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Original Paper

Meeting report of the 2nd International Fluid Academy Day. Part 3: results of the survey amongst critical care physicians on the knowledge of fluid management, hemodynamic and organ function monitoring

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Abstract ***Background*** Fluid management in the critically ill has been neglected for way too long and although the use of invasive and less invasive hemodynamic monitoring is steadily increasing in the ICU, many questions remain unanswered. Recent data suggest that fluids should be dealt with as any other type of medication and that perioperative optimisation and goal directed therapy guided by hemodynamic monitoring could improve outcome. Furthermore, new devices have become available to assess other organ functions, which, in combination with serum biomarkers could help the clinician with decision making. ***Objective*** To assess the awareness and current knowledge on fluid management and hemodynamic and organ function monitoring among critical care physicians attending the 2nd International Fluid Academy Day (iFAD) meeting. ***Methods*** A 21-item knowledge questionnaire was shown electronically to the participants of the 2nd international fluid academy day (iFAD) held on Saturday November 17th 2012 in Antwerp ("Radisson SAS Hotel Congress and Convention Centre", Antwerp, Belgium). Each question was shown before the lecture covering the topic under study. The same questions were repeated at the end of the iFAD to see whether a learning curve could be observed. Results from the two voting sessions were then compared. This paper reports on the global results of both parts of the questionnaire including knowledge questions (KQ) on fluid management, fluid responsiveness, hemodynamic and other organ function monitoring, totalling 10 KQ's on fluid management and 11 KQ's on organ function monitoring. The respondents also provided information on their country of residence, basic speciality and years of experience. Participants of the conference voluntarily completed the survey on the 21 knowledge questions via a voting system and the answers were recorded automatically and exported to an Excel worksheet. Statistical analysis was performed with SPSS software (version 17.0.1;SPSS, Chicago, IL, USA). A subgroup of respondents (n=89) also filled in a paper survey with 20 general questions, 4 questions on demographics, 8 questions on fluid management and 8 questions on organ function monitoring. ***Results*** Two hundred forty one (80.3%) of the 300 distributed voting pads among the 401 second iFAD participants were actively used during the conference day. The average overall score on the 21 knowledge questions on fluid management, fluid responsiveness, hemodynamic and organ function monitoring after the first vote was 20.4±13.8% *vs* 37.9±22.4% after the second vote ($p<0.0001$). Fifty three (20.7%) of the 241 voters also participated in the first iFAD meeting in 2011. The best score after the first vote was for Germany (that scored worst in the 2011 iFAD congress!), with a score of 26.3±14.0% after the first round and 43.7±12.8% after the second round. Russia had the worst score with 16.0±10.8% after the first round and 30.0%±18.4% after the second round. Although not statistically significant, residents in training had the best score with 21.8±14.3% after the first vote and also after the second vote with 41.0±24.2%, very closely followed by the intensivists with 5—15 years of experience (ANOVA, p=NS). Interestingly, the 14 people reporting 'not being a doctor' scored the best with 24.3±15.2% during the first round. Doctors reporting internal

medicine as their basic speciality training scored the best with 21.7±14.4%, closely followed by the emergency physicians. Surgeons scored the worst during the first round (18.9%±11.7). Also after the second vote, internal medicine specialists scored best with a total score of 41.7±23.0% and anaesthesiologists and intensivists scored worst but with only small, non-significant differences (ANOVA, *p*=NS). Not surprisingly, the bigger the ICU in which intensivists worked, the better the scores. The results of the subgroup of respondents (n=89) that also filled in a paper survey with general questions will also be reported herein. ***Conclusions*** With a global knowledge score of 20.4±13.8% after the first vote versus 37.9±22.4% after the second vote this survey confirms that there is a general lack of knowledge on fluid management, hemodynamic monitoring and assessment of preload parameters, fluid responsiveness and other organ function monitoring techniques. Since correct fluid management and early intervention with goal directed therapy to support end-organ function can reduce morbidity and mortality in critically ill patients, further educational efforts should be directed towards improving the knowledge on organ function monitoring to optimize and guide fluid management, and this is exactly the main purpose of the 3rd International Fluid Academy Days in 2013.

Key words albumin • cardiac output • colloids • crystalloids • fluid management • fluid responsiveness • knowledge • monitoring organ function • teaching • survey • voting

Introduction

The second International Fluid Academy Day (iFAD) was held on Saturday November 17th in 2012 at the Radisson Blu Astrid Hotel in Antwerp, Belgium (www.fluid-academy.org). This meeting was attended by 340 doctors, 28 faculty, 99 nurses together with 33 people form the industry totalling 500 healthcare workers. Fluid management in the critically ill has been neglected for way too long. Many questions with regard to the type of fluids, the timing and the dosing remain unanswered. Recent data and the results of large multicentre randomized controlled clinical trials suggest that fluids should be dealt with as any other type of medication with indications and contraindications and possible side effects [28]. Although the use of less invasive hemodynamic monitoring with either calibrated or uncalibrated techniques is steadily increasing in the intensive care unit (ICU), many questions with regard to their indications and pitfalls remain unanswered [2, 38]. Moreover, other techniques like microdialysis, bioreactance, electrical impedance tomography, and serum biomarkers have become readily available. Some studies suggest that perioperative optimisation with goal directed therapy (GDT) guided by hemodynamic monitoring could improve outcome. The aim of this survey was to assess the awareness and current knowledge on fluid management, fluid responsiveness, hemodynamic and other organ monitoring among critical care physicians attending the 2nd iFAD.

Methods

During the main medical iFAD symposium a voting system was used (n=300). A 21-item knowledge questionnaire was shown electronically to the participants of the second international fluid academy day (iFAD) held in Antwerp (Belgium) on November 17th in 2012. Each question was shown before the lecture covering the topic under study. The same questions were repeated at the end of the iFAD to see whether a learning curve could be observed. Results from the two voting sessions were compared. This paper reports on the global results of both parts of the questionnaire including 10 knowledge questions (KQ) on fluid management and 11 knowledge questions on hemodynamic and other organ function monitoring and fluid responsiveness. The respondents also provided information on their country of residence, basic speciality and years of experience. The results of the subgroup of respondents (n=89) that also filled in a paper survey with general questions (GQ) will also be reported herein. The paper survey consisted of 20 questions: with 4 general questions related to demographics, 8 general questions related to fluid management and finally 8 general questions related to monitoring.

Participants of the conference voluntarily completed the survey via a voting system and the answers were recorded automatically and exported to an Excel worksheet. Statistical analysis was performed with SPSS software (version 17.0.1;SPSS, Chicago, IL, USA). Continuous data were expressed by mean ± standard deviation (SD) and compared with the 2-tailed (un)paired Student's t test or Mann Whitney U test when appropriate. Categorical data were expressed as frequency distributions and/or percentages, and the Pearson Chi^2 or Fisher exact test was used when appropriate to determine intergroup differences. Two-sided p values of 0.05 or less were considered to indicate statistical significance.

Results

Demographics of respondents

Two hundred forty one (80.3%) of the 300 distributed voting pads among the 401 second iFAD participants were actively used during the conference day. The pri-

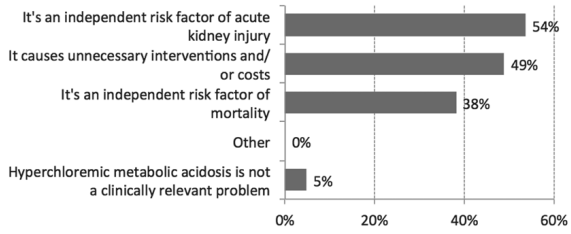

Fig. 1. Distribution of answers (in %) on general question 1 (GQ1): What do you think of the clinical relevance of hyperchloremic metabolic acidosis?

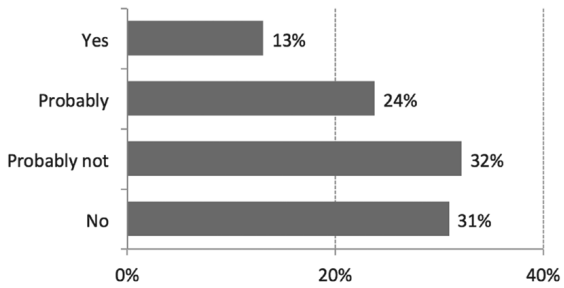

Fig. 2. Distribution of answers (in %) on general question 2 (GQ2): Do you think giving a balanced crystalloid with a potassium concentration of 5 mEq/L should be avoided in patients with a creatinine clearance less than 25 ml/min and normal saline used instead?

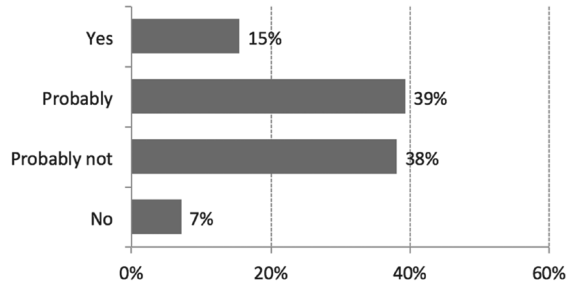

Fig. 3. Distribution of answers (in %) on general question 3 (GQ3): Do you think the normal use (respecting dosing limits) of balanced tetrastarch (e.g. VoluLyte, Tetraspan, PlasmaVolume Redibag,…) can induce acute kidney injury?

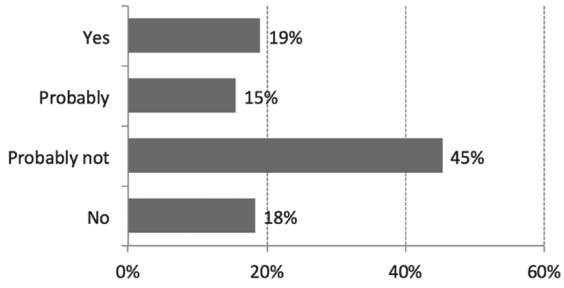

Fig. 4. Distribution of answers (in %) on general question 4 (GQ4): Do you think the use of hyperoncotic human albumin 20% is a problem in the treatment of patients with traumatic brain injury?

mary discipline of the respondents was anaesthesiology 37.8%, intensive care medicine 29.0%, emergency medicine 7.5%, internal medicine 16.2%, surgery 3.7% while 5.8% were not a doctor. The respondents resided in the following countries: Belgium 38.6%, The Netherlands 13.3%, United Kingdom 7.1%, Germany 7.9%, France 5.0%, Spain 4.6%, Poland 2.9%, Russia 2.1% and 18.7% came from other countries. With regard to the years of experience in the ICU, 32.1% (compared to 6.3% in 2011) answered to be in training, 9.6% had 1 to 5 years of experience, 19.6% between 5 and 15 and 32.9% stated to have more than 15 years experience, finally 5.8% answered not to be a medical doctor. Of our iFAD audience, 15.8% worked in an ICU with a maximum of 8 beds, 19.1% worked in an ICU with 9-15 beds, 29.9% worked in an ICU with 16—30 beds and 30.7% worked in an ICU with at least 30 beds (for 4.6% of our voters this question was not feasible).

From the subgroup (n=89) that also filled in a paper survey 53% came from Belgium, 20% from The Netherlands and 27% from other countries. From these 89 respondents 38% were in training, 22% had more than 15 years of experience, 18% had between 5 and 15 years of experience, 6% less than 5 years and 16% reported not to be a doctor. The primary speciality was anaesthesia in 19%, internal medicine in 22%, intensive care in 21%, emergency medicine in 10%, and surgery on 2% (the others not being a doctor).

Hyperchloremic metabolic acidosis

GQ1. What do you think of the clinical relevance of hyperchloremic metabolic acidosis? Possible answers were: 1) It's an independent risk factor of acute kidney injury, 2) It causes unnecessary interventions and/or costs, 3) It's an independent risk factor of mortality, 4) Other, or 5) Hyperchloremic metabolic acidosis is not a clinically relevant problem

Figure 1 shows the distribution of answers (in %) on GQ1. In total 54% answered "It's an independent risk factor of acute kidney injury", followed by 49% stating "It causes unnecessary interventions and/ or costs".

Balanced crystalloid solutions

GQ2. Do you think giving a balanced crystalloid with a potassium concentration of 5 mEq/L should be avoided in patients with a creatinine clearance less than 25 ml/min and normal saline used instead? Possible answers were: 1) Yes, 2) Probably, 3) Probably not and 4) No.

Figure 2 shows the distribution of answers (in %) on GQ2. In total 32% answered "Probably not", followed by 31% stating "no".

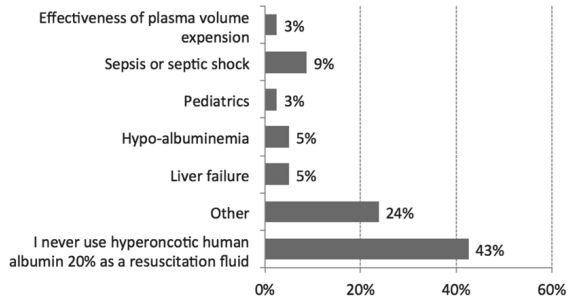

Fig. 5. Distribution of answers (in %) on general question 5 (GQ5): What is the primary reason you use hyperoncotic human albumin 20% as a resuscitation fluid?

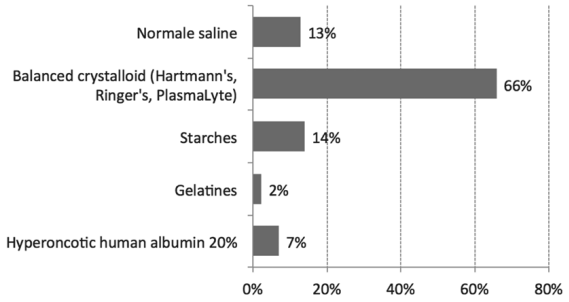

Fig. 6. Distribution of answers (in %) on general question 6 (GQ6): What would be your primary choice of fluids for an episode of hypotension in a fluid responsive patient with severe sepsis when his/her maintenance requirements are fully covered by enteral nutrition with a normal chest X-ray and FiO_2 40%

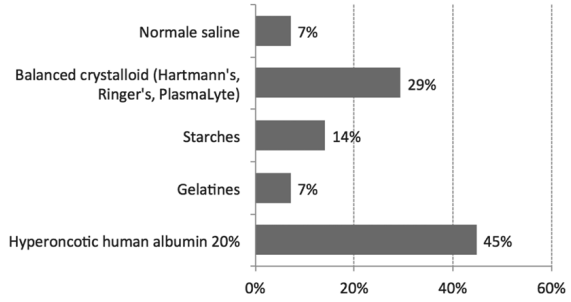

Fig. 7. Distribution of answers (in percentage) on general question 7 (GQ7): What would be your primary choice of fluids for an episode of hypotension in a fluid responsive patient with severe sepsis when his/her maintenance requirements are fully covered by enteral nutrition, his/her chest X-ray showing bilateral infiltrates and FiO2 of 100%

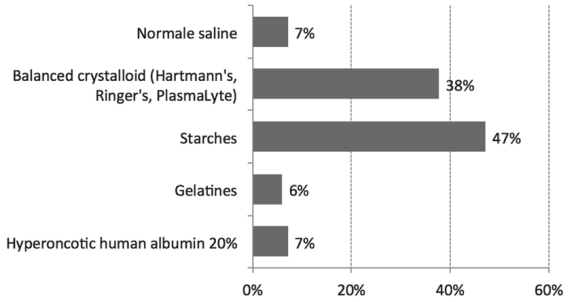

Fig. 8. Distribution of answers (in %) on general question 8 (GQ8): What is your primary choice of fluids for an episode of hypotension during trauma surgery when blood is not available

Balanced colloid solutions

GQ3. Do you think the normal use (respecting dosing limits) of balanced tetrastarch (eg VoluLyte, Tetraspan, PlasmaVolume Redibag,…) can induce acute kidney injury? Possible answers were: 1) Yes, 2) Probably, 3) Probably not and 4) No.

Figure 3 shows the distribution of answers (in %) on GQ3. In total 39% answered "Probably", followed by 38% stating "Probably not".

Hyperoncotic albumin in traumatic brain injury

GQ4. Do you think the use of hyperoncotic human albumin 20% is a problem in the treatment of patients with traumatic brain injury? Possible answers were: 1) Yes, 2) Probably, 3) Probably not and 4) No.

Figure 4 shows the distribution of answers (in %) on GQ4. In total 45% answered "Probably not", followed by 19% stating "Yes".

Indications for hyperoncotic albumin

GQ5. What is the primary reason you use hyperoncotic human albumin 20% as a resuscitation fluid? Possible answers were: 1) I never use hyperoncotic human albumin 20% as a resuscitation fluid, 2) Liver failure, 4) Hypo-albuminemia, 5) Pediatrics, 6) Sepsis or septic shock, 7) Effectiveness of plasma volume expansion, or 8) Other

Figure 5 shows the distribution of answers (in %) on GQ5. In total 43% answered "I never use hyperoncotic human albumin 20% as a resuscitation fluid", followed by 24% stating "Other".

Resuscitation fluid in sepsis without acute lung injury

GQ6. What would be your primary choice of fluids for an episode of hypotension in a fluid responsive patient with severe sepsis when his/her maintenance requirements are fully covered by enteral nutrition with a normal chest X-ray and FiO_2 40%? Possible answers were: 1) Normal saline, 2) Balanced crystalloid (Hartmann's, Ringer's, PlasmaLyte), 3) Starches, 4) Gelatines, or 5) Hyperoncotic human albumin 20%

Figure 6 shows the distribution of answers (in %) on GQ6. In total 66% answered "Balanced crystalloid

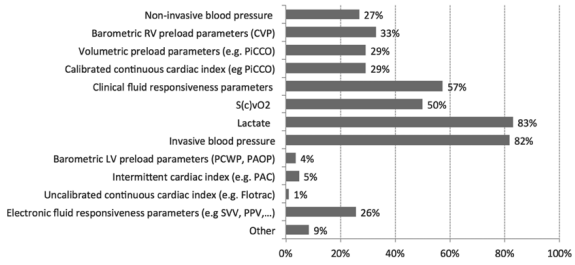

Fig. 9. Distribution of answers (in %) on general question 9 (GQ9): What do you consider the minimal monitoring for handling a patient with severe sepsis?

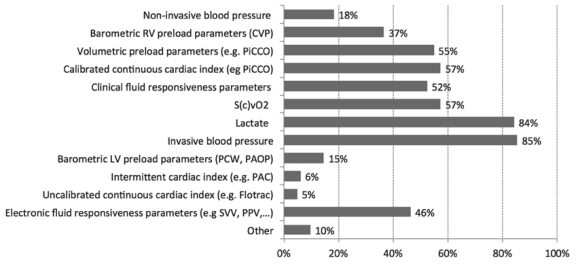

Fig. 10. Distribution of answers (in %) on general question 10 (GQ10): What do you consider the minimal monitoring for handling a patient with septic shock?

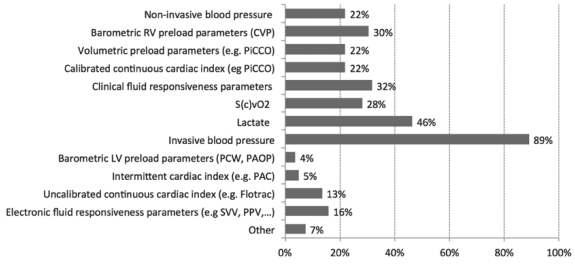

Fig. 11. Distribution of answers (in %) on general question 11 (GQ11): What do you consider the minimal monitoring for handling a patient during high risk surgery?

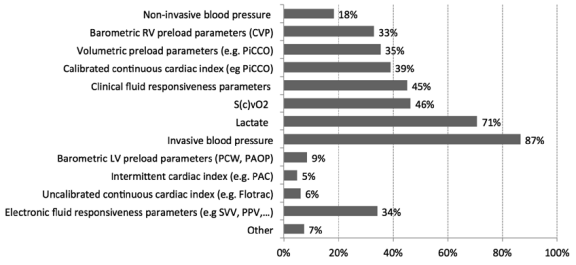

Fig. 12. Distribution of answers (in %) on general question 12 (GQ12): What do you consider the minimal monitoring for handling a patient in shock after major trauma?

(Hartmann's, Ringer's, PlasmaLyte)", followed by 14% stating "Starches".

Resuscitation fluid in sepsis with acute lung injury

GQ7. What would be your primary choice of fluids for an episode of hypotension in a fluid responsive patient with severe sepsis when his/her maintenance requirements are fully covered by enteral nutrition, his/her chest X-ray showing bilateral infiltrates and whose FiO_2 is 100%? Possible answers were: 1) Normal saline, 2) Balanced crystalloid (Hartmann's, Ringer's, PlasmaLyte), 3) Starches, 4) Gelatines, or 5) Hyperoncotic human albumin 20%

Figure 7 shows the distribution of answers (in %) on GQ7. In total 45% answered "Hyperoncotic human albumin 20%", followed by 29% stating "Balanced crystalloid (Hartmann's, Ringer's, PlasmaLyte)".

Resuscitation fluid during surgery

GQ8. What is your primary choice of fluids for an episode of hypotension during trauma surgery when blood is not available? Possible answers were: 1) Normal saline, 2) Balanced crystalloid (Hartmann's, Ringer's, PlasmaLyte), 3) Starches, 4) Gelatines, or 5) Hyperoncotic human albumin 20%

Figure 8 shows the distribution of answers (in %) on GQ8. In total 47% answered "Starches", followed by 38% stating "Balanced crystalloid (Hartmann's, Ringer's, PlasmaLyte)".

Monitoring in severe sepsis

GQ9. What do you consider the minimal monitoring for handling a patient with severe sepsis? Possible answers were: 1) Electronic fluid responsiveness parameters (eg SVV, PPV,…), 2) Uncalibrated continuous cardiac index (eg Flotrac), 3) Intermittent cardiac index (eg PAC), 4) Barometric LV preload parameters (PCWP, PAOP), 5) Invasive blood pressure, 6) Lactate , 7) $S_{(c)v}O_2$, 8) Clinical fluid responsiveness parameters, 9) Calibrated continuous cardiac index (eg PiCCO), 10) Volumetric preload parameters (eg PiCCO), 11) Barometric RV preload parameters (CVP), 12) Non-invasive blood pressure, or 13) Other.

Figure 9 shows the distribution of answers (in %) on GQ9. In total 83% answered "Lactate", followed by 82% stating "Invasive blood pressure" and 57% choosing "Clinical fluid responsiveness parameters".

Monitoring in septic shock

GQ10. What do you consider the minimal monitoring for handling a patient with septic shock? Possible answers were: 1) Electronic fluid responsiveness parameters (e.g SVV, PPV,…), 2) Uncalibrated continuous cardiac index (eg Flotrac), 3) Intermittent cardiac index (eg PAC), 4) Barometric LV preload parameters (PCWP, PAOP), 5) Invasive blood pressure, 6) Lactate , 7) $S_{(c)v}O_2$, 8) Clinical fluid responsiveness parameters, 9) Calibrated continuous cardiac index (eg PiCCO), 10) Volumetric preload parameters (eg PiCCO), 11) Barometric RV preload parameters (CVP), 12) Non-invasive blood pressure, or 13) Other.

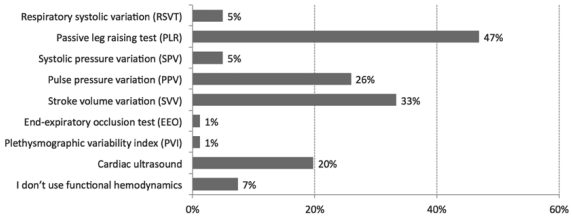

Fig. 13. Distribution of answers (in %) on general question 13 (GQ13): What is your preferred index or test for fluid responsiveness?

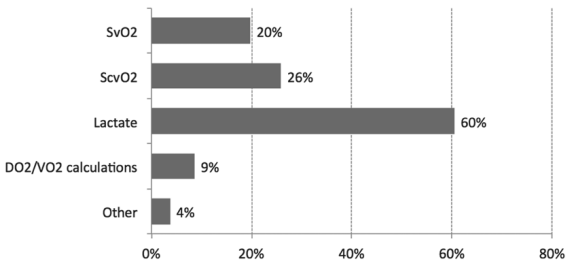

Fig. 14. Distribution of answers (in %) on general question 14 (GQ14): What is your preferred method to measure tissue oxygenation?

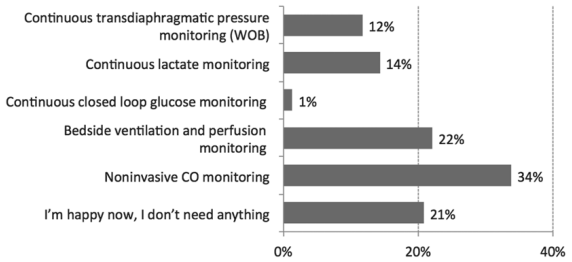

Fig. 15. Distribution of answers (in %) on general question 15 (GQ15): What would be the most valuable new technology development in your ICU?

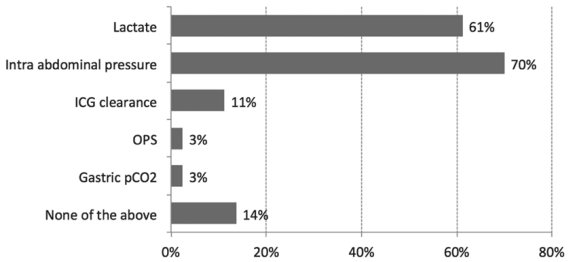

Fig. 16. Distribution of answers (in %) on general question 16 (GQ16): How do you assess hepatosplanchnic perfusion?

Figure 10 shows the distribution of answers (in %) on GQ10. In total 85% answered "Invasive blood pressure", followed by 84% stating "Lactate", and 57% choosing "Calibrated continuous cardiac index (eg PiCCO) either with or without $S_{(c)v}O_2$, measurement".

Monitoring during high risk surgery

GQ11. What do you consider the minimal monitoring for handling a patient during high risk surgery? Possible answers were: 1) Electronic fluid responsiveness parameters (e.g SVV, PPV,…), 2) Uncalibrated continuous cardiac index (eg Flotrac), 3) Intermittent cardiac index (eg PAC), 4) Barometric LV preload parameters (PCWP, PAOP), 5) Invasive blood pressure, 6) Lactate, 7) $S_{(c)v}O_2$, 8) Clinical fluid responsiveness parameters, 9) Calibrated continuous cardiac index (eg PiCCO), 10) Volumetric preload parameters (eg PiCCO), 11) Barometric RV preload parameters (CVP), 12) Non-invasive blood pressure, or 13) Other.

Figure 11 shows the distribution of answers (in %) on GQ11. In total 89% answered "Invasive blood pressure", followed by 46% stating "Lactate", and 32% choosing "Clinical fluid responsiveness parameters".

Monitoring in trauma

GQ12. What do you consider the minimal monitoring for handling a patient in shock after major trauma? Possible answers were:1) Electronic fluid responsiveness parameters (e.g SVV, PPV,…), 2) Uncalibrated continuous cardiac index (eg Flotrac), 3) Intermittent cardiac index (eg PAC), 4) Barometric LV preload parameters (PCWP, PAOP), 5) Invasive blood pressure, 6) Lactate , 7) $S_{(c)v}O_2$, 8) Clinical fluid responsiveness parameters, 9) Calibrated continuous cardiac index (eg PiCCO), 10) Volumetric preload parameters (eg PiCCO), 11) Barometric RV preload parameters (CVP), 12) Non-invasive blood pressure, or 13) Other.

Figure 12 shows the distribution of answers (in %) on GQ12. In total 87% answered "Invasive blood pressure", followed by 71% stating "Lactate", and 46% choosing "Measurement of $S_{(c)v}O_2$,".

Fluid responsiveness

GQ13. What is your preferred index or test for fluid responsiveness?

Possible answers were: 1) I don't use functional hemodynamics, 2) Cardiac ultrasound, 3) Plethysmographic variability index (PVI), 4) End-expiratory occlusion test (EEO), 5) Stroke volume variation (SVV), 6) Pulse pressure variation (PPV), 7) Systolic pressure variation (SPV), 8) Passive leg raising test (PLR), or 9) Respiratory systolic variation (RSVT).

Figure 13 shows the distribution of answers (in %) on GQ13. In total 47% answered "Passive leg raising test", followed by 33% stating "SVV", and 26% choosing "PPV".

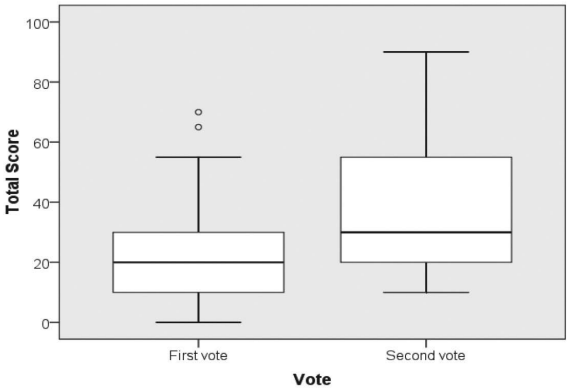

Fig. 17. Boxplots showing final total score on knowledge questions 1 to 21 (KQ1—KQ21) expressed as a percentage before the lecture (white box, first vote) and after the lecture had been given (white box, second vote) (p<0.0001)

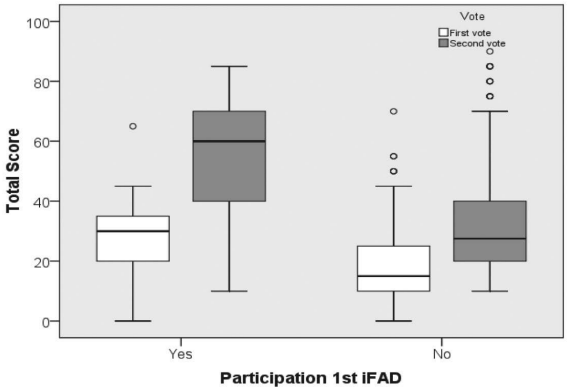

Fig. 18. Boxplots showing final total score on knowledge questions 1 to 21 (KQ1—KQ21) expressed as a percentage before the lecture (white box, first vote) and after the lecture had been given (grey box, second vote). People who attended the first iFAD had better scores than those who didn't, with 27.6±13.9% *vs* 18.4±13.1% respectively on the first vote (p<0.001), and 51.7±21.5% *vs* 34±21.2% respectively on the second vote (p<0.001)

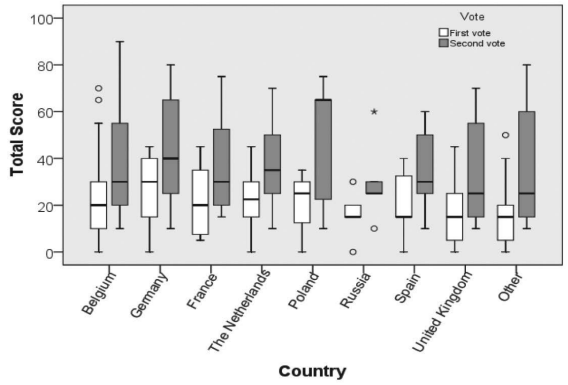

Fig. 19. Boxplots showing final total score on knowledge questions 1 to 21 (KQ1—KQ21) expressed as a percentage before the lecture (white box, first vote) and after the lecture had been given (grey box, second vote) and according to country of origin of participant (a significant increase was observed in all countries except Russia)

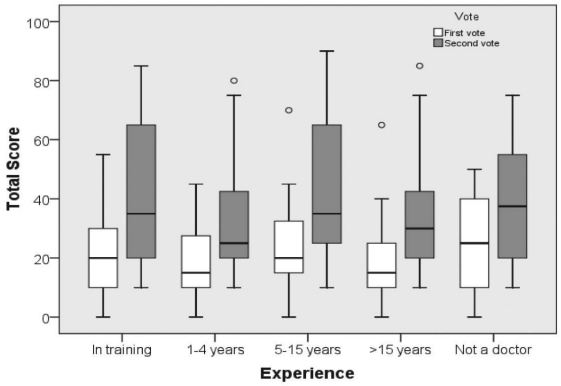

Fig. 20. Boxplots showing final total score on knowledge questions 1 to 21 (KQ1—KQ21) expressed as a percentage before the lecture (white box, first vote) and after the lecture had been given (grey box, second vote) and according to years of training of participants (a significant increase was observed in all groups)

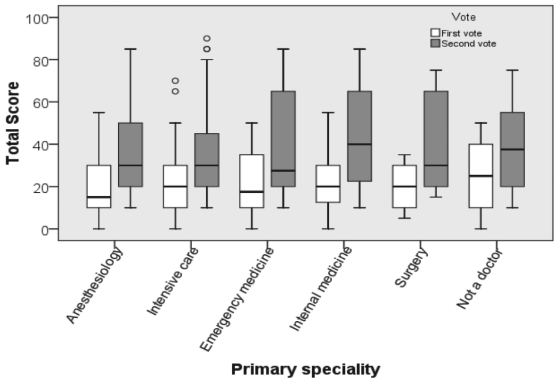

Fig. 21. Boxplots showing final total score on knowledge questions 1 to 21 (KQ1—KQ21) expressed as a percentage before the lecture (white box, first vote) and after the lecture had been given (grey box, second vote) and according to primary speciality. People working as internal medicine physicians had the best score after the first vote with 21.7±14.4% and also performed best after the second vote 41.7±24% (p<0.001)(a significant increase was observed in all groups).

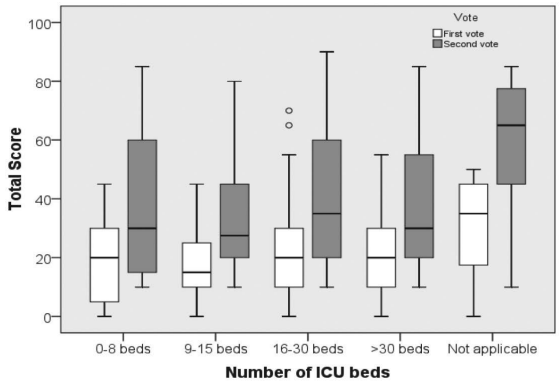

Fig. 22. Boxplots showing final total score on knowledge questions 1 to 21 (KQ1—KQ21) expressed as a percentage before the lecture (white box, first vote) and after the lecture had been given (grey box, second vote) and according to number of ICU beds (a significant increase was observed in all groups).

Monitoring of tissue oxygenation

GQ14. What is your preferred method to measure tissue oxygenation?

Possible answers were: 1) DO_2/VO_2 calculations, 2) Lactate, 3) $S_{cv}O_2$, 4) S_vO_2, or 5) Other).

Figure 14 shows the distribution of answers (in %) on GQ14. In total 60% answered "Lactate", followed by 26% stating "$S_{cv}O_2$", and 20% choosing "S_vO_2".

New ICU technology

GQ15. What would be the most valuable new technology development in your ICU? Possible answers were: 1) I'm happy now, I don't need anything, 2) Noninvasive CO monitoring, 3) Bedside ventilation and perfusion monitoring, 4) Continuous closed loop glucose monitoring , 5) Continuous lactate monitoring, or 6) Continuous transdiaphragmatic pressure monitoring (WOB).

Figure 15 shows the distribution of answers (in %) on GQ15. In total 34% answered "Noninvasive CO monitoring", followed by 22% stating "Bedside ventilation and perfusion monitoring", and 14% choosing "Continuous lactate monitoring".

Monitoring hepatosplanchnic perfusion

GQ16. How do you assess hepatosplanchnic perfusion? Possible answers were: 1) Gastric pCO2, 2) OPS, 3) ICG clearance, 4) Intra abdominal pressure, 5) Lactate, or 6) None of the above.

Figure 16 shows the distribution of answers (in %) on GQ16. In total 70% answered "Intra abdominal pressure", followed by 61% stating "Lactate", and 11% choosing "ICG clearance".

Final knowledge score on hemodynamic monitoring

The final total score obtained by adding the individual results for KQ1 to KQ21 is shown in Figure 17. A significant increase was observed in the total final score from 20.4±13.8% *vs* 37.9±22.4% after the second vote ($p<0.0001$). Fifty three (20.7%) of the 241 voters also participated in the first iFAD meeting in 2011. Figure 18 shows the evolution of the final score for the people who attended the first iFAD and those who did not. People who attended the first iFAD had better scores than those who did not with 27.6±13.9% *vs* 18.4±13.1% respectively on the first vote ($p<0.001$), and 51.7±21.5% *vs* 34±21.2% respectively on the second vote ($p<0.001$). The best score after the first vote was for Germany (that scored worst in the 2011 iFAD congress!), with a score of 26.3±14.1% after the first round and 43.7±12.8% after the second round. Russia had the worst score with 16.0±10.9% after the first round and 30.0%±18.4% after the second round. Figure 19 shows the evolution of the final score for each country (a significant increase was observed in all countries except Russia). Although not statistically significant, residents in training had the best score with 21.8±14.3% after the first vote and also after the second vote with 41.0±24.2%, very closely followed by the intensivists with 5—15 years of experience (ANOVA, p=NS). Interestingly, the 14 people reporting 'not being a doctor' scored the best with 24.3±15.2% during the first round. Figure 20 shows the results after the first and second vote with regard to years of training. Doctors reporting internal medicine as their basic speciality training scored the best with 21.7±14.4%, closely followed by the emergency physicians. Surgeons scored the worst during the first round (18.9%±11.7). Also after the second vote, internal medicine specialists scored best with a total score of 41.7±23.0% and anaesthesiologists and intensivists scored worst but with only small, non-significant differences (ANOVA, p=NS). Figure 21 shows the final score according to primary speciality. Not surprisingly, the bigger the ICU in which intensivists worked, the better the scores. Figure 22 shows the final score according to number of ICU beds.

Discussion

Fluid management

The answers to the general questions reveal some interesting points for further discussion. It is re-assuring that the majority of participants is convinced that hyperchloremic metabolic acidosis is a clinically relevant topic (with only 5% believing that it is not a clinically relevant topic), as this has been the subject of recent research (albeit retrospectively) [46]. Most of the respondents agree that hyperchloremic metabolic acidosis is related to organ failure, costs and consumption of ICU resources and even mortality [14, 43, 52]. However, as of today no large randomized controlled clinical trials are available comparing balanced *vs* unbalanced solutions, although there are some trials under way and as we speak a small pilot study examining the use of saline versus Plasma-Lyte A in initial resuscitation of trauma patients in a randomized fashion has been finished and published [50].

With regard to the capability of balanced solutions to reverse metabolic acidosis it is again re-assuring that the majority of respondents (63%) believe that giving a balanced solution with a potassium content of 5 mEq/L is not a problem in patients with a creatinine clearance less than 25 ml/min. In those patients administration of "normal saline" may further compromise kidney function and increase the serum potassium levels due to the metabolic acidosis.

On the other hand, only a small majority of respondents (54%) knows that the normal use (respecting

dosing limits) of balanced tetrastarch (eg VoluLyte, Tetraspan, PlasmaVolume Redibag,…) can induce acute kidney injury. Recent data from large randomized controlled trials confirmed that starches are an independent risk factor for acute kidney injury and the need for renal replacement therapy [37, 39].

Hypertonic solutions and especially small volume resuscitation (at a dose of 4ml/kg given over 10 minutes) may have some indications and beneficial effects over normal crystalloid or colloid administration, however a large portion of the participants (43%) stated never to use hypertonic albumin solutions [49, 51]. Recent data and results from meta-analyses confirm the potential beneficial effects of albumin (and especially hyperoncotic albumin 20%), in patients with septic shock and capillary leak, the majority of participants uses albumin to correct hypo-albuminemia in this setting [7, 8, 11, 47]. However one must avoid using hypo- or isotonic albumin in he setting of traumatic brain injury or intracranial hypertension [36]. On the other hand 64% of respondents believe that the use of hyperoncotic human albumin 20% is not a problem in the treatment of patients with traumatic brain injury, and this is probably correct. It should be reserved for those cases where serum albumin levels are below 24 g/L a positive cumulative fluid balance and end-organ dysfunction like increased Intraabdominal pressure or acute lung injury. Albumin administration should be guided towards serum albumin levels of 30g/L and normalization of colloid oncotic pressure [32].

Fluid management in severe sepsis with normal lung function is mainly based on administration of balanced crystalloids (66% of respondents) and starches (14%) in order to rapidly restore the intravascular space and avoidance of large amounts of fluid given that may result a positive cumulative fluid balance. However animal data showed that colloids but not crystalloids prevent increase in the gut wet-to-dry ratio colloids gut oedema [22, 42]. Increased gut oedema on the other hand results in diminished intestinal contractility [48]. Decreased contractility may further promote ileus, intestinal swelling, increased Intraabdominal pressure, mesenteric vein compression and venous hypertension, triggering a vicious cycle leading to more fluid administration [3, 23, 26, 27]. Although few data are available to support their general use, it is also good to know that the majority of iFAD participants are using balanced last generation starches as their preferred colloid [16, 21]. In case of severe sepsis with chest X-ray showing bilateral infiltrates and FiO_2 of 100%, the majority of the respondents (45%) would now be in favour of using hyperoncotic human albumin 20%. Indeed hyperoncotic solutions have been shown to be able to mobilize peripheral oedema in patients with acute lung injury or acute respiratory distress syndrome and increased extravascular lung water in the setting of capillary leak and fluid overload [8, 33, 34].

The last word has not been said with regard to the eternal colloid *vs* crystalloid debate, however in view of the results of the recent large multicentre trials one must be very cautious when it comes to fluid administration, and the best fluid is probably the one that has not been given [13, 37, 39]. The preferred fluids for an episode of hypotension during trauma surgery when blood is not available were starches (47%) followed by balanced crystalloids (38%). Indeed recent studies, reviews and meta-analyses using starches in a goal directed setting during perioperative optimization showed beneficial results [6, 9, 10, 12, 15, 18]. A mixed fluid regimen approach as suggested by Prof Jean-Louis Vincent, combining crystalloid maintenance fluid with a mixture of new generation balanced waxy maze starches (during trauma and bleeding), hyperoncotic albumin and blood products seems the best option to guarantee that the oxygen gets to the tissues. In real life we do drink different types of fluids, we may start with an aperitif, have some wine and water, and end with a coffee followed by a digestif. Starting with the coffee may compromise later food digestion… Fluids must be seen and treated as any other drug we give to our patients with indications and contra-indications and possible side effects on renal and liver function and coagulation parameters [28, 30]. Avoiding fluid overload and avoiding a positive cumulative fluid balance with the instauration of late conservative fluid management or even late goal directed fluid removal may even have a greater impact on outcome than the initial early goal directed therapy [35].

Hemodynamic and organ function monitoring, preload and fluid responsiveness

In order to guide our fluid management we must perform hemodynamic monitoring and while the pulmonary artery catheter may have become obsolete after the negative trials [4, 5, 17] it is always better to perform some kind of monitoring because clinical examination with estimation of CO is far from accurate [30]. Noninavsive CO monitoring devices have gained their place in the modern ICU and the calibrated transpulmonary thermodilution techniques (with PiCCO or EV1000) seem most popular in difficult unstable critical care patients with changing conditions of preload, afterload and contractility. In patients with severe sepsis, the majority of respondents consider invasive blood pressure (82%) and lactate measurements (83%) as their minimal monitoring tools, followed by clinical fluid responsiveness parameters (like passive leg raising test) in 57% and $S_{(c)v}O_2$ measurements in 50% of cases. Passive leg raising is preferred because this does not administer exogenous fluids to the patient [29, 31]. Minimal invasive or less invasive cardiac output monitors are only used in 29% and 27% respectively in severe sepsis. A majority (33%) still prefers barometric preload indicators (CVP) as compared to volumetric ones (29%). In patients with septic shock on the other hand more respondents will

now choose for calibrated CO monitoring (57%) and volumetric preload indicators (55%), while invasive blood pressure monitoring (85%) and serial lactate measurements (84%) still form the cornerstone of minimal monitoring. During high risk surgery next to the same basic monitoring parameters, barometric (CVP) preload (32%) and clinical fluid responsive parameters (33%) are mostly used, while in major trauma these are clinical fluid responsive parameters (45%) and $S_{(c)v}O_2$ measurements (46%).

Assessment of fluid responsiveness may even be more important than defining cardiac preload since regardless of a low, normal or high preload the patient may still be fluid responsiveness. It is re-assuring that only 7% from the participants stated that they never use functional hemodynamic parameters, although the ultimate goal should be that every-one uses these parameters before fluid administration. The use of SVV (33%) or PPV (26%) in combination with the passive leg raising test (47%) or the end-expiratory occlusion test (1%) may prevent unnecessary fluid boluses from being administered to the patient [31]. Cardiac ultrasound is used in 20% and can indeed be considered as a gold standard and the "modern stethoscope" for the intensivist. The European definition of shock states that a patient is in shock when there is a mismatch between oxygen delivery and oxygen consumption, as evidenced by increased lactate levels. The majority of participants (60%) indeed stated to use lactate levels in shock patients to assess tissue oxygenation, followed by $S_{cv}O_2$ (26%) and S_vO_2 (20%), while only few perform DO2/VO2 calculations (9%) [1, 19, 20]. Gastro-intestinal dysfunction and hepatosplanchnic perfusion is hard to measure and quantify at the bedside and this was the subject of a recent consensus report and multicentre study [44, 45]. The mechanism of gastro-intestinal injury (related to increased vascular permeability) is widely recognized and accepted in the lung and kidneys, where it is classified as acute lung and kidney injury (ALI/AKI) [24]. The same pathological process occurs in the gut, but this concept is much slower to seep through. However, the role of the gut as the motor of organ dysfunction syndrome cannot be denied and difficulties in assessing gut function should not deter us from recognizing that concept [25]. The majority of the respondents (70%) believe that Intraabdominal pressure is the key factor to assess hepatosplanchnic perfusion, followed by lactate and indocyanine green plasma disappearance rate, while only few use orthogonal polarization spectroscopy (3%) or gastric tonometry (3%). New techniques like the measurement of serum levels of citrulline and i-FABP may help us to better understand the impact of sepsis on the GI tract [40, 41].

Amongst future techniques and the most valuable new technology development most respondents answered in favour of noninvasive cardiac output monitoring (34%), followed by bedside ventilation and perfusion monitoring (22%) and continuous lactate monitoring (14%). These future techniques may help us to better guide our fluid management.

Conclusions

With an average total global knowledge score of 20.4±13.8% after the first vote versus 37.9±22.4% after the second vote this survey confirms that there is a general lack of knowledge on fluid management, hemodynamic monitoring and assessment of preload parameters, fluid responsiveness and other organ function monitoring techniques. Since correct fluid management with fluids treated as drugs is extremely important, further educational efforts should be directed towards improving the knowledge on hemodynamic and organ function monitoring to guide this fluid management. This can be done by organising state of the art lectures and evaluating acquired knowledge with a voting system to detect a positive learning curve. The future of fluid management and hemodynamic monitoring depends not only on new fluids and new technologies but also on our recognition of the complexities of hemodynamic monitoring in relation to guiding our fluid management. Where physical examination has been the cornerstone in medicine for decades, "physiological" examination, incorporating information that can be obtained with modern technologies at the bedside is the path to follow.

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