** FOAM is a collection of resources, a community and an ethos. The FOAM community spontaneously emerged from the collection of constantly evolving, collaborative and interactive open access medical education resources being distributed on the web with one objective — to make the world a better place [1]. FOAM is independent of platform or media — FOAM is a personalised continuously expanding database of resources for medical education: it includes blogs, podcasts, tweets, Google hangouts, online videos, text documents, photographs, facebook groups, and a whole lot more [2].

**Discussion:** Traditional media are organized by few sources for many receivers. The quality is mediated by publishers and training is required. It is expensive to publish and access is limited. Publication process takes time and the publication is permanent once published. Social Media (SoMe) on the other hand has many sources (eg SMICC and SMACC) for many receivers. Quality is mediated by participants and there is no training. It is cheap or free to publish with unlimited accessibility. Publication is immediate and SoMe are flexible even after publication. By sharing our specific competencies, protocols and experiences we can shift to a new online learning paradigm that will carry medical education via internet 2.0 to a new era. Peer review seems to be broken as half-million papers published per year (> 1 per minute). The question therefore arises whether FOAM could possibly replace peer review? The answer is maybe: FOAM ignores traditional hierarchy, it is free and has equitable access 24/7, it crosses professional boundaries, it is multi-national, transparent, robust and finally FOAM is apolitical. Recently because of the increase in and awareness surrounding FOAM

a social media index (SMI) has been suggested [3] while others suggested the so-called Kardashian index (KI) [4]. The SMI enables to assess the impact and quality of FOAM resources, and enables educators to receive scholarly credit and learners to identify respected resources. The KI a measure of discrepancy between a scientist's social media profile and publication record based on the direct comparison of numbers of citations and Twitter followers. Possible dangers of FOAM are related to the reliability and correctness of the information provided. Recently a quality label for medical websites has been launched (the so called HONcode by the Health on the Net foundation https://www.healthonnet.org/HONcode/Conduct.html). Another danger related to SoMe and FOAM is reductive education: First we read the textbook, then we just read the chapter, then just the paper, then just the abstract and now we just read the Tweet…

**Take home messages:**

- FOAM stand for Free Open Access Medical education.
- The FOAM movement is steadily increasing and replacing traditional media and traditional sources for medical knowledge dissemination.
- In the future FOAM has a possibility to replace peer review.
- The SMI and KI have been developed to quantify SoMe scientific output.
- Quality of FOAM content needs to be validated.
- Reductive education and fake news are potential dangers.

**Conflict of interest:** none.

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## I024. Introduction to the international fluid academy and the 4 phases, 4 d's and 4 questions in relation to fluid management


*Manu L.N.G. Malbrain*

ICU Director, University Hospital Brussels (UZB), Jette, Belgium
Faculty of Medicine and Pharmacy, Vrije Universiteit Brussel (VUB), Brussels, Belgium


**Learning objectives:** To understand the mission of the International Fluid Academy (iFA), as part of iMERiT (International Medical Education and Research Initiative). To describe the International Fluid Academy Days (iFAD) and the available member resources on the fluidacademy.org website within the FOAM (Free Open Access Medical education) philosophy. To describe the 4 phases of fluid management. To describe the 4 D's of fluid therapy and the analogy to antibiotic therapy. To describe the 4 questions that need to be answered during fluid management.

**Background:** The iFA started as local initiative from the pharmaceutical working group on fluids from the Ziekenhuis Netwerk Antwerpen (www.zna.be). Today iFA and iFAD are integrated within the not-for-profit charitable organization iMERiT, International Medical Education and Research Initiative, under Belgian law. The mission of the iFA is to foster education and promote research on fluid management and monitoring in critically ill patients, and thereby improve the survival of critically ill patients by bringing together physicians, nurses, and others from a variety of clinical disciplines. The primary goal of the iFA is to establish an international collaboration group with the final aim to improve and standardize care and outcome of critically ill patients with an emphasis on fluids, fluid management, monitoring and organ support. The iFA is proud to announce that the fluidacademy.org website is now an official SMACC-affiliated site (Social Media and Critical Care) adhering to the FOAM (Free Open Access Medical education) principles. Recently the first scientific papers endorsed by an unrestricted iFA--educational grant have been published under the FOAM label [1–3]. The impact of these publications in the scientific community has been significant as shown by their Altmetric scores (Table 1).

**Discussion:** The application of what we already know will have a bigger impact than any drug or fluid or technology likely to be introduced in the next decade. Therefore we should consider and treat fluids as drugs and take into account the 4 D's of fluid therapy [4, 5]. Fluids are drugs. There are different types of fluids (crystalloids vs. colloids, synthetic vs. blood derived, balanced vs. unbalanced, intravenous vs. oral administration). Each fluid comes with its indications, contraindications and possible adverse effects. Possible

**Table 1.** Social and scientific impact of iFA-endorsed publications

| | Wise *et al.* [2] | Reintam Blaser *et al.* [1] | Van Regenmortel *et al.* [3] |
|---|---|---|---|
| Publication date | 5/01/17 | 6/02/17 | 20/05/17 |
| DOI | http://link.springer.com/article/10.1007/s00268-016-3865-7 | http://link.springer.com/article/10.1007/s00134-016-4665-0 | https://doi.org/10.1093/bja/aex118 |
| Shares | 254 | 258 | 20 |
| Blogs | 1 | | |
| Tweeters | 166 | 181 | 88 |
| Facebook | 8 | 15 | 20 |
| Google+ | 2 | | |
| Mendely | 41 | 141 | 8 |
| Downloads | 17,000 | 29,000 | 1321 |
| Citations | 1 | 10 | 0 |
| Altmetric score | 125 | 96 | 58 |
| All research outputs | #69,926 of 8,648,028 outputs | #68,288 of 8,648,028 outputs | #174,542 of 8,642,273 outputs |
| Outputs from WJS | #10 of 1,773 outputs | #7 of 2,194 outputs | #20 of 2,645 outputs |
| Outputs of similar age | #5,009 of 291,379 outputs | #5,068 of 293,379 outputs | #10,896 of 251,585 outputs |
| Outputs similar age WJS | #1 of 58 outputs | #3 of 119 outputs | #2 of 70 outputs |
| Top Ranking | 5% | 5% | 5% |

indications are fluids for resuscitation, maintenance or replacement. Fluid therapy needs to be appropriate and in some cases combination therapy is needed. It is all about giving the right fluid for the right patient at the right time. The dose of fluids is important. As Paracelsus nicely stated already back in 16$^{th}$ century: "All things are poison, and nothing is without poison; only the dose permits something not to be poisonous". This also refers to the pharmacodynamics and kinetics of fluids within the body. The response to IV fluids needs to be assessed by means of hemodyanmic monitoring and dynamic tests (like passive leg raising, pulse pressure variation,…). Appropriate duration is important. Fluid administration needs to be tailored to response and stopped when no longer needed. Finally de-escalation needs to be considered. This follows the principles of the ROSE concept and the 4 phases of fluid management [6]. The 4 basic questions that need to be answered are when to start and stop fluid administration and when to start and stop fluid removal?

**Take home messages:**

- The mission of the iFA is to foster education and promote research on fluid management and monitoring in critically ill patients, and thereby improve the survival of critically ill patients by bringing together physicians, nurses, and others from a variety of clinical disciplines.
- The iFA and iFAD are part of iMERiT (a not-for-profit charitable organization under Belgian law).
- The iFA website is now an official SMACC affiliated website adhering to the FOAM principles (Free Open Access Medical eduction).
- Each ICU clinician should be aware of the 4 phases of fluid management within the ROSE concept.
- Each ICU physician should be aware of the 4 D's of fluid therapy in analogy to antibiotic therapy: Drug — Dose — Duration — De-escalation.
- Each ICU physician needs to answer 4 questions in relation to fluid management: When to start fluids? — When to stop fluids? — When to start fluid removal? — When to stop fluid removal?

**Conflict of interest:** The author declares a possible conflict of interest in relation to the content of this abstract and presentation as he is member of the medical advisory board of Pulsion Medical Systems (now part of Maquet Getinge group).

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## I025. The importance of extravascular lung water in the ards definition

*Manu L.N.G. Malbrain*

ICU Director, University Hospital Brussels (UZB), Jette, Belgium
Faculty of Medicine and Pharmacy, Vrije Universiteit Brussel (VUB), Brussels, Belgium

**Learning objectives:** To list the old American-European consensus definitions on ARDS (acute respiratory distress syndrome). To present the "new" Berlin ARDS definitions. To understand where the old and new definitions differ from each other. To explain why the new definitions are suboptimal. To explain how to measure EVLWI (extravascular lung water index) and PVPI (pulmonary vascular permeability index). To expand on the importance of EVLW in future ARDS definitions.

**Background:** The first acute respiratory distress consensus definitions date from 1998. The North American European Consensus Conference was held in 1994 and defined ARDS as acute respiratory failure with: Acute onset, bilateral chest infiltrates on radiograph, a $PaO_2/FiO_2$ below 200 (ALI < 300 vs. ARDS < 200) and absence of congestive heart failure as evidenced by a wedge pressure below 18 mm Hg [1]. Recently in Berlin a new ARDS definitions was suggested [2] and a consensus of 16 was published with an update on respiratory monitoring [3]. The new Berlin Definition, focused on feasibility, reliability, validity, and objective evaluation of its performance. The new definition proposed 3 mutually exclusive categories of ARDS based on degree of hypoxemia: mild (200 mm Hg < $PaO_2/FiO_2$ ≤ 300 mm Hg), moderate (100 mm Hg < $PaO_2/FiO_2$ ≤ 200 mm Hg), and severe ($PaO_2/FiO_2$ ≤ 100 mm Hg) and 4 ancillary variables for severe ARDS: radiographic severity, respiratory system compliance (≤ 40 mL cm $H_2O^{-1}$), positive end-expiratory pressure (≥ 10 cm $H_2O$), and corrected expired volume per minute (≥ 10 L $min^{-1}$). This blog summarizes our previous comments and a call for a new and simple definition for ARDS [4]. The Berlin definitions are summarized in Table 1.

**Discussion:** A new and simple definition for acute lung injury. A recent study by LeTourneau et al. adds another brick to the growing wall of studies supporting the clinical usefulness of extravascular lung water (EVLW) measurements by transpulmonary thermodilution (TPTD) [5]. Previous studies have demonstrated that TPTD provides a clinically acceptable estimation of EVLW as compared to thermo-dye dilution [6], quantitative CT scan [7] and gravimetry [8, 9], is able to detect small changes in EVLW content [10], and is useful to assess the efficacy of therapy [11, 12]. Previous studies also showed that EVLW is also a prognostic marker in patients with acute lung injury (ALI) and acute respiratory distress syndrome (ARDS), actually a better prognostic marker of mortality than dead-space fraction [13]. In the present issue the same group suggests that EVLW is an early marker of ALI, EVLW increasing in average 2.6 days before the appearance of ALI criteria, as currently defined by the American and European Consensus Conference. The consequences of an early detection of ALI remain to be established but one can easily imagine that it would affect the way patients are treated, for instance the amount of fluid they receive, and ultimately the duration of mechanical ventilation and ICU length of stay. Further studies are of course needed to confirm this hypothesis. Interestingly, in light of their findings, LeTourneau *et al.* [5] also suggest to revisit the current definition of ALI/ARDS. The limitations of the current definition: The current definition of ALI/ARDS is based on the association of bilateral pulmonary infiltrates on chest radiography, a $PaO_2/FiO_2$ ratio below 300/200 mm Hg, and the lack of evidence for left ventricular dysfunction. This definition may indeed deserve to be revisited for the following reasons. First, chest radiography has several limitations in patients mechanically ventilated in supine position: movements of the chest wall, radiograph film placed posterior to the thorax, sub-optimal orientation of the radiograph

**Table 1.** The Berlin Definition of ARDS

| | Acute respiratory distress syndrome |
|---|---|
| Timing | Within 1 week of a known clinical insult or new or woresening respiratory symptoms |
| Chest imaging[a] | Bilateral opacities — not fully explained by effusions, lobar/lung collapse, or nodules |
| Origin of edema | Respiratory failure not fully explained by cardiac failure or fluid overload<br>Need objective assessment (eg, echocardiography) to exclude hydrostatic edema if no risk factor present |
| Oxygenation[b] | |
| Mild | 200 mm Hg < $PaO_2/FIO_2$ ≤ 300 mm Hg with PEEP or CPAP ≥ 5 cm $H_2O$[c] |
| Moderate | 100 mm Hg < $PaO_2/FIO_2$ ≤ 200 mm Hg with PEEP ≥ 5 cm $H_2O$[c] |
| Severe | $PaO_2/FIO_2$ ≤ 100 mm Hg with PEEP ≥ 5 cm $H_2O$[c] |

Abbreviations: CPAP, continuous positive airway pressure; $FIO_2$, fraction of inspired oxygen; $PaO_2$, partial pressure of arterial oxygen; PEEP, positive end-expiratory pressure
[a]Chest radiograph or computed tomography scan
[b]If altitude is higher than 1000 m, the correction factor should be calculated as follows: [$PaO_2/HO_2$ × (barometric pressure/760)]
[c]This may be delivered noninvasively in the mild acute respiratory distress syndrome group

beam, pleural effusion superimposed on lung opacities [14]. As a result, chest radiography lacks of sensitivity and specificity to detect pulmonary edema [15] and may be mistaken with pleural effusions, that are not necessarily related to increased EVLW [16]. Second, it is now well established [17] that the $PaO_2/FiO_2$ ratio depends on $FiO_2$, the relationship between the numerator and the denominator being non linear. As a result, decreasing $FiO_2$ decreases the $PaO_2/FiO_2$ ratio, which may wrongly suggest a worsening of lung inflammation. Moreover this ratio also depends on the level of positive end-expiratory pressure (PEEP) used. The current definition also does not take into account the differences that may exist between primary and secondary ALI/ARDS and the role of intra-abdominal pressure (IAP) [18–20]. Finally, as pointed out by LeTourneau *et al.* [5], the evidence for cardiac dysfunction does not imply causality: patients with chronic cardiac diseases have an abnormal cardiac function on echocardiography also when they develop lung injury. Therefore, the existence of a disease known to increase pulmonary vascular permeability seems more important than the lack of left ventricular dysfunction in order to accurately diagnose ALI/ARDS. Towards a new definition for ALI and ARDS: Although not a bedside technique, the CT scan is often performed in patients with acute respiratory failure and is dramatically useful to characterize the lung disease process (bilateral or not, patchy or posterior condensations), to quantify pleural effusion, as well as to assess lung recruitment induced by PEEP or other maneuvers. Therefore, the information provided by the CT scan — when performed — could be integrated to the definition of ALI/ARDS. As suggested by LeTourneau *et al.* [5], it may also be wise to use EVLW as a definition criteria. Although TPTD is useful to assess hemodynamic parameters [21] and detect right-to-left intracardiac shunts [22], it is not yet standard of care. The use of TPTD requires a central venous catheter for cold bolus injections (the thermal indicator) and a central (usually femoral) thermistor-tipped arterial catheter to record thermodilution curves. The use of femoral arterial catheters remains today an exception in the US. The reasons for that are unclear since complications are rare [23] and may not be more frequent than with radial catheters. Moreover, the femoral arterial pressure is well known to give a better estimate of central pressure, particularly in septic patients [24]. If most patients with severe ARDS are frequently instrumented with an arterial line and a central venous line, it is usually not the case at a early stage of lung inflammation. Therefore one may hardly impose EVLW as a mandatory criteria for defining ALI/ARDS. TPTD measurements also allow to calculate the pulmonary vascular permeability index (PVPI) which allows stratification into hydrostatic versus permeability lung edema [25]. A recent study showed that PVPI had the best predictive power for diagnosing ARDS [26]. However, when TPTD is used, we fully agree with LeTourneau *et al.* [5] that it would make sense to take into account EVLW measurements. As pointed out by others it may be equally important to differentiate primary (pulmonary) versus secondary (extrapulmonary) ALI/ARDS, the latter usually associated with increased IAP, as this may dramatically impact the respiratory mechanics and the way we should recruit and set PEEP [20, 27, 28]. Finally, as already suggested by others [17] it might also be wise to integrate $FiO_2$ in the definition. For instance one may propose to replace the $PaO_2/FiO_2$ ratio < 300 by the need to use a $FiO_2 > 40\%$ to maintain a $SaO_2 > 95\%$ and the $PaO_2/FiO_2$ ratio < 200 by the need to use a $FiO_2 > 60\%$. Although this suggestion has also limitations since a patient may be on 70% $FiO_2$ but he/she may not need it (eg underlying COPD) — we still have to look at P/F ratios at that time — so the combination between $FiO_2$ and P/F ratio makes sense in specific cases. A recent study suggests that adding PEEP to the definition would not help [29].

**Table 2.** A new definition for Acute Lung Injury & ARDS

| |
|---|
| A PULMONARY disease process known to increase pulmonary vascular permeability (normal IAP) |
| a) Viral or bacterial pneumonia |
| b) Gastric or smoke inhalation |
| c) Other |
| An EXTRAPULMONARY disease process known to increase pulmonary vascular permeability (increased IAP > 12 mm Hg) |
| a) Chest trauma and/or polytrauma and/or polytransfusion |
| b) Pancreatitis or severe burns or severe sepsis or septic shock |
| c) Other |
| Evidence for lung edema |
| a) Bilateral pulmonary infiltrates on chest radiography (with exclusion of pleural effusion or atelectasis) and/or |
| b) EVLWI > 10 mL $kg^{-1}$ and/or |
| c) PVPI > 2.5 and/or |
| d) Bilateral consolidations on chest CT scan |
| The need for |
| a) $FiO_2$ between 0.4 and 0.6 to maintain $SaO_2 > 95\%$ (ALI) |
| b) $FiO_2 > 0.6$ to maintain $SaO_2 > 95\%$ (ARDS) |
| c) Regardless of PEEP level |

**Take home messages:** In summary, when taking into consideration all the elements discussed above, one may propose a new definition for ALI/ARDS described in Table 2 [4]. With this definition, a patient with swine flu, an EVLWI > 10 mL $kg^{-1}$ PBW and ventilated with a $FiO_2$ of 50% would have ALI, a patient with bacterial pneumonia, bilateral consolidations on CT scan and ventilated with a FiO2 of 70% would have an ARDS, and so on. We believe this definition has the advantage to be simple and to take into account the clinical and physiological information most clinicians have access to when treating patients with acute respiratory failure in 2017.

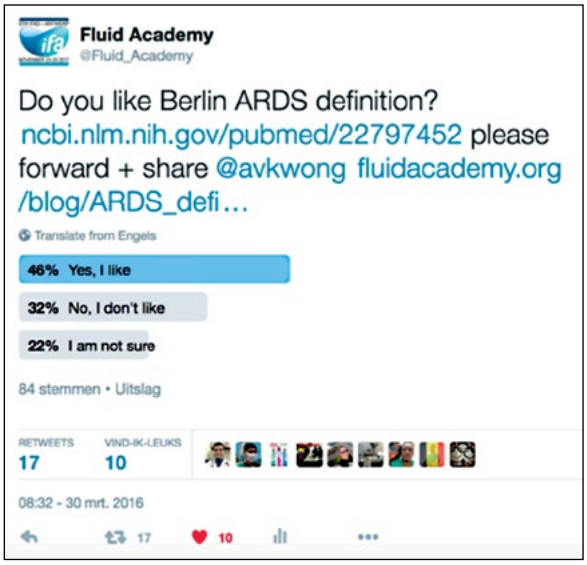


**Figure 1**

A recent internet poll concluded that only 46% of the respondents liked the Berlin definitions (Fig. 1), while 22% were not sure and 32% definitely did not like them...

**Conflict of interest:** The author is member of the medical advisory board of Pulsion Medical Systems (now part of Maquet Getinge group).

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## I026. The role of bio-electrical impedance analysis in critically ill patients

*Manu L.N.G. Malbrain*

ICU Director, University Hospital Brussels (UZB), Jette, Belgium
Faculty of Medicine and Pharmacy, Vrije Universiteit Brussel (VUB), Brussels, Belgium

**Learning objectives:** To explain the different methods to assess hypervolemia. To explain the mechanism of bio--electrical impedance analysis (BIA). To list the different parameters that can be measured with BIA. To list the recent relevant literature in the critically ill.

**Background:** The association of a positive fluid balance and increased morbidity and mortality has been well documented [1–5]. However, little is known about the best method to assess fluid status and fluid overload (FO). FO is defined by a cutoff value of 10% of fluid accumulation above baseline body weight [5–7]. The human body consists of around 60% of water, 18% protein, 16% fat and 6% minerals [8]. The intracellular water (ICW) counts for two-thirds of total body water (TBW) while one-third is extracellular water (ECW). The ECW contains 75% interstitial (IS) fluids and 25% intravascular (IV) fluids. Thus, the plasma accounts for only 5.5% of TBW. In critically ill patients, fluid overload results mainly from an excessive fluid administration. After 1 hour, infusion of 1 liter of isotonic fluid (e.g. so-called normal saline) will increase the intravascular volume with 250 ml and the IS volume with 750 ml. On the other hand, infusion of 1 liter of hypotonic fluid (e.g. glucose or dextrose 5% in water) will increase the IV volume after 1 hour with 100 ml and the IS volume with 900 ml. Therefore, hypotonic solutions should not be used during the resuscitation phase but only for maintenance.

**Discussion:** FO is usually accompanied by some degree of pulmonary edema (especially in sepsis and capillary leak) and can be assessed by clinical signs (anasarca, pitting edema, body weight), biomarkers, assessment of daily and cumulative fluid balance, hemodynamic monitoring (e.g. extravascular lung water (EVLW) measurement via transpulmonary thermodilution). Biomarkers include beta type natriuretic peptide (BNP), low albumin and total protein levels (hemodilution), increased urine albumin over creatinine ratio, increased serum C-reactive protein (CRP) over albumin ratio. Finally, FO can also be assessed with bio-electrical impedance analysis (BIA). BIA uses an electric current transmitted at different frequencies to measure regional, segmental or whole body impedance, phase angle, resistance, reactance and capacitance [8, 9]. New multifrequency and multipolar techniques allow measurement of TBW with separation into ECW and ICW and provide an estimate of volume excess (VE) or thus FO [8]. BIA may provide useful information not only in patients with chronic kidney disease (CKD) on hemodialysis but also in critically ill patients with burns, trauma, and sepsis undergoing fluid resuscitation or goal directed therapy [10–13]. After a brief overview of relevant definitions, this book chapter summarizes the recent literature on how to assess fluid overload with a focus on BIA, and its role to guide fluid management in critically ill patients.

**Take home messages:** Bio-electrical impedance analysis seems a promising tool if performed correctly. It is non--invasive and relatively inexpensive and can be performed at bedside, while it does not expose to ionizing radiation. Modern devices have very limited between-observer variations. However, BIA parameters are population-specific and one must be aware of clinical situations that may interfere with the measurement like visible oedema, nutritional status, or fluid and salt administration. BIA allows assessment of TBW, ICW, ECW, ECW/ICW ratio and VE and as such it can help guiding fluid management, resuscitation de-resuscitation. The latter is especially important in patients not transgressing spontaneously from the Ebb to Flow phase of shock. New devices may also offer insights in intravascular and extravascular fluid volume which could be helpful to define dialysis dose and quality Kt/V, moreover it can estimate the volume of distribution to understand better drug pharmacokinetics and pharmacodynamics. More research is needed in critically ill septic patients before widespread use of BIA can be suggested in this population.

**Conflict of interest:** The author consults for Maltron International.

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## I027. Fluids in the elderly

*Marcia McDougall*

Department of Anesthesia and Intensive Care, Victoria Hospital, Kirkcaldy, Fife, Scotland

**Learning objectives:** To understand why the elderly are at particular risk of morbidity and mortality from too much or too little intravenous fluid; to recognise how these harms may be avoided in hospital care.

**Background:** Elderly patients, particularly those with co-morbidities or impaired renal function, are poorly able to deal with too much or too little intravenous fluid and often suffer morbidity and mortality as a result.

**Discussion:** Results of British surveys show that adverse events occur in up to 20% of elderly patients receiving IV fluids [1, 2]. Improving practice in this area would seem to be a straightforward way of reducing iatrogenic harm but a culture of fluid prescribing being seen as an unimportant task [3] and being left to the most junior member of the medical team has meant that knowledge and education for medical and nursing staff about this important area has been neglected over the years [4, 5]. Hospital systems are often not designed to make careful prescribing an easy task. Elderly patients with dementia who cannot regulate their own fluid intake often become dehydrated. Surgical patients are particularly at risk of fluid overload peri-operatively as shown by many studies in elective colorectal surgery [6, 7]. Introducing strategies to educate staff, provide logical prescription strategies and improve fluid balance charting should reduce harm in this common but undervalued area of practice.

**Take home messages:** Do you know whether elderly and other patients in your hospital are coming to harm from too much or too little fluid? Aiming for normovolaemia in all hospital patients (other than when a 'dry' strategy may be indicated in ICU patients) should be a key skill, taught to all junior doctors and reinforced by senior doctors, aided by careful fluid balance charting.

**Conflict of interest:** The author has given talks on fluid guidelines at educational meetings sponsored by Baxter Healthcare and has been a member of an advisory panel on intravenous fluid development for Baxter Healthcare.

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## I028. Lessons from the NHS — introducing a fluid protocol in your hospital

*Marcia McDougall*

Department of Anesthesia and Intensive Care, Victoria Hospital, Kirkcaldy, Fife, Scotland

**Learning objectives:** To understand why having fluid guidelines in hospitals may improve patient care, prevent complications and save money.

To understand the processes required to introduce widespread change in a complex and variable environment.

**Background:** Inconsistency and a lack of education in good fluid prescribing [1, 2], combined with inaccurate recording of fluid balance, leads to morbidity and mortality in patients receiving intravenous fluids, particularly the elderly.

**Discussion:** A strategy to improve education, monitoring and prescribing was introduced hospital wide, based work done in Southampton and on the UK NICE Guidelines on Intravenous Fluid Therapy in Adults in Hospital [2, 3] and outcomes relating to fluid use, process measures and biochemical parameters are being monitored. The background and strategy are described and the process has resulted in considerable change of culture and awareness around fluid prescribing with a consistent approach from medical and nursing staff, resulting in improved knowledge and practice. Improved patient outcomes are difficult to quantify but the project coincides with a general decrease in mortality across the acute hospital and has not led to safety concerns over changes in fluid use. In addition, significant cost savings have occurred due to a reduction in the total volumes of fluid used. Changes to types of fluid used have been significant with a large decrease in volumes of saline used throughout

the hospital, based on an increasing recognition that 0.9% saline is associated with increased complications over balanced solutions in some circumstances [4–6].

**Take home messages:** Fluid prescription and fluid balance charting are complex procedures which may be associated with considerable harm. Hospitals should look at their practice in this area and consider introducing guidelines and educational strategies to improve and regulate practice. This is a complex undertaking and will take time and effort but will benefit patients.

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## I029. Cytokine removal in critically ill patients: clinical experience, tips and tricks

*Zsolt Molnar*

Department of Anaesthesiology and Intensive Therapy, University of Szeged, Hungary

**Learning objectives:** To get an understanding of the pathophysiology of dysregulated host response in the critically ill patients and to highlight the potential role of regaining balance by extracorporeal removal of cytokines.

**Background:** Overwhelming host response, often referred to as cytokine storm, causes an imbalance between the pro-, and anti-inflammatory host response, which is one the main reasons why critically ill patients develop multiple organ dysfunction at the beginning of their course of illness [1]. Although, most patients respond to standard therapy — such as resuscitation, source control and organ support, very well, but there are some who may benefit from adjuvant therapies [2].

**Discussion:** One of the potential alternatives is the extracorporeal removal of cytokines, by a a CytoSorb® adsorber. The adsorber contains biocompatible polimer polystyrene beads, which remove cytokines in masses under the size of 55 kDa. It can be applied on its own as a hemoperfusion or in combination with renal replacement therapies. Research is ongoing to have a better understanding on the effects of the therapy and to pinpoint the best target population who would benefit the most. Nevertheless, at present there have been several animal experiments and case reports/case series published, most concluding that treatment with CytoSorb® eliminates cytokines, attenuates inflammatory response, improves organ function and the treatment seems safe. According to the recent results of the international CytoSorb® Registry, treatment was applied in patients with septic shock in whom the mortality was predicted to be as high as 80%, while the observed mortality was 65% [3]. It is important to note that extracorporeal removal of cytokines is not indicated in septic shock only, but it does have a potential rationale in other scenarios as well, such as: complicated cardiac surgery, pancreatitis, acute liver failure, etc., whenever there is a cytokine storm due to overwhelming inflammatory response, causing severe organ dysfunction, not responding to standard therapy.

**Take home messages:**

- Dysregulated host response and cytokine storm can cause life threatening organ dysfunction in any critically ill condition.
- Extracorporeal removal of cytokines by CytoSorb® may help to regain balance between pro-, and anti-inflammatory forces.
- According to the results of the available experimental and human studies, the treatment is safe, it attenuates inflammatory response, which was followed by improvement in organ function.

**Conflict of interest:** The author is a consultant for CytoSorbents Europe.

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## I030. Iatrogenic hemodilution: a possible cause for avoidable blood transfusions?

*Azriel Perel*

Department of Anesthesiology and Intensive Care, Sheba Medical Center, Tel Aviv University, Israel

**Learning objectives:** This lecture addresses the development of iatrogenic hemodilution due to fluid administration and its possible impact on decisions to transfuse blood.

**Background:** The administration of intravenous fluids is probably the most frequently initiated therapy in critically ill patients. Although life-saving in many instances, fluid administration is associated with many side-effects and possible complications, especially when given in excess [1]. One such aspect of IV fluid administration is the development of iatrogenic hemodilution, since the increase in plasma volume causes a relative, but not absolute, reduction in the hemoglobin (Hb) concentration [2]. This is similar to the observed decrease in serum creatinine levels following fluid accumulation, a decrease that may lead to a delayed diagnosis or underestimation of acute kidney injury. Hemodilution may also result in a loss of erythrocyte-filled capillaries, leading to a reduction in the oxygen-carrying capacity and effective microcirculatory oxygen delivery with the possible development of organ dysfunction. In addition, because the associated decrease in Hb levels, fluid administration may cause a paradoxical decrease in oxygen delivery ($DO_2$), especially in patients that do not increase their cardiac output following the fluid loading [3]. A hitherto less recognized impact of iatrogenic hemodilution, is that in some patients the decrease in the Hb levels to below the 'transfusion threshold' may cause clinicians to administer blood transfusions that are potentially avoidable [2].

**Discussion:** A restrictive approach to blood transfusions is recommended by most current guidelines [4], although there may be susceptible patient populations in whom a more liberal transfusion strategy may be beneficial. However, the extensive discussions regarding the appropriate transfusion threshold have not adequately addressed the potential impact of iatrogenic hemodilution on the Hb level during dynamic clinical conditions that necessitate fluid administration [5]. In one of the largest randomized controlled trials (RCTs) on perioperative goal-directed therapy GDT, the incidence of blood transfusions was double (22 vs. 11%) in the GDT group patients, who received nearly twice the amount of colloids, compared to the standard-care group, even though the same transfusion threshold (Hb > 8 g $dL^{-1}$) was used for both groups [6]. The most feasible explanation for this clinically relevant and statistically significant difference ($P = 0.04$ based on a chi square test), which was not calculated nor discussed in the article [6], is that more patients in the GDT group reached Hb levels below the transfusion threshold due to hemodilution, prompting physicians to order more blood transfusions in the intervention group [2]. Other RCTs have also reported that patients in the GDT group, who received significantly more colloid boluses, received significantly more blood transfusions and had significantly higher blood loss (due to probable dilutional coagulopathy) compared to the standard therapy group. It seems, therefore, that the administration of greater amounts of fluids within a GDT protocol is frequently associated with more blood transfusions. It should be noted, however, that when fluid administration restores a depleted blood volume due to previous hemorrhage, the fall in Hb concentration may in fact reflect true (and not dilutional) anemia [2]. Continuous non-invasive monitoring of Hb (SpHb) through advanced pulse oximeters, may be a useful trend monitor in the management of severe perioperative bleeding [4]. In addition, by offering real-time visibility of changes in Hb levels, SpHb monitoring may also detect real-time development of iatrogenic hemodilution in non-bleeding patients [2].

**Take home messages:**

- One of the common side effects of fluid administration is the development of iatrogenic hemodilution.
- Iatrogenic hemodilution may cause a paradoxical decrease in DO2 especially in 'non-responders'.
- Iatrogenic hemodilution may cause the Hb levels to decrease below the 'transfusion threshold' and hence prompt the administration of avoidable blood transfusion, as has been clearly the case in a number of GDT studies.
- Continuous non-invasive monitoring of Hb (SpHb) by advanced pulse oximeters, offers real-time visibility of changes in Hb levels, and may thus serve as a useful tool to detect real-time development of iatrogenic hemodilution in non-bleeding patients.

**Conflict of interest:** The author is a consultant to Masimo Inc., Irvine, Ca., USA) and to Pulsion/GETINGE (Munich, Germany).

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## I031. The oxygen reserve index: a new paradigm in monitoring oxygenation

*Azriel Perel*

Department of Anesthesiology and Intensive Care, Sheba Medical Center, Tel Aviv University, Israel

**Learning** objectives: This lecture addresses the Oxygen Reserve Index (ORI) which is a new parameter that can assess oxygenation in the moderate hyperoxemia range (100–200 mm Hg) via a pulse oximeter sensor.

**Background:** The vast majority of surgical and critically ill patients receive supplemental oxygen in order to prevent the potentially deleterious effects of hypoxia. On the other hand, the administration of oxygen may induce hyperoxemia, which can be potentially detrimental. Oxygen therapy should therefore be precisely titrated and accurately monitored. Although pulse oximetry has become an indispensable monitoring technology to detect hypoxemia, its value in assessing the oxygenation status beyond the range of maximal arterial oxygen saturation ($SpO_2 \geq 97\%$) is very limited. In order to assess oxygenation status in this range we need to rely on blood gas analysis, which is intermittent, invasive and frequently delayed. New developments in multi-wavelength Pulse Co-Oximetry provide us with the opportunity to monitor, continuously and non-invasively, the oxygenation status in the moderate hyperoxemia range (100–200 mm Hg) [1]. When oxygen is being administered, the $PaO_2$ increases to > 100 mm Hg and the $SpO_2$ maximizes at close to 100%. However, the venous oxygen saturation ($SvO_2$) at the measurement site continues to increase until it stabilizes (at about 80% saturation) when the $PaO_2$ reaches about 200 mm Hg. By combining the Fick and oxygen content equations, the resulting change in light absorption over this $PaO_2$ range is the basis for the ORI calculation. The ORI is an index with a unit-less scale between 0.00 and 1.00 [1].

**Discussion:** The ORI may provide an early alarm when oxygenation deteriorates well before any changes in $SpO_2$ occur [2–4]. For example, during induction of anesthesia in children the ORI detected an impeding desaturation in median of 31.5 s (range 19–34.3 s) before changes in $SpO_2$ occurred [2]. Such early warning has been acknowledged to have a promising role for patient safety, as it might give clinicians time for corrective actions [5]. The ORI may also reflect the response to oxygen administration during pre-oxygenation or immediately after the initiation of oxygen therapy. The lack of response of the ORI under such circumstances may imply that the patient is not ready to be intubated, or that a right-to-left shunt is present (e.g., ARDS). The ORI may facilitate oxygen titration and prevent unintended hyperoxia. Such hyperoxia, which is very prevalent in ICU patients, may be detrimental even when moderate [6]. By being able to identify $PaO_2$ values above 100 mm Hg, the ORI may also allow the increase of the $FiO_2$ to high $SpO_2$ levels. Finally yet importantly, the ORI may reflect the immediate effects of changes in PEEP levels and of lung recruitment maneuvers (J. Belda, personal communication) [1].

**Take home messages:**

- The ORI is a new parameter that improves the assessment of the oxygenation well above the range of routine pulse oximetry in patients that receive oxygen therapy.
- The ORI may provide early warning of deteriorating oxygenation well before any changes in $SpO_2$ occur.
- The ORI may reflect the response to pre-oxygenation.
- The ORI may facilitate the titration of the $FiO_2$ so that maximal $FiO_2$ can be administered without the occurrence of unintended hyperoxia.
- The ORI may provide information about changes in $PaO_2$ following lung recruitment.

**Conflict of interest:** The author is a consultant to Masimo Inc., Irvine, Ca., USA) and to Pulsion/GETINGE (Munich, Germany).

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## I032. Transoesophageal cardiac ultrasound: a true haemodynamic monitor

*Jan Poelaert*

Department of Anesthesia, University Hospital Brussels, Jette, Belgium

**Learning objectives:** Summarize the potential of transoesophageal echocardiography (TOE) in haemodynamic monitoring, elucidating the three pillars of haemodynamics: preload, systolic ventricular function and contractility, and afterload.

**Background:** Whereas transoesophageal cardiac ultrasound is used since more than thirty years, the technique has evolved as a powerful imaging and monitoring device in critically ill patients [1]. Since the impact of the pulmonary artery catheter has been waned, cardiac ultrasound in general and the transoesphageal approach in particular has grown with progression of the technology towards a very specific imaging facility [2–5]. Typically, flows could be monitored across the different cardiac chambers and in the major vessels [6], providing insight in left and right ventricular function, stroke volume, loading conditions [7, 8] and morphology and function of different valves.

**Discussion:** With TOE and Doppler echocardiography, it is relatively easy to estimate load-dependent characteristics as SV, cardiac output, and positive maximum first derivative of pressure, corrected for time (+dP/dtmean) [6].

With TOE it is possible to rationally approach the issue of hypotension. In this respect, a short-axis view of the LV is the best choice of images to start a cardiac ultrasound investigation, as this image provides information on the three fundamental issues: (1) global ventricular function; (2) the presence of regional wall motion abnormalities; and (3) the first indication of volaemia. If global ventricular function is normal, any other cause of the hypotension than the heart should be investigated (eg, sepsis, vasoplegia, and technical problems). If hypotension is combined with a decreased global LV function, a complete echocardiogram should reveal the causes of this haemodynamic instability. In addition, some relatively easy haemodynamic features can be measured and estimated to obtain a global picture of the haemodynamics.

Cardiac ultrasound in general and TOE in particular needs extensive education and training to obtain the required knowledge on anatomical and physiological issues of function of the heart and circulation characteristics and the necessary skills to visualize the various images. In particular, this is true considering diastolic function, right heart physiology and valve morphology and function. TOE has become the key decisive technique in patients during and after mitral valve plasty [9].

**Take home messages:** TOE offers a major tool in diagnosis and haemodynamic monitoring of cardiac disease and haemodynamic derangement of the critically ill, both intra-operatively as well as in the ICU. Knowledge and skills need to be obtained by means of extensive study.

**Conflict of interest:** none.

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## I033. The case for betablockers

*Sebastian Rehberg*

Department of Anaesthesiology, University Hospital of Greifswald, Germany

**Learning objectives:** To introduce the rational as well as potential benefits for the use of betablockers in septic shock and to summarize current evidence.

**Background:** Activation of the sympatho-adrenergic system is essential for survival in the initial phase of septic shock. However, if it persists, it turns into a significant contributor to mortality („fiendly fire"). Based on this pathophysiological background completely blocking sympathetic activation is not advisible. Instead, regulating the adrenergic response by a titrated betablocker infusion maybe a reasonable approach.

**Discussion:** Although the concept maybe compelling, the risk of heamodynamic deterioration in patients requiring

high vasopressor support needs to be considered. Accordingly, a titrated, continous infusion of a short-acting beta blocker was used in already volume resuscitated septic shock patients [1, 2]. The two pilot studies demonstrated a reduction in heart rate and catecholamine requirements as well as an increase in stroke volume and a preserved microvascular blood flow. In addition to haemodynamic optimisation, additional metabolic and anti-inflammatory effects of beta blockers might contribute to the observed beneficial effects. Another question in respect to the treatment regime is the optimal variable to guide beta-blocker medication: is the heart rate the right target? If yes, what is the most beneficial range? Future studies are currently performed to reveal further insights into these issues. Notably, a retrospective study suggested that in patients with preexisting chronic beta blockade continuation of this treatment during the acute phase of septic shock is associated with lower mortality rates than pausing it. If these results are verified, contiuous infusions of short acting beta blockers might enable the continuation of beta blockade in these patients much more reliable than a continued oral medication.

**Take home messages:** Evidence is increasing rapidly that beta blockade seems to have beneficial effects in patients with septic shock. The complete mechanism of action (and the optimal treatment regime are still under investigation. Therefore, beta blocker treatment of septic shock patients does not represent a standard of care at the present time and patients need to be carefully selected.

**Conflict of interest:** The author received personal fees and travel reimbursements from Amomed.

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## I034. The case for vasopressin


*Sebastian Rehberg*

Department of Anaesthesiology, University Hospital of Greifswald, Germany


**Learning objectives:** To reinforce the use of vasopressin according to current guidelines and to summarize additional recommendations based on current clinical evidence.

**Background:** Catecholamines can have detrimental effects especially in high doses. These are associated with increased mortality rates in certain patients. Therefore, non-adrenergic vasopressin receptor agonists represent alternatives with a potentially lower risk profile, a higher effectivity in these shock patients and potential additional benefits on organ function.

**Discussion:** Two large randomized controlled trials demonstrated that vasopressin as a supplement to or substitution of norepinephrine has an equal efficacy and a similar safety profile as norepinephrine in septic patients [1, 2]. Current evidence suggests an early use of vasopressin and a titrated infusion according to therapeutic goals rather than a last resort therapy and a fixed infusion rate for hormone substitution. Subgroup analysis revealed potential benefits over norepinephrine in respect to renal function. In addition, vasopressin plays an important role to reduce catecholamine doses as pointed out in the current sepsis guidelines. Of note, the highly selective vasopressin 1a-receptor agonist selepressin not only stabilized haemodynamics more effectively than norepinephrine but also reduced cumulative fluid balance in septic shock [3]. Furthermore, in vasoplegic shock following cardiac surgery first-line vasopressin improved clinical outcome compared with standard treatment using norepinephrine in a recent randomized, controlled study [4]. In addition, a study investigating the use of vasopressin in haemorrhagic shock has been completed and the results are expected shortly.

**Take home messages:** Current guidelines recommend vasopressin as the second-line vasopressor in septic patients with the indication to increase mean arterial pressure or to reduce catecholamine doses. In addition to haemodymic management, there may be additional benefits of vasopressin agonists in respect to renal function and positive fluid balance. Notably, first-line vasopressin maybe superior to norepinephrine in vasoplegic shock following cardiac surgery.

**Conflict of interest:** The author received personal fees and travel reimbursements from Amomed.

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## I035. Vasopressin in different types of vasoplegic shock

*Sebastian Rehberg*

Department of Anaesthesiology, University Hospital of Greifswald, Germany

**Learning objectives:** To briefly summarize current clinical evidence for the use of vasopressin in the treatment of different types of vasoplegic shock.

**Background:** Vasopressin is recommended by current guidelines as second-line vasopressor in septic shock. However, the optimal therapeutic regime in respect to dose, time points of initiation and discontinuation is still under investigation. In addition, the first large randomized, controlled study on first-line vasopressin in patients with vasoplegic shock following cardiac surgery suggests a superiority vs. norepinephrine (VANCS).

**Discussion:** New evidence on the use of vasopressin reinforces the early start of treatment in septic shock patients [1]. Even a first-line approach tested in the VANISH trial was demonstrated to be as safe and effective than the standard vasopressor norepinephrine [2]. In addition, potential benefits of vasopressin on renal function in septic shock require further investigation. Notably, retrospective data suggest that contrary to current practice it may be beneficial to discontinue vasopressin after norepinephrine to reduce the risk of haemodynamic instability [3]. In vasoplegic shock following cardiac surgery, first-line vasopressin significantly reduced the composite endpoint of mortality and severe complications as compared to first-line norepinephrine [4]. Interestingly, both the VANISH and the VANCS trial used doses up to 0.06 U/min that are higher than currently recommended.

**Take home messages:** The role of Vasopressin as an effective and safe vasopressor in septic shock has been further reinforced by the VANISH trial and may become even more relevant within the concept of decatecholaminisation. In vasoplegic shock following cardiac surgery, first randomized controlled trials emphasize the potential benefit of vasopressin vs. norepinephrine even as first-line treatment.

**Conflict of interest:** The author received personal fees and travel reimbursements from Amomed.

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## I036. The rationale, process and implications of the recent early enteral nutrition guidelines

*Annika Reintam Blaser*

Department of Anaesthesiology and Intensive Care, Tartu, Estonia, Department of Intensive Care Medicine, Lucerne Cantonal Hospital, Lucerne, Switzerland

**Learning objectives:** Understanding the rationale, process and implications of the recently published ESICM Early Enteral Nutrition Guidelines [1].

**Background:** The Working Group on Gastrointestinal Function of the Section of Metabolism, Endocrinology and Nutrition took the task to issue guidelines for the application of early enteral nutrition (EEN) addressing several specific conditions where safety and/or feasibility of EEN may be questioned.

Rationale for these guidelines was:

- To give practical recommendations in a poorly studied area.
- Go beyond the recommendation „use EN if patient is stable and GI tract intact".
- Combine questions „early vs. late nutrition" and „enteral vs. parenteral nutrition".
- Avoid statements as „no recommendation can be made" due to their uselessness in clinical practice.

**Discussion:** After addressing the effect of EEN in an unselected population of ICU patients, ESICM EEN guidelines [1] addressed 24 different clinical conditions/situations and issued 17 recommendations favoring EEN and 7 recommendations favoring delayed EN. All issued recommendations were weak, many were based on expert opinion.

Clearly, any guidelines cannot make existing evidence better, but they can present the information in a systematized manner, and next to providing support for clinicians in daily practice they may help to point out weaknesses in existing evidence aiming improvement in future studies.

Several issues that were revealed during the EEN guideline process and that made strong recommendations impossible, are listed and shortly discussed below.

1. Identification of studies performed in ICU patients. Using respective key words in search resulted in identification of some studies where not all patients were treated in the ICU. On the other hand, several similar studies were not identified via this search. Many papers did not specify, whether and how many patients were treated in the ICU. The working group discussed the following options used in some earlier meta-analyses: setting either mortality cut-off (e.g. 5% in the control group) or APACHE II score cut-off (e.g. > 10 points) to identify severely ill patients most likely treated in the ICU. However, the group decided not to use such cut-offs to avoid

an additional arbitrary factor. Instead, studies identified during the primary search with "ICU" key words were first analysed separately and thereafter together with additional studies identified during narrowed searches for sub-questions (e.g. major surgery).

2. Time point for "early" was defined based on a chosen time-point in available studies. It remains unknown, whether the identified time point "early = within 48h of (ICU) admission" will prove to be the best cut-off distinguishing between early and delayed nutrition.
3. High risk of bias in most of nutrition studies. We considered that observational studies evaluating early EN were all intrinsically biased, because patients who are less severely ill are more likely to receive and tolerate early EN. Accordingly, although all observational studies were critically assessed during the study process and helped to form expert opinion, no recommendations based solely on observational studies were issued. Moreover, risk of bias was also high in randomized controlled trials, because of non-blinding. Such risk of bias is most relevant regarding outcome that allows/requires some subjective evaluation (e.g. infections outcome).
4. Heterogeneity between the studies regarding inclusion criteria. Most of the studies have addressed a specific group of patients (e.g. pancreatitis) and not a "general, unselected population of critically ill". Therefore, it needs to be underlined that the analysis of "unselected" actually included studies with different selected groups.
5. Heterogeneity in nutritional interventions. Route for EN (nasogastric, nasoduodenal, nasojejunal and surgical jejunostomy all together), initial dosage and progression of EEN vs. delayed EN vs. PN.
6. Heterogeneity in outcome variables: mortality outcome includes any mortality (ICU, hospital, 28 days and 90 days); infections outcome did include different infections. In general, there is no consensus on reasonable outcome variables for nutritional interventions. Mortality has been used in most of the studies, however, the rationale behind the hypothesis that mortality during ICU stay would be caused solely with nutrition strategy remains unclear.

Addressing and acknowledging these issues is necessary not only for a correct interpretation of evidence and formulation of recommendations, but also for improvement in future studies.

**Take home messages:**

- Current evidence allows issuing weak recommendations to use EEN (started within 48 h) in the majority of ICU patients, suggested exclusions are uncontrolled shock, uncontrolled hypoxemia, uncontrolled acidosis, uncontrolled upper gastrointestinal bleeding, gastric aspirate volume > 500 mL $6h^{-1}$, bowel ischemia, bowel obstruction, abdominal compartment syndrome, and high-output intestinal fistula without distal feeding access.
- EEN should always be started at low dose under careful monitoring of tolerance.
- Harm caused by EN in specific conditions at specific time points cannot be excluded and any new large study could theoretically change the direction of recommendations.

**Conflict of interest:** Annika Reintam Blaser is the first author of ESICM EEN guidelines.

**Reference:**

1. Reintam Blaser A, Starkopf J, Alhazzani W, et al.; ESICM Working Group on Gastrointestinal Function. Early enteral nutrition in critically ill patients: ESICM clinical practice guidelines. Intensive Care Med. 2017; 43(3): 380–398, doi: 10.1007/s.

## I037. How to develop a protocol for management of gastrointestinal problems in the ICU

*Annika Reintam Blaser*

Department of Anaesthesiology and Intensive Care, Tartu, Estonia, Department of Intensive Care Medicine, Lucerne Cantonal Hospital, Lucerne, Switzerland

**Learning objectives:** Obtaining the overview on aspects that need to be considered for development of a local protocol for management of gastrointestinal problems in the ICU.

**Background:** There are multiple factors leading to gastrointestinal (GI) problems in ICU patients, whereas options to monitor and improve GI function are very limited. Despite many functions of GI system are known (digestion and absorption, endocrine, immune and barrier function), bedside assessment is mainly limited to signs of GI dysmotility, relying on subjective clinical evaluation.

**Discussion:** Most of the GI problems are non-specific (may occur in medical or surgical patients with or without primary abdominal pathology), manifesting in either reduced (gastro- or intestinal paralysis) or increased (diarrhea) GI motility. Multiple factors that impair GI motility include: hypoperfusion, electrolyte disturbances (mainly hypokalemia and hypomagnesemia), infection, gut oedema and variety of medications (opioids, sedatives, vasopressors etc). Factors that are known to improve GI motility include: enteral nutrition, prokinetics, laxatives, epidural analgesia and mobilization. A standardized, algorithm-based approach could assist in decision-making in this area of multiple vague definitions. Such standardized management algorithm should complete the local feeding protocol and include the following aspects:

7. Routine standardized assessment of GI symptoms. Use available definitions [1].
8. If oral diet is not applicable, aim early enteral nutrition (within 48h of admission) started at low rate (10–20 mL $h^{-1}$). Consider reasons to delay EN [2] and minimize the risk of aspiration.
9. Consider application of laxatives early (within 48h of admission) in case of absence of stool passage. Check contraindications, side effects and time required for effect of specific laxatives.
10. In case GI symptoms suggesting impaired motility (vomiting, large gastric aspirate volumes, abdominal distension, no passage for more than 3 days):
    - Rule out (or initiate respective treatment of) obstruction, bowel perforation, intestinal ischemia and abdominal compartment syndrome.
    - Consider repeated measurements of intra-abdominal pressure [3].
    - Give laxatives, correct electrolyte levels and consider reduction of medications impairing GI motility.
    - Thereafter, if problems persist and include symptoms/signs of upper GI paralysis (vomiting, increased gastric aspirate/residual volume), start metoclopramide (check contraindications first) 3 × 10 mg $day^{-1}$ (reduce dosage to 1–2 × 10 mg $day^{-1}$ in case of renal failure).
    - If no effect after 24h or contraindications to metoclopramide, add erythromycin (e.g. 3 × 100 mg $day^{-1}$). Set the time limit to metoclopramide and erythromycin treatment (e.g. 3 days).
    - If prokinetic treatment appears ineffective for 1–2 days and the problem is limited to gastroparesis, consider postpyloric feeding. Rule out small intestinal dilatation.
    - If the main problem appears to be the lower GI tract and the bowel is distended, consider neostigmine (e.g. 0.4–0.8 mg $h^{-1}$ until the effect or maximum dosage of 2.5 mg).
11. If the problem is diarrhoea:
    - Stop laxatives and prokinetics,
    - Rule out or treat infectious diarrhea [4],
    - Differential diagnosis to identify a trigger
        - Review medication list and feeding formula,
        - Consider pancreatic exocrine insufficiency and bile acid malabsorption.
12. Consider:
    - Abdominal sepsis/abscess(es) as a possible reason for GI problems
        - Presence of bowel oedema. Careful initiation and progression of enteral nutrition, especially if bowel oedema is combined with bowel distension
        - Specific surgery-related problems (e.g. intestinal fistula, high-output stoma, pancreatic fistula etc.) that may need specific approach beyond standard management protocol.

**Take home messages:**

- Monitoring of GI dysfunction is largely based on subjective clinical assessment.
- Pharmacological treatments are limited, have side-effects and should be applied in a limited dosage and for a limited time period.
- An algorithm-based approach may help in decision-making.

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## I038. Sepsis and ards — how can functional imaging help?


*Daniel A. Reuter*

Department of Anesthesia, Rostock University Hospital, Rostock, Germany


**Learning objectives:** To learn about the different imaging techniques that exist like electrical impedance tomography to quantify ventilation and or perfiusion in patients with ARDS.

**Background:** Imaging of internal body structures plays a pivotal part in diagnosing and understanding disease. Radiographic examinations including computed tomography and magnetic resonance imaging are daily and indispensable tools in clinical practice. However, in particular bedside imaging by sonography has revolutionized medicine. It has allowed us not only to assess anatomical structures of multiple organs, but even more important, it has enabled us to visualize and to quantify organ function in real time right at the bed side. The non-invasive assessment of myocardial function, or the quantification of (regional) blood flows are only two examples.

However, ultrasonography hast three major draw-backs in intensive care medicine: First, some structures, for example

the lungs, can only be partially visualized — either, they are to big to be seen in total, or they are hidden by other structures, which are not transparent for the ultrasound beam. Investigations therefore often reflect only (more or less) representative regions of the whole organ. Second, standardized examinations and analyses still need high personal experience, since the assessment of optimal images for many organ systems deserve — besides the ability to abstract and to interpret the images — high manual skills to gain adequate image quality. And third, continuous reproducible, and automated data sampling over longer periods of time, which is the basic definition of "monitoring", is — with very view exemptions, such as Doppler derived assessment of blood flow by specific probes — not possible.

**Discussion:** Electrical impedance tomography is a functional imaging technology, which is based on the assessment of electrical impedance changes over time within structures of the body [1]. Electrical impedance is changing, when the composition of components of a structure with different impedance characteristics is changing: Within the thorax, these components are mainly air and lung tissue: During deep inspiration, there is much air (electrical impedance high), and few lung tissue (impedance low); during deep expiration, it is the other way round, there is only few air with high impedance, and much lung tissue with low impedance. Changes in impedance give us therefore indirect information on the degree of aeration within the lungs. If this change in impedance is now mapped according to the anatomical structures and color-coded, it can give us functional images of changes in aeration over time within the different parts of the lungs. Electrical impedance tomography therefore allows us to visualize and to monitor the degree of aeration of the lungs. However, it is important to underline once more that electrical impedance tomography does not directly provide images of anatomical structures, as it is with radiological examinations or ultrasound. It is always the illustration of changes in physical qualities of body regions/tissues over time that is transferred in pictures. Electrical impedance tomography has a high temporal resolution, which also determines its strengths — assessing and imaging dynamic changes over time — functional imaging in its deeper sense. However, the major draw-back is the low spatial resolution, when compared to radiographic modalities or ultrasound. Clinical data on EIT are still sparse. The greatest knowledge has been gained so far in the field of ventilation, where in particular titration of PEEP and monitoring of "protective ventilation" by EIT has been described [2]. But also assessment and monitoring of pulmonary edema and central cardiocirculatory function by EIT are currently vivid fields of clinical research [3, 4].

**Take home message:** EIT provides functional imaging of aeration of the lungs. An increasing body of evidence suggests that EIT can serve as a helpful tool for monitoring and guiding of ventilation strategies in critically ill patients and in patients undergoing general anesthesia. Further, first experimental data suggest that central hemodynamics might be assessable by EIT.

**Conflict of interest:** none.

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## I039. Workshop on hemodynamic monitoring


*Daniel Reuter[1], Xavier Monnet[2], David Kaufman[3], Azriel Perel[4]*

[1]Department of Anesthesia, Rostock University Hospital, Rostock, Germany
[2]Professor of Intensive Care at the Paris-South University, and Medical Intensive Care Unit of the Bicêtre Hospital (Paris-South University Hospitals), Paris, France
[3]Director, Medical ICU, NYU-Langone Medical Center, New York, NY, USA
[4]Department of Anesthesiology and Intensive Care, Sheba Medical Center, Tel Aviv University, Israel


**Learning objectives:** Importance of advanced hemodynamic monitoring; brief overview of methods for monitoring cardiac output, fluid responsiveness, preload, and fluid overload; limitations of methods; differential diagnosis of shock by advanced hemodynamic monitoring; therapeutic targets.

**Background:** Hemodynamic management is one of the major tasks in critically ill patients in shock. Of course, for that reason, hemodynamic monitoring, which also allows adequate differential diagnosis of the reasons for hemodynamic instability is essential. There is increasing evidence that measurement of blood pressures for the assessment of cardiac performance (arterial blood pressure), or for the assessment of cardiac preload (central venous pressure, pulmonary artery occlusion pressure) are not sufficient for adequate therapeutic decisions in complex clinical situations. It has been shown that measuring cardiac output, assessing fluid responsiveness, and quantifying volumetric preload can add very useful information for hemodynamic management in those patients.

**Discussion:** Although measuring cardiac output by thermodilution is the clinical gold standard, its invasiveness is associa-

ted with additional risks for the patient. Further, measurements need to be performed manually, and are not continuous. Less invasive techniques are arterial pulse contour analysis, which can be applied on a central (aortic) signal, or a peripheral (radial artery) signal. It is even possible to apply it with a completely non-invasive approach using vascular unloading technique, bioreactance or applanation tonometry. In a modified form, pulse contour analysis can also be used to assess fluid responsiveness using the plethysmographic signal of pulse oximetry. However, the benefit of non-invasiveness must always be outweighed against the need for precise and robust measurements. Limitations and pitfalls of each monitoring technique need to be known for clinical decision making. One of the most important property of hemodynamic monitoring techniques is to provide a real-time, continuous measurement of cardiac output. This is particularly true for the dynamic prediction of fluid responsiveness, which is based on the changes in cardiac output and stroke volume induced by short-term changes in cardiac preload. Assessing pulse pressure variations induced by mechanical ventilation requires a continuous monitoring of blood pressure, which is often invasive but can also be estimated by attractive non-invasive techniques. The effects of passive leg raising might also be transient and must be assessed by a continuous, real-time measurement of cardiac output. This is also the case for the variations in stroke volume induced by changing mechanical ventilation, through ventilatory holds, changes in pressure or in tidal volume.

Beyond cardiac output, monitoring techniques might provide information regarding other features of the hemodynamic status. This is particularly true for the invasive techniques, which can assess cardiac preload, cardiac contractility and indices of the risk of excessive fluid administration like extravascular lung water. These techniques are indicated for the most complex, severe critically ill patients.

**Take home message:** Adequate and reliable monitoring of cardiac output, preload, and fluid responsiveness, as well as assessing signs of fluid overload are indispensable for adequate decision making with regard to hemodynamic therapy. A stepwise concept from non-invasive to invasive approaches needs to be tailored to the individual patient needs.

**Conflict of interest:** Daniel Reuter: Advising services to Pulsion, CN Systems, and Masimo; Xavier Monnet: Advising services to Pulsion and Cheetah; Azriel Perel: Independent consultant to Masimo Inc., Ca., USA and Pulsion / Getinge (Munich, Germany); David Kaufman: member of medical advisory board Pulsion Medical systems (Getinge).

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## I040. Perioperative fluid management in times of eras (early recovery after surgery)


*Daniel A. Reuter*

Department of Anesthesia, Rostock University Hospital, Rostock, Germany


**Learning points:**

- Pathophysiological rationale of ERAS principles,
- Hemodynamic early goal directed therapy strategies,
- Need forindividualized treatment goals.

**Background:** „Early Recovery after Surgery" means a multidisciplinary approach in the perioperative treatment of patients scheduled for major surgery.

**Take home messages:** The aim of this structured approach is to reduce complications caused by surgery and by hospitalization, to improve recovery, and to shorten hospital stay. Besides optimization of patient preparation for surgery (including dietary plans, shortened periops of preoperative fasting, strategies of patient blood management, and others), optimized analgesia, and earliest postoperative mobilization, in particular perioperative hemodynamic and fluid management plays a pivotal role in this multimodal treatment concept. A continuous treatment concept, starting already preoperatively, to be continued during surgery and on the ICU, as well as postoperatively on the normal ward needs to be implemented and followed by all caregivers.

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## I041. How can the swan help in sepsis and ARDS?


*Thomas W.L. Scheeren*

Department of Anesthesiology, University of Groningen, University Medical Center Groningen, PO Box 30 001, 9700 RB Groningen, The Netherlands


**Learning objectives:** To get an idea of how monitoring using the pulmonary artery catheter (PAC or Swan) can be used to manage ICU patients that suffer from sepsis or ARDS.

**Background:** Whilst 20 years ago, the PAC was used in almost all critically ill patients, nowadays little is done to monitor hemodynamics in the ICU. Actually, hemodynamic monitoring is nowadays limited to measurements of heart rate and arterial (and central venous) pressure, and the use o f the PAC is declining [1]. Reasons for this decline include evidence of insufficient physician's knowledge in terms of measurements and interpretation of the PAC data, the facts that large RCTs showing no beneficial effect or even harmful effects of maximizing CO, and the emergence of other advanced and less invasive hemodynamic monitoring systems including bedside echocardiography. Hence, there is a growing need for clarification of the current role of the PAC at least for the management of patients with hemodynamic instability, shock, sepsis and ARDS.

**Discussion:** The PAC is still the gold standard method for measuring cardiac output (CO). Furthermore, it can help answering the question of the measured CO is adequate for the patient or situation by measuring mixed venous oxygen saturation ($SvO_2$) [2] or the veno-arterial CO2 difference (Pv--aCO2) [3]. The PAC can further be used to decide if a patient needs fluids as well as when to stop giving fluids. Finally, the PAC helps assessing right ventricular function, which has been shown being associated with outcome [4].

**Take home message:** the use of the PAC is recommended in patients with circulatory failure in combination with sepsis and ARDS [5, 6].

**Conflict of interest:** The author has received honoraria for consulting and lecturing from Edwards Lifesciences and Masimo Corp. as well as for lecturing from Pulsion Medical Systems (now part of Maquet Getinge group).

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## I042. Innovative hemodynamics


*Thomas W.L. Scheeren*

Department of Anesthesiology, University of Groningen, University Medical Center Groningen, PO Box 30 001, 9700 RB Groningen, The Netherlands


**Learning objectives:** This lecture introduces innovative ways of assessing the hemodynamic status of a patient. It includes functional hemodynamic monitoring such as measuring the dynamic arterial elastance ($Ea_{dyn}$), the mean systemic filling pressure, and finally the hypotension prediction indicator (HPI).

**Background:** Elastance is a measure of the tendency of a vessel or organ to recoil toward its original dimensions upon removal of a distending or compressing force ($E = \Delta P / \Delta V$). It is the reciprocal (inverse) of compliance ($C = \Delta V / \Delta P$). Arterial elastance (Ea) is a measure of arterial wall stiffness (or arterial load), i.e. the expression of the total afterload imposed on the left ventricle [1]. It is determined by the total arterial compliance, impedance and the systolic and diastolic time intervals and describes the capability of the arterial vessels to increase pressure in hypotensive patients when LV stroke volume increases. The dynamic arterial elastance (Eadyn) is a functional measure of arterial wall stiffness (or arterial load) and mainly determined by the central vascular compartment (big arteries). It is obtained during a respiratory cycle as the ratio between pulse pressure variation (PPV, pressure based) and stroke volume variation (SVV, volume or flow based), relating changes in pressure to changes in flow. The mean systemic filling pressure (MSFP) is defined as the mean pressure that exists in the circulatory system when the blood has had a chance to redistribute evenly to all vessels and organs (i.e. at cardiocirculatory arrest) and is a measure of the filling of the cardiovascular system. It mainly determines venous return and thus cardiac output. Since it is difficult to directly measure in patients, an analogue that can be calculated from arterial and central venous pressure and cardiac output has been suggested [2]. From this, Pvr, the driving pressure for venous return ( = Pmsa–central venous pressure) and heart performance (EH; Pvr/Pmsa) can be calculated [3]. We assessed the significance of this analogue of the mean systemic filling pressure (Pmsa) and its derived variables, in providing a physiology based discrimination between responders and non-responders to fluid resuscitation during liver surgery [4].

The hypotension probability indicator (HPI) informs clinicians of potentially developing hypotension (defined as mean arterial pressure < 65 mm Hg). It is based on multiple features of the arterial pressure waveform and a mathematical algorithm developed by learning from past hypotensive events (big data) using machine learning methods. It also provides clinicians with insights into potential factors related to high hypotension probability through an advanced secondary screen feature built into the software.

**Discussion:** Measuring Eadyn should be considered primarily in hypotensive patients to identify patients who might benefit from fluid or vasopressor administration. If Eadyn is high and the patient is preload- dependent, arterial pressure will improve along with CO after volume expansion. The greater the Eadyn, the greater will be the improvement in arterial pressure after volume expansion [5]. If the arterial vessels becomes stiffer, then for the same stroke volume change, arterial pulse pressure will change more and vice versa. If arterial compliance decreased (vasoconstriction), then the PPV/SVV ratio (Eadyn) increases, while with vasodilation, the Eadyn decreases.

Changes in Pmsa, Pvr and EH reflect changes in effective circulating volume and heart performance following fluid resuscitation, providing a physiologic discrimination between fluid responders and non-responders [4].

**Take home message:** Eadyn is a surrogate of cardiac afterload and capable of differentiating arterial vasodilatation from hypovolaemia as a cause of hypotension. It can be used to assess vascular tone and the need for fluid and vasopressor therapy in hypotensive patients at the bedside. Pmsa can be used to track fluid-induced volume changes. Pvr can predict fluid responsiveness as good as the dynamic variables PPV and SVV. EH is a measure of cardiac performance. HPI can predict hypotension reliably up to 10 min before it actually occurs. The hypotension probability indicator (HPI) predicts hypotension reliably up to 10 min before its occurrence better than changes in MAP do. Thus, it can buy time to take corrective measures before hypotension actually occurs.

**Conflict of interest:** The author has received honoraria for consulting and lecturing from Edwards Lifesciences and Masimo Corp. as well as for lecturing from Pulsion Medical Systems (now part of Maquet Getinge group).

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## I043. Calibrating pulse contour analysis: why bother?


*Thomas W.L. Scheeren*

Department of Anesthesiology, University of Groningen, University Medical Center Groningen, PO Box 30 001, 9700 RB Groningen, The Netherlands


**Learning objectives:** To get an understanding of the multiple hemodynamic information that can be derived from the arterial waveform as a prerequisite for accepting the need to (re-) calibrate pulse contour analysis derived variables.

**Background:** The arterial waveform does not only contain information on arterial blood pressures (systolic, mean, diastolic), but its morphological features can be used to extract advanced hemodynamic information by pulse contour analysis (PCA). Within each cardiac cycle, several cardiac sub-phases of the arterial pressure waveform can be analyzed and related to specific physiological effects, such as cardiac contractility, stroke volume, arterial compliance, vascular tone and afterload. Several commercially available less invasive monitoring devices uses one or several of these features to provide advanced hemodynamic information [1]. While some of these devices offer the possibility to (re-) calibrate the waveform based information by values obtained from reference methods (e.g. thermodilution), others do not (so-called uncalibrated or auto-calibrated systems). This has implications for the accuracy and trending ability of these devices [1, 2].

**Discussion:** When repeated CI measurements were performed in defined time intervals from the last calibration in critically ill patients equipped with a PiCCO device, the percentage error between PCA-derived and thermodilution cardiac index was acceptable (< 30%) only in the first hour after the last calibration, even without intervention [3]. When volume (500 mL colloid) was applied in patients undergoing cardiac surgery, PCA significantly underestimated the volume-induced increase in cardiac index measured by transpulmonary thermodilution by about 50% [4]. Similarly, when vasodilation was induced with increasing doses of prostaglandin E1 (PGE1), the bias and percentage error between PCA and thermodilution derived cardiac output increased with increasing PGE1 dose [5]. Finally, increasing vascular tone by various vasopressors reduced the accuracy of PCA-derived cardiac output as well as the concordance rate of changes in cardiac output as observed with 2 different methods [6].

**Take home message:** PCA-derived hemodynamic variables have to be recalibrated frequently, particularly after interventions such as volume application or changes in vasomotor tone as induced by vasoactive medication, in order to give accurate readings of cardiac output and other PCA derived hemodynamic variables.

**Conflict of interest:** The author has received honoraria for consulting and lecturing from Edwards Lifesciences and Masimo Corp. as well as for lecturing from Pulsion Medical Systems (now part of Maquet Getinge group).

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## I044. How to start a nutrition team in your hospital

*Karen Schoonheydt*

Intensive Care Unit, ZNA Stuivenberg, Antwerp, Belgium

**Learning objectives:** tips and tricks on how to start a nutrition team within a hospital and within an ICU unit.

**Background:** Malnutrition is a problem in many hospitalised patients and the malnourishment usually increases during their stay. Malnutrition is a frequently missed diagnosis because nurses as well as physicians are not familiar with it. The consequences of malnutrition are often underestimated.

**Discussion:** The start up of a nutrition team is a time consuming business with a lot of stakeholders within the hospital. Involvement of the executive board of the hospital is mandatory to succeed. Cooperation of the nursing team and the dieticians is of utmost importance. Knowledge, connectedness and autonomy are cornerstones to assure involvement of the nursing and dieticians team. The main driver for nursing teams, physicians as well as managers is better care for patients. These general principles are explained while we share our experience in setting up a nutrition team. How to overcome the many obstacles like lowbudget, low nurse/patient ratio are highlighted by examples.

**Take home message:** Gather a team of motivated people around you and pick a few feasible goals for your hospital or ICU. Then just do it!

**Conflict of interest:** none.

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## I045. Meta-analysis of fluid overload

*Jon A. Silversides*

Consultant in Critical Care and Anaesthesia, Belfast Health and Social Care Trust, United Kingdom

**Learning objectives:** To review the current evidence for strategies to prevent or treat fluid overload in critically ill patients. To discuss future avenues for research in the prevention and management of fluid overload.

**Background:** Intravenous fluid administration, in the form of fluid boluses, maintenance fluids, and diluents for medications, is ubiquitous in critical care. In the context of increased capillary permeability, endocrine influences predisposing to sodium and water retention, and acute kidney injury (AKI), all of which are common in critical illness, the accumulation of large volumes of this fluid in the interstitium is a frequent occurrence, and may impair oxygen delivery. Numerous observational studies have demonstrated an association between the accumulation of a positive fluid balance and adverse outcomes in critically ill patients [1–3], and it has been suggested that strategies aimed at prevention or treatment of fluid overload may be beneficial following haemodynamic stabilisation [4, 5].

**Discussion:** We undertook a systematic review and meta-analysis of the literature [6, 7], aiming to evaluate the impact of a conservative fluid or active deresuscitation strategy compared with standard care or a liberal fluid strategy in critically ill adult or paediatric patients with sepsis, systemic inflammatory response syndrome (SIRS), or acute respiratory distress syndrome (ARDS) on mortality and other clinical outcomes.

We searched Medline, Embase, and the Cochrane central register of controlled trials, and manually searched conference proceedings for the last 5 years. Two reviewers inde-

pendently assessed publications. We included randomised controlled trials comparing two or more fluid regimens in which fluid balance differed, and observational studies investigating the relationship between fluid volume administered or fluid balance achieved and patient outcomes. We excluded studies published before 1980, studies of neonatal, post-cardiac surgical, or heart failure patients, and observational studies with fewer than 50 participants.

Forty-nine studies were included, of which eleven were randomised controlled trials. In a meta-analysis of the randomised trials (2,051 patients) using a random effects model, there was no significant difference in mortality with conservative or deresuscitative strategies compared to a liberal strategy or usual care (pooled risk ratio [RR] 0.92, 95% confidence interval [CI] 0.82–1.02, $I^2 = 0\%$). However, conservative or deresuscitative strategies resulted in more ventilator-free days and reduced length of ICU stay compared to a liberal strategy or standard care [8].

Marked clinical heterogeneity was evident between trials, leaving considerable uncertainty as to the optimum strategy to test in future trials, and demonstrating the need for considerable further pilot work to define optimal intervention strategies before proceeding to large multicentre trials, which will likely require several thousand patients.

**Take home messages:**

- A conservative or deresuscitative approach to fluid management improves some outcomes in patients with sepsis and ARDS, although the effect on mortality is uncertain and the level of evidence was low or very low for all outcomes.
- A conservative or deresuscitative does not appear to increase the incidence of acute kidney injury or renal replacement therapy.
- Considerable pilot work remains to be done to optimise interventions to be tested in large randomised trials comparing alternative fluid regimens.

**Conflict of interest:** none.

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## I046. Sepsis 3.0 how did we get there, a critical analysis?


*Mervyn Singer*

Intensive Care Unit, University College London, London, UK


**Learning objectives:** To understand how Sepsis-3 evolved sepsis definitions and criteria from Sepsis-1 and -2.

**Background:** The first sepsis definitions ('Sepsis-1') by Bone et al was developed in 1991, principally to assist industry with trials of novel immunomodulatory agents in sepsis. They introduced the concept of SIRS, sepsis, severe sepsis and septic shock however the latter two were poorly characterized clinically. The next iteration ('Sepsis-2') in 2002 recognized the limitations of Sepsis-1 but acknowledged the lack of sufficient evidence to drive change. In consequence, they simply expanded the list of clinical features that could be associated with sepsis. As a consequence of the poor clinical characterization of severe sepsis and septic shock, the epidemiology of sepsis has been a total mess in terms of both incidence and mortality. Multiple studies confirmed that SIRS was both non-specific and also excluded a significant number of infected patients with organ failure.

**Discussion:** In the light of these issues, SCCM and ESICM convened a Task Force in 2014 who then spent nearly two years critically revising the literature and offering a data-based approach to (i) develop new definitions representative of the current understanding of sepsis pathophysiology and (ii) providing explicit clinical criteria to aid epidemiology, coding and research. 'Sepsis-3' was thus born in February 2016 with endorsement from over 40 professional societies worldwide.

**Take home messages:**

- The earlier Sepsis definitions (from 1991 and 2002) were useful in their time but required updating in view of their limitations.
- Sepsis-3 offers new definitions of sepsis and septic shock that embrace our current understanding of pathophysiology.
- By offering specific clinical criteria, Sepsis-3 aids epidemiology, coding and research.

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## I047. Sepsis 3.0 was it worth the wait?

*Mervyn Singer*

Intensive Care Unit, University College London, London, UK

**Learning objectives:** To discuss outputs since the publication of Sepsis-3 in February 2016

**Background:** The intention of 'Sepsis-3' was to reach a broad audience to adopt a common language, to aid epidemiology and coding, and to facilitate research. Since February 2016, the main paper has received > 2 million views and > 800 citations. It was the 19th most discussed scientific paper in 2016 and is currently 158th of 8.5 million papers in terms of quality and quantity of online attention. Studies are now appearing that confirm its utility, with much more consistent mortality rates for sepsis and septic shock being reported from different countries.

**Discussion:** Sepsis-3 is being adopted into the new ICD-11 international coding system launching in 2019. In terms of research, some fascinating outputs have been recently forthcoming from re-analysis of large multicentre trials and in paediatrics. The Sepsis-3 Task Force recognized there would be some detractors as the definitions and criteria are necessarily based on opinion, albeit data-based, and the Task Force itself could not always achieve an unanimous view. However, controversy is welcomed as this encourages debate and further research.

**Take home messages:**

- Sepsis-3 has achieved very wide coverage since publication.
- Early studies confirm its utility in improving the quality of sepsis epidemiology and potentially improving clinical trials.
- Sepsis-3 cannot be the final word but will hopefully encourage the research needed to take the next steps forward.

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## I048. Importance of gastrointestinal symptoms in the ICU

*Joel Starkopf*

Department of Anaesthesiology and Intensive Care, University of Tartu, Tartu University Hospital, Estonia

**Learning objectives:** This lecture addresses the importance of gastrointestinal (GI) symptoms in ICU patient.

**Background:** The abdominal problems are common in ICU. They can be the initial indication for admission or often develop secondarily in course of underlying disease. The GI function in critically ill patients, however, is only vaguely assessed when compared to other organ systems. Large inconsistency exists in terminology describing GI symptoms and disorders, including the terms of GI dysfunction and GI failure. There is no single laboratory numerical or physiological sign available for trustworthy assessment of GI function in ICU patients. Recent publications demonstrate efforts undertaken in unification of terminology and definitions [1].

**Discussion:** Different GI signs may be observed in up to 60% of mechanically ventilated patients [2–4]. Twenty percent of ICU patients exhibit about three or more GI symptoms during their ICU stay. Six percent have three or more symptoms concomitantly, and this has been shown to be an independent predictor of mortality [4]. Especially high is the impact of GI symptoms if they develop secondarily, as shown in cardiac surgery patients [5, 6].

GI symptoms are difficult to evaluate in sedated, mechanically ventilated patient. High inter-individual variability further complicates the picture. Still, practitioners have to identify and document the symptoms like nausea and vomiting, absent peristalsis, gastroparesis and bowel paralysis, bowel dilatation and distension, diarrhoea, and intra-abdominal hypertension [1, 7]. Only few numericals are available for daily practice. Measurement of gastric residual volume (GRV) helps to detect gastroparesis if nasogastric tube is in place. A single gastric residual volume exceeding 200 mL and a total gastric residual volume above 1,000 mL 24 $h^{-1}$ could be considered as being increased [8].

However, these thresholds are arbitrary. GRV above 500 ml should be considered as a sign of gastroparesis. Increased GRV may be a sign of abnormal gastric emptying, which requires specific attention. In the future, gastric ultrasound may found its place for monitoring gastric filling.

Intra-abdominal pressure (IAP) measurement is well validated in ICU patients. IAP reflects the internal milieu for organs in abdominal compartment. Intra-abdominal hypertension (IAH) is often associated with GI symptoms, and is related to impaired outcome.

For assessment of severity of GI dysfunction, a descriptive grading system for Acute Gastrointestinal Injury can be applied [1]. Evaluation of GI symptoms is essential part of enteral feeding protocol. Further, recognition of particular GI symptoms may demand rapid imaging studies required for timely diagnosing of critical abdominal syndromes such as mesenteric ischaemia, bowel perforation, volvulus, or abdominal compartment syndrome.

**Take home messages:**

- GI symptoms occur in more than half of ICU patients and are associated with adverse outcome.
- Daily clinical evaluation remains the main bedside tool for assessment of GI function.
- Measurements of GRVs are useful for bedside assessment of gastric emptying.
- IAP measurements should be applied in patients at risk of development of IAH.
- Prompt recognition of symptoms related to time-critical abdominal problems is of crucial importance.

**Conflict of interest:** The author declares no possible conflict of interest in relation to the content of this abstract and presentation.

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## I049. How to set up a nutrition guideline in your unit? the evidence

*Joel Starkopf*

Department of Anaesthesiology and Intensive Care, University of Tartu, Tartu University Hospital, Estonia

**Learning objectives:** To discuss the existing recommendations on clinical nutrition and to provide ideas for implementing institutional nutrition protocols.

**Background:** The scientific evidence on clinical nutrition has summarized into recommendations by internationally recognized organisations on the field, ESPEN and ASPEN, and most recently by Surviving Sepsis Guideline (SSC) [1–4]. Whether and to what extent these recommendations are applicable to every ICU patient is discussable.

**Discussion:** ASPEN guidelines present the six-step nutrition bundle. The practitioners are encouraged to [1] assess patients on admission to ICU for nutrition risk, and calculate both energy and protein requirements to determine goals of nutrition therapy; [2] initiate enteral nutrition (EN) within 24–48 hours after admission to the ICU, and increase to goals over the first week of ICU stay; [3] to take steps to reduce risk of aspiration or improve tolerance to gastric feeding; [4] implement EN protocols with institution-specific strategies; [5] not to use gastric residual volumes (GRV) as part of routine care to monitor EN; and (6) start parenteral nutrition (PN) early when EN is not feasible or sufficient in high-risk or poorly nourished patients. All these points include some extent of difficulties at practical implication. For example, there is no universal and well-validated tool for nutrition risk assessment, and calculations for energy and protein requirements can be much debated. Recommendation to abandon GRV measurements stands in weak evidence and is not shared by all experts. In many ICUs the majority of patients stay for less than 7 days, and therefore the question of the priority of nutrition often arises.

SSC gives 13 recommendations on nutrition. Only four of them are strong recommendations, and the quality of evidence of them is only moderate. All others are weak recommendations either on moderate or low quality of evidence. Common to all recent guidelines is the preference given to EN over PN, albeit the evidence is not strong.

Many basic questions in nutrition and metabolism are still opened and remain to be addressed [5]. Among others, the effects of continuous versus intermittent feeding as well as high versus low protein diet, either combined with active mobilisation or not, require testing in further randomized controlled trials.

One complicating factor in setting of institutional protocol is that the impact of clinical nutrition on patient recovery

remains often hidden for intensivists. We also do not always recognize the shortcomings of nutritional therapy. The electronic patient data management systems for automatic calculation of calories and nutrients delivered, as well as indirect calorimetry, physiotherapy and/or dietician support are not uniformly available in ICUs through the European countries. The nursing standards, including the workload and level of independency, vary significantly.

All above-mentioned aspects make it impossible to recommend universally applicable nutritional protocol. Despite of this, each institution or department is encouraged to standardize their nutritional therapies in lines of current guidelines. The protocol should adapt the local case-mix and standards of care, and should be upgraded regularly according to the accumulating evidence and availability of new technologies. Importantly, the analysis of nutritional data of your own unit (similar to antibiotic stewardship) is of great value, and may provide arguments for structural changes in your daily practice. Every critically ill patient deserves an optimal nutritional regimen, and all possible tools and interventions should be applied to make this happen.

**Take home messages:**

- Lack of strong evidence behind of many consensus recommendations. Despite of this, the guidelines provide a good starting point for setting up your institutional protocol.
- Differences in case mix and available resources may result in different nutritional protocols.
- Enteral feeding should be preferred as a feeding route.
- Many of the common beliefs in nutrition and metabolism are still not sufficiently proven.
- **Conflict of interest:** none.

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## I050. Visualizing the endothelial glycocalyx


*Bernard M. van den Berg*

The Einthoven Laboratory for Vascular and Regenerative Medicine — Division of Nephrology, LUMC, Leiden, the Netherlands


**Learning objectives**: Endothelial cells perform key homeostatic functions such as regulating blood flow, permeability, and aiding immune surveillance for pathogens. While endothelial activation serves normal physiological adaptation, maladaptation of these endothelial functions has been identified as an important effector mechanism in the progression of renal disease as well as the associated development of cardiovascular disease. The primary interface between blood and the endothelium is the glycocalyx. This carbohydrate-rich gel-like structure with its associated proteins mediates most of the regulatory functions of the endothelium. Because the endothelial glycocalyx is a highly dynamic and fragile structure ex vivo, and traditional tissue processing for staining and perfusion-fixation usually results in a partial or complete loss of the glycocalyx, studying its dimensions and function has proven to be challenging. In this lecture, I will outline the core functions of the glycocalyx and focus on different techniques to study structure-function relationships in kidney and vasculature.

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## I051. Fluid use in resource-poor countries


*Robert Wise*

Critical Care Department, Edendale Hospital, Edendale, Kwazulu-Natal, South Africa


**Learning objectives:** There is very little data on fluid use in resource-poor countries. Intravenous fluid use in these countries is largely dictated by cost and availablility. Blood products are scarce and expensive, and may result in different fluid strategies compared to developed countries. As a consequence, hydroxyethyl starch may be used more often when compared to developed countries. Evaluation of haemodynamic status in resource-poor countries is most likely reliant on static markers and clinical accumen alone.

**Background:** Data about fluid use in resource-poor countries is scarce. Finfer et al published a large international cross-sectional study of resuscitation fluid practices in critically ill patients in 2010. However, only 1 of the 391 intensive care units (ICUs) involved was from a low-middle-income economy. Hammond et al. compared these findings to fluid resuscitation practices in 2014, but again there was very limited

involvement of low-middle-income countries (3 countries, 7 out of 426 ICUs). Added to this is the dearth of knowledge regarding transfusion practices in developing countries. The availablity of blood products is certainly more limited, even in fairly prosperous African countries, such as South Africa.

**Discussion:** Preliminary data being analysed from a low--middle-income country suggests the majorty of perioperative physicians use crystalloids in initial trauma resuscitation. Practices involving hydroxyethyl starch may differ from that of the developed world, particualry in trauma patients, where blood products are not always available. Interestingly, synthetic colloids appear to be frequently used in hypotensive trauma patients (with a normal haemoglobin) and who have not responded to crystalloid resuscitation. Recently published evidence on hydroxyethyl starch appears to have changed practice in developed countries, but it is still uncertain whether these practices have been adopted universally. Cardiac output monitors are not readily available in poorly resourced countries and thus infrequently used, with clinical signs and static markers forming the mainstay of intrasvacular volume assessment. Data pertaining to the availabliliy of blood products in resource-poor countries is lacking, however, information from South Africa shows a blood shortage crisis that will worsen with a dwindling donor population and a high HIV infection rate.

**Take** home messages:

- Critical care data, including that related to fluid use, from resource-poor countries is limited.
- Fluid pratices may differ from developed countries and are significantly influenced by cost and availability.
- Future research needs to actively find ways of including low and middle-income countries to positively influence the majority of the world's critical care practice.
- A cost-effective and clinically integrated critical care database can provide a solution for widespread data collection.

**Conflict of interest:** Dr Rob Wise declares that he has received a travel honorarium from the South African National Blood Service (not-for-profit organisation) for participation in the Saving Mothers Campaign in South Africa. He has no conflicts of interest with commerical companies.

**Acknowledgement:** Drs Marcelle Jagga and Guy Picken.

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## I052. Closing the colloid crystalloid debate: the glycocalix point of view

*Thomas E. Woodcock*

Intensive Care Medicine, Consultant, Fluidphysiology.org

**Learning onjectives:** Understand two important roles of the endothelial glycocalyx: Explain the Glycocalyx Model, or Michel Weinbaum Model, and the steady-state Starling Principle: Appreciate the role of context sensitivity in the way infused fluids are distributed after infusion: Learn to regulate the rate of resuscitation from low venular pressure (hypovolaemia) and avoid uncritical bolus therapy, e.g. "30 mL $kg^{-1}$" which is emerging as harmful.

**Background:** The presence of an intravascular gel phase that excludes red blood cells and impedes the intravascular distribution of larger molecules largely accounts for the dilutional anaemia associated with colloid resuscitation compared to crystalloid resuscitation. The glycocalyx model, or the Michel Weinbaum model, explains how the anatomic asymmetry of the vascular barrier causes functional asymmetry, a one-way valve mechanism that allows paracellular solvent filtration from plasma to the tissues but prevents absorption.

**Discussion:** Before the confirmation of the steady state Starling Principle 13 years ago (Adamson *et al.* 2004) it was reasonable to presume that biophysical oncotic pressure therapy should, at least temporarily, favour plasma volume expansion over tissue fluid volume. With understanding of the new physiology comes the realisation that rate-controlled crystalloid resuscitation from low venular pressure (hypovolaemia) makes more sense, while the colloid solutions are more effective at sustained fluid overloading to raised venular and capillary pressures with oedema.

**Take home message:** Context-sensitivity is an important factor in choosing a suitable intravenous infusion (or none). While venular & capillary pressure is low, rate-controlled crystalloid resuscitation is the physiologically-rational approach. If the prescribers objective is to achieve supranormal venular pressure and sustained plasma hypervolaemia colloid-containing solutions are physiologically rational,

though in the longer term (within 24 hours) oedema will be an inevitable price to pay.

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## I053. Basic science overview; the Michel Weinbaum glycocalyx model and the extravascular circulation of albumin and fluid

*Thomas E. Woodcock*

Intensive Care Medicine, Consultant, Fluidphysiology.org

**Learning objectives:** Emphasising the endothelial glycocalix as a luminal extension of intracellular structural proteins, regulating intracellular processes like intercellular adhesion and NO synthesis. It is continually growing/shedding.

**Background:** The glycocalyx model, or the Michel Weinbaum model, explains how the anatomic asymmetry of the vascular barrier causes functional asymmetry, a one-way valve mechanism that allows paracellular solvent filtration from plasma to the tissues but prevents absorption. Filtered fluid enters an extravascular circulation of extracellular fluid which parallels the circulation of the solute albumin. The transcapillary escape of albumin from plasma to interstitium is both convective (with paracellular glycocalyx-filtered fluid) and diffusive (through transcellular 'large pores').

**Discussion:** Before the confirmation of the steady state Starling Principle 13 years ago (Adamson *et al.* 2004) it was believed that capillaries formed a symmetric plasma — tissue barrier that filtered solvent when the hydrostatic Starling forces predominated, and reabsorbed filtered solvent when the osmotic Starling forces were greater. We now understand that the filtered solvent perfuses the extracellular matrix before entering the lymphatic vascular system. In health about half of the total lymph solvent flow is reabsorbed in lymph nodes by specialised fenestrated capillaries, while the remainder of the solvent and all the albumin solute continues to the thoracic duct which empties into the vena cava. In very recent developments an intracranial lymphatic vascular system has been discovered and a new description of cerebral fluid dynamics needs to be ascertained.

**Take home messages:** The dispositions of filtered fluid and albumin are to be considered features of dynamic equilibriums of two vital circulations rather than adjoining stagnant compartments of plasma and interstitial fluid. At any instant there is more extravascular than intravascular albumin, and when capillary permeability to albumin increases (surgery, trauma, sepsis etc) the proportion of total body albumin which is in the interstitium increases. Hypoalbuminaemia does not indicate low total body albumin.

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## I054. Basic science overview; plasma volume, tissue oedema and the steady-state starling principle

*Thomas E. Woodcock*

Intensive Care Medicine, Consultant, Fluidphysiology.org

**Learning objectives:** Emphasising the endothelial glycocalix as a luminal extension of intracellular structural proteins, regulating intracellular processes like intercellular adhesion and NO synthesis. It is continually growing/shedding.

**Background:** There is still much confusion amongst physicians about the role of albumin in determining plasma volume and tissue oedema which leads to irrational albumin therapy. In critical care practice it was demonstrated many years ago that there is no correlation between plasma [albumin] and oncotic pressure, and that with attention to fluid balance hypoalbuminaemia does not invariably cause oedema.

**Discussion:** Extracellular fluid contains lots of sodium and albumin compared with intracellular fluid, and it has been fashionable to ascribe tissue oedema to too much sodium and not enough albumin. Now that we know that plasma volume and interstitial fluid volume exist in a dynamic equilibrium of two extracellular fluid circulations we can look to the Starling forces that regulate Jv, the transendothelial fluid filtration rate from plasma to tissues, and $Q_{lymph}$, the lymph flow rate that returns interstitial fluid to the blood stream. If we raise capillary pressure and Jv by fluid loading or arteriolar vasodilation the proportion of interstitial fluid to plasma rises, while if we lower capillary pressure and Jv by venesection or arteriolar vasoconstriction plasma volume is protected while interstitial volume decreases with continued return of lymph until there is a new equilibrium where Jv = Qlymph. In severe acute reduction of capillary pressure the rebalancing of the steady-state Starling forces includes a transient and limited reabsorption of tissue fluid to protect the plasma volume, known as autotransfusion. In health the balance of plasma volume to interstitial fluid volume is mi-

nute-to-minute autoregulated through many neurohumoral mechanisms, of which the most important are natriuretic peptides opposed by the renin-angiotensin-aldosterone pathway. As atrial pressure rises, natriuretic peptide is secreted to bind and activate renal and peripheral vascular guanylyl cyclase/ natriuretic peptide receptor-A (GC-A/NPRA). While a change in vascular permeability to albumin is one of the consequences of GC-A/NPRA activation, the disposition of albumin is not the primary determinant of plasma volume. **Take home messages:** Successful treatment to manipulate plasma volume and tissue oedema requires an appreciation that they are interdependent and driven by the Starling forces at play in the steady state Starling principle. Neither albumin nor biophysical oncotic pressure therapy with exogenous colloid solutions boost plasma volume without increasing interstitial fluid volume.

**Reference:**

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## I055. CACU, critical and acute care ultrasound course

*Adrian Wong*

Oxford University Hospitals NHS Foundation Trust, UK

**Background:** Point-of-care ultrasound has become increasingly integrated into the practice of intensive care across with several accreditation programmes being developed by leading professional organisation and societies (ICS UK, CUSIC, SCCM, ESICM courses, Dutch ICS, ICARUS, WinFocus, HandsOnEcho and CACU in Belgium etc). This course incorporates aspects of all these programmes into a one-day innovative, modular course. Cross-over between morning and afternoon modules is possible.

**Learning objective:**

- Gain a foundation in the ultrasound skills needed for Intensive Care
- Interact with expert colleagues in the spirit of collaboration and shared learning
- Lectures and practical experience in:
- Transthoracic echocardiography and FATE,
  - Lung US and BLUE,
  - Abdominal US and FAST,
  - Vascular US;
- Ultrasound in shock and as a guide to fluid resuscitation and SESAME,
- Hands-on sessions with phantoms for vascular access and transesophageal echocardiography (advanced),
- Interactive cases and voting.

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## Open access papers published in Anaesthesiology Intensive therapy

The proceedings of the 6th iFAD will be published in the journal Medical Fluids in collaboration with Anaesthesiology Intensive Therapy (AIT). The editor-in-chief is Prof Dr Radoslaw Owczuk and Prof Dr Manu Malbrain is associate--editor for critical care. In the Anaesthesiology Intensive Ther 2017; 49(5) issue and this supplement you can read the meeting proceedings with the invited lectures together with the "poster" and "invited" abstracts. The proceedings of the 6th iFAD will be published in the journal Medical Fluids in collaboration with Anaesthesiology Intensive Therapy (AIT). The editor-in-chief is Prof Dr Radoslaw Owczuk and Prof Dr Manu Malbrain is associate-editor for critical care. In the Anaesthesiology Intensive Ther 2017; 49(5) issue and this supplement you can read the meeting proceedings with the invited lectures together with the "poster" and "invited" abstracts. For the third time, a number of invited reviews will be published during the iFAD meeting, dealing with fluid management, hemodynamic monitoring and ultrasound written by key-opinion leaders (Daniel Lichtenstein, Pietro Caironi, Robert Hahn, Jan Poelaert, Paul Elbers, Ruth Kleinpell, Manu L.N.G. Malbrain, David Muckart, Paul Marik… just to name a few). "Anaesthesiology Intensive Therapy" is the official journal of the Polish Society of Anaesthesiology and Intensive Therapy (editor-in-chief Prof Dr Radoslaw Owczuk). The journal, published five times a year, is targeted at the members of the Polish Society of Anaesthesiology and Intensive Therapy as well as physicians who specialize in these areas. Every issue contains original papers, commentaries, literature reviews, case studies, and letters to the Editors. The journal is indexed in Medline (PubMed), Elsevier, Index Copernicus (6.08) as well in the databases of the Polish Ministry of Science and Higher Education (6) and Polish Medical Library. The journal is financially supported by Polish Ministry of Science and Higher Educations under the "Index Plus" programme. The electronic copy is the primary one. Articles published in "Anaesthesiology Intensive Therapy" are free of charge without article processing charges (APC), the papers are listed on PubMed and the PDF's are available for download as Open Access via the website: http:// czasopisma.viamedica.pl/ait/index. We encourage researchers to submit their next paper to AIT as the journal is *PubMed listed, free of charge and available as Open Access*. Because the scientific programme has been doubled with the pre-congress courses we will only include a couple of editorials and review papers. All the other articles can be viewed and downloaded from the website under the Open Access CC BY Licence 4.0. Below follows the ist of iFAD review papers. Check out on the website https://journals.viamedica.pl/anaesthesiology_intensivetherapy/issue/view/3288.

## Editorials


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