Perioperative fluid therapy recommendations for major abdominal surgery. Via RICA recommendations revisited. Part I: Physiolo....

Article · May 2017
DOI: 10.1016/j.redare.2017.02.009

CITATION
1

READS
172

8 authors, including:

Javier Ripollés-Melchor
Hospital Universitario Infanta Leonor
106 PUBLICATIONS 160 CITATIONS

Daniel Chappell
Ludwig-Maximilians-University of Munich
135 PUBLICATIONS 3,602 CITATIONS

Angel Vicente Espinosa
Örebro University Hospital
41 PUBLICATIONS 113 CITATIONS

Alfredo Abad Gurumeta
Hospital Universitario Infanta Leonor, Madrid...
161 PUBLICATIONS 160 CITATIONS

Some of the authors of this publication are also working on these related projects:

- Perioperative Fluid Therapy View project
- PALANCE Study View project
SPECIAL ARTICLE

Perioperative fluid therapy recommendations for major abdominal surgery. Via RICA recommendations revisited. Part I: Physiological background

Recomendaciones de fluidoterapia perioperatoria para la cirugía abdominal mayor. Revisión de las recomendaciones de la Vía RICA. Parte I: Fundamentos fisiológicos

J. Ripollés-Melchor a,*, D. Chappell b, Á. Espinosa c, M.G. Mhyten d, A. Abad-Gurumeta a, S.D. Bergese e, R. Casans-Francés f, J.M. Calvo-Vecino g

a Departamento de Anestesia, Hospital Universitario Infanta Leonor, Universidad Complutense de Madrid, Madrid, Spain
b Departamento de Anestesia, Hospital Universitario LMU de Múnich, Múnich, Germany
c Departamento de Anestesia Cardiovascular y Torácica, y Cuidados Intensivos, Bahrain Defence Force Hospital, Riffa, Bahrain
d University College London Hospital, National Institute of Health Research, Biomedical Research Centre, Londres, United Kingdom
e Departamento de Anestesia y Neurocirugía, Wexner Medical Center, The Ohio State University, Columbus, OH, United States
f Departamento de Anestesia, Hospital Clínico Universitario Lozano Blesa, Zaragoza, Spain
g Departamento de Anestesia, Complejo Asistencial de Salamanca, Universidad de Salamanca, Salamanca, Spain

Received 21 January 2017; accepted 8 February 2017

Introduction

About 230 million patients undergo surgery each year.1 Reported mortality rates for elective non-cardiac surgery range from 1% to 4%.2 Although less than 15% of in-patient procedures are performed in high-risk patients, such patients account for 80% of deaths.3

Since postoperative complications lead to a decrease in long-term survival and an increase in hospital costs,1,5 different perioperative strategies have been introduced in an attempt to reduce these complications and improve quality patient recovery. In the late 1990s, Henrik Kehlet introduced a comprehensive concept of perioperative care, known as
'enhanced recovery after surgery' (ERAS), or the Enhanced Recovery Protocol (ERP), aimed at reducing surgery-related physical and psychological stress, which in turn reduces the rate of perioperative complications, and ultimately hastens full recovery. In 2014, the Spanish Ministry of Health published a suite of recommendations on perioperative management of patients undergoing major abdominal surgery within ERAS.

Perioperative fluid management is one of the most widely discussed topics, especially in major surgeries associated with considerable stress response, altered capillary permeability, and large fluid shifts. Fluid therapy is a complex intervention at multiple levels. The maintenance of appropriate fluid levels in the perioperative period is crucial. Postoperative increase in body weight, a sign of hypervolemia and a manifestation of interstitial oedema, is strongly correlated with postoperative complications, including the pulmonary, cardiac, gastrointestinal, and renal. Hypovolemia leads to tissue hypoperfusion and altered organ function. Therefore, both hyper- and hypovolemia can contribute to morbidity and mortality (Fig. 1).

The following review aims to expand and revisit the fluid therapy recommendations included in RICA from a physiological point of view.

Physiological background

Body fluid distribution

Water makes up approximately 60% of the total body weight in the adult, although the ratio of water to adipose tissue varies widely with weight, age and gender. Water is distributed in the two main compartments of the body: the intracellular compartment (the largest, representing about two thirds of body water), and the extracellular compartment, comprising the plasma and the interstitial compartments. The interstitial compartment is actually a matrix, a collagen/gel substance that gives the interstitium its structural rigidity and resistance to gravity, and can maintain structural integrity during extracellular volume depletion. The collagen/gel interstitial space is an important reservoir of extracellular fluid (Fig. 2).

The endothelial surface layer

The Starling principle governs the displacement of fluids between vascular and interstitial spaces, and is determined by the balance between the hydrostatic pressure and colloid osmotic pressure in both spaces. It does not really determine the plasma/interstitium distribution ratio, but rather explains the movement of water across the capillary wall. Hence, the classic Starling principle was modified to accommodate the "glycocalyx concept", in which not only the endothelial cell line, but also the surface layer of the vascular endothelium as the physiologically active barrier. This goes against the original Starling principle, in which only the endothelial cell line is responsible for the vascular barrier function.

The vascular endothelium is the key barrier between the intravascular and interstitial spaces. The movement of water and solutes between these two compartments occurs through a double capillary membrane, and can follow the modified Starling equation and the so-called "glycocalyx-Junction-break model". The vascular endothelium is a single cell layer covering the luminal face of all blood vessels. On the vascular side of the endothelial cells lies a continuous layer of glycosaminoglycan chains, membrane-bound proteoglycans and glycoproteins that collectively form the endothelial glycocalyx. This basal skeleton binds albumin, forming an endothelial surface layer interacting dynamically with all blood constituents. It has now been established that the endothelial glycocalyx, besides being a physical barrier between the blood and the middle layer of the vessels or tissue in the case of capillaries, has a key role in maintaining vascular homeostasis, contributing to vascular tone regulation and mechanical impulse
transduction, and is also responsible for variations in red blood cell velocity. Furthermore, it participates in numerous physiological processes, including vascular permeability, adhesion of leukocytes to the vessel wall, transmission of shear stress, and modulation of inflammatory and haemostatic processes. The endothelial glycocalyx is considered the natural gateway to the interstitial space. Under physiological conditions, the endothelial surface layer (ESL) has a thickness of approximately 1 μm and binds approximately 800 mL of blood plasma, so that plasma volume can be divided into 2 parts: circulating and non-circulating. Physiologically, the ESL has been estimated to comprise as much as 25% of the total intravascular space. The presence of a healthy vascular membrane maintains a barrier to prevent excessive fluid shifts. It acts as a primary molecular filter, retaining proteins and generating an effective oncotic gradient. A small space between the wall of the anatomical vessel and the ESL remains almost free of proteins, so that fluid loss across the vascular barrier is limited by oncotic pressure gradient within the ESL (Fig. 3).

Preserving the glycocalyx

There are two prerequisites for a functioning vascular barrier: an intact endothelial glycocalyx, and a sufficiently high concentration of albumin which is able to bind (electrostatically) to the endothelial glycocalyx, thereby forming a tight meshwork hindering passage of colloids through the ESL. The intact vascular barrier cannot be penetrated by large molecules and proteins in relevant amounts, and it therefore enables the circulation to generate a positive intravascular blood pressure without excessive loss of fluid into the interstitial space.

The endothelial glycocalyx structure is fairly stable under physiological conditions, maintaining a balance between the synthesis of new glycans and shear-dependent shedding of exiting glycans. Degradation of the endothelial glycocalyx is associated with capillary leakage and oedema formation; this can occur in inflammatory states, including perioperative states, ischaemia–reperfusion, sepsis, or trauma. Thus, the preservation of the glycocalyx must be considered in any perioperative fluid therapy strategy in order to minimize fluid displacement. Administration of excessive fluids will result in hypervolemia and a subsequent increase in intravascular hydrostatic pressure resulting in the release of certain substances, such as atrial natriuretic peptides, which can damage the endothelial glycocalyx. Fluid shifts from the intravascular to the interstitial space can be classified into 2 types: type 1, occurring even when the vascular barrier is intact, including the passage of an almost protein-free fluid in the interstitium; and type 2, which consists of fluids containing protein close to plasma concentration, crossing an altered vascular barrier. Following surgery, this shift occurs for 3 reasons: First, increased protein permeability of capillaries and venules by endothelial damage caused by mechanical stress or inflammation due surgical manipulation. Secondly, reperfusion injury and inflammatory mediators that alter the vascular barrier. Thirdly, iatrogenic hypervolemia. Type 1 fluid shifting should be minimized by adequate monitoring and limitation of fluids. Reducing the endocrine and immune response that leads to surgery can decrease glycocalyx disruption and limit type 2 alterations. Prophylactic fluid boluses to anticipate acute bleeding or to extend intravascular blood volume in a normovolaemic patient is unreasonable. Selecting the right fluid for each situation is key. Rehm et al. infused a large colloidal bolus to expand blood volume, and observed a reduced intravascular volume effect of around 40% of the infused amount. As the other 60% seems to have been shifted towards the interstitial compartment, generating tissue oedema. This application of iso-oncotic colloids outside a proper indication significantly reduced the total volume of the endothelial surface layer to 1/3 of the initial value, presumably altering vascular biology; likewise, liberal administration of crystalloid solution without proper indication can result in pronounced extravasation. The association of inadequate fluid (both in type and quantity) and surgical stress causes a decrease in plasma albumin, and promotes inflammation, glycocalyx degradation, and the formation of interstitial oedema due to vascular leakage.

Figure 3 Electronic microscope image of a left ventricular myocardial capillary in a rat model (a) perfused with an alcian blue 8GX staining solution, or (b) treated with hyaluronidase before staining. Bar = 1 μm. (Courtesy of B.M. van den Berg [38]).
fluid must be chosen in accordance with the compartment it is needed to fill: colloids for intravascular space, and crystalloid for the extracellular space, to replace insensible losses and urine output. It becomes apparent that accurate measurement of perioperative fluid losses is essential.

**Intraoperative fluid loss**

A conventional infusion regimen during major surgery should be based on physiological considerations. Patients undergoing major abdominal surgery often receive preoperative crystalloid loading, e.g. 2 mL/kg/h of fasting, and then additional crystalloids to replace blood losses. Frequently patients receive 4–8 mL/kg/h of crystalloid, based on suspected ongoing losses, such as third spacing and perspiration. This formula may result in basal crystalloid infusion rates of up to 20 mL/kg/h, which means 1.6 litres in an 80 kg adult.

Fluid shift is a common phenomenon during and after surgical procedures; however, preoperative fluid deficit and perioperative insensible losses are usually overestimated for 3 reasons: the belief in the existence of the so-called “third space”; preoperative fasting; and insensible losses due to surgical body exposure. Despite the evidence, the misleading concept of a third anatomic space that should be refilled persists. The third space refers to sequestration of fluid in a non-functional extracellular space that is beyond osmotic equilibrium with the vascular space; however, classical third-space fluid losses have never been measured directly, and actually do not exist. 52

In the last 50 years, many studies have reported high fluid loss due to perspiration in major abdominal surgery: (bodyweight + 40) (kg) × 1 (mL/kg/h). 53 Lamke et al. experimentally evaluated insensible perspiration and showed that it was highly overestimated; they calculated that baseline evaporation during extended abdominal surgery was approximately 0.5–1 mL/kg/h at the most. 54

The impact of preoperative fasting is also seriously overestimated. Even after prolonged pre-operative fasting, patients remain intravascularly normovolaemic; preoperative fasting, therefore, does not increase the proportion of responders to a PLR test. 55, 56

**Maintenance fluid therapy**

A maintenance balanced fluid therapy is recommended in order to avoid fluid overload

”The objective of care is to maintain normal physiology and normal function of organs, with a normal blood volume, functional body water and electrolytes. This can never be achieved by inundation”. 58 These principles proposed by Moore and Shires in the 1960s remain in force today. Many recent trials and papers have addressed the important issue of restrictive versus liberal fluid strategies in the perioperative setting. 59, 60 The difficulty of interpreting the different results originates from the lack of definition and standard criteria for “restrictive” and “liberal” fluid management, and has prevented the development of guidelines for perioperative fixed-volume regimens. 61 Rahbari et al. proposed standardized definitions for the terms standard, restrictive and supplemental fluid therapy. A meta-analysis suggests that in patients undergoing colorectal resection, restrictive rather than standard fluid substitution reduces postoperative morbidity (OR 0.41 (95% CI 0.22–0.77); P = 0.005), but it included only 4 small studies, involving a total of 393 patients. 62 Varadhan and Lobo proposed a new classification of perioperative fluid management, defining it as balanced (1.75-2.75 L/24h) or imbalanced. The balanced group presented a 59% reduction in risk of developing complications and a shorter length of stay. 63 Recently published clinical practice guidelines, using the same definitions, found similar results. Their recommendation was to perform balanced fluid maintenance until the start of oral tolerance. Remarkably, they even found a decreased hospital stay of more than 2 days. 64

Maintenance fluid should be administered to maintain a patient’s pre-operative weight by replacing ongoing losses, such as from urine and insensible perspiration. Infusion of balanced crystalloid should not normally exceed 3 mL/kg/h, as perspiration losses are typically only 0.5–1.0 mL/kg/h even during major abdominal surgery. 65

Recently, perioperative fluid utilization and associated outcomes of colorectal surgery were evaluated by a retrospective analysis of 106,900 patients in US Premier Research Database. The analysis revealed that both highly restrictive and liberal fluid strategies used on the first operative day result in worse outcomes compared to a zero-balance fluid therapy. 66 The findings suggest that an applicable, protocol-based approach to optimal fluid management may improve outcomes, and confirm the traditional fluid volume infused vs. complications curve (Fig. 2). As stated by the British Consensus Guidelines for Intravenous Fluid Therapy in Adult Surgical Patients, 67 correction of volume deficit during major surgery should be directed towards a particular goal.

The upcoming results of the RELIEF study (NCT01422150) might determine whether liberal or restrictive maintenance fluid therapy is more beneficial. This will be the largest perioperative fluid study to date, a randomized controlled trial of liberal (Intraoperative and first 24 h ≈ 5 L) vs. restrictive (intraoperative and first 24 h ≈ 2.5 L) fluid therapy in over 2800 patients undergoing elective intra-abdominal surgery.

**Crystalloids**

The most widely used intravenous crystalloid is still 0.9% saline. 68 The use of the term “normal” may have contributed to the widespread acceptance of 0.9% saline into clinical practice. Despite being referred to as “normal”, 0.9% saline is not physiologically “normal” at all. 69 Firstly, compared to human serum, saline has nearly 10% higher Na concentration and 50% higher Cl concentration. Secondly, the strong ion difference (SID) of 0.9% saline is “zero” and differs completely from that of plasma (approx. +40). Large volume infusions of 0.9% saline can cause hyperchloaemia acidosis, 69 which is associated with reduced gastric blood flow, reduced mucosal pH and delayed recovery of gut function. 70 Furthermore, hypochloaemia may also adversely affect renal
function due to renal vasoconstriction, mediated primarily by effects on afferent and intrarenal arterial vessels.

Unlike 0.9% saline, buffered crystalloid solutions contain physiological or near physiological amounts of chloride. The key differences between 0.9% saline and buffered/balanced crystalloids is the presence of metabolizable anions, such as lactate, acetate, malate or gluconate, which act as physiological buffers to generate bicarbonate. Despite the fact that buffered crystalloid fluids more closely resemble the composition of human plasma, no perfectly balanced or physiologically "normal" crystalloid fluid is currently available (Table 1).

There are few studies comparing the effect of 0.9% saline and buffered/balanced crystalloids during the perioperative period. Most randomized trials to date have included few patients and analyzed physiological and/or biochemical outcomes. These studies showed balanced crystalloid infusion to have a better biochemical profile, but could not demonstrate a difference in either postoperative complications or hospital length of stay. Recently, the Saline versus Plasma-Lyte for Intravenous Fluid Therapy (SPLIT) research program showed that the use of a buffered crystalloid compared with saline did not reduce the risk of acute kidney injury (AKI) in patients admitted to intensive care units (9.6% vs. 9.2%). Within the SPLIT program, a single-centre, double-blind, crossover trial in 1380 major surgical patients was unable to show a decrease in AKI: 52 (10.9%) patients in the Plasma-Lyte 148 group compared to 59 (9.3%) in the 0.9% saline group developed postoperative AKI.

Despite this, giving several litres of 0.9% saline will result in hyperchloraemia, so continuing this fluid strategy is not rational. RICA and NICE guidelines, and the recently published German volume therapy guidelines, recommend avoiding saline 0.9% both during the perioperative period and both during ICU.

### Colloids versus crystalloids for stroke volume optimization

Current best practice seems to be the combination of a fixed crystalloid administration (the combination of maintenance and replacement solutions) and a rational goal-directed approach to resuscitation fluids. However, only 2 RCTs have specifically studied which fluid maintenance strategy was more effective in the context of goal-directed haemodynamic therapy (GDHT). The results of these studies were contradictory. Futier et al. randomize 70 patients undergoing major abdominal surgery to 6 mL/kg/h or 12 mL/kg/h of crystalloid (a more conservative liberal fluid strategy); in both groups, fluid bolus was administered when respiratory variation in peak aortic flow velocity was greater than 13%. The restrictive fluid strategy was associated with an increase in the incidence of patients with hypovolaemia and postoperative complications. Lobo et al., meanwhile, showed that the infusion of 4 mL/kg/h compared to 12 mL/kg/h of lactated Ringer’s solution as maintenance fluid during GDHT with DO₂- and lactate-guided

### Table 1 Characteristics of common crystalloid solutions compared to human plasma.

<table>
<thead>
<tr>
<th></th>
<th>Plasma</th>
<th>0.9% saline</th>
<th>Ringer’s lactate (lactate buffered solution)</th>
<th>Ionosteril® (acetate buffered solution)</th>
<th>Sterofundin ISO® (acetate &amp; malate buffered solution)</th>
<th>PlasmaLyte 148® (acetate &amp; gluconate buffered solution)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (mmol/l)</td>
<td>136–145</td>
<td>154</td>
<td>130</td>
<td>137</td>
<td>145</td>
<td>140</td>
</tr>
<tr>
<td>Potassium (mmol/l)</td>
<td>3.5–5.0</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Magnesium (mmol/l)</td>
<td>0.8–1.0</td>
<td>4</td>
<td>1.25</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Calcium (mmol/l)</td>
<td>2.2–2.6</td>
<td>3</td>
<td>1.65</td>
<td>2</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>Chloride (mmol/l)</td>
<td>98–106</td>
<td>154</td>
<td>109</td>
<td>110</td>
<td>127</td>
<td>98</td>
</tr>
<tr>
<td>Acetate (mmol/l)</td>
<td></td>
<td></td>
<td>36.8</td>
<td>24</td>
<td>27</td>
<td>23</td>
</tr>
<tr>
<td>Gluconate (mmol/l)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactate (mmol/l)</td>
<td></td>
<td></td>
<td>28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malate (mmol/l)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>eSID (mEq/l)</td>
<td>42</td>
<td>28</td>
<td>36.8</td>
<td>25.5</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>Theoretical osmolality (mosmol/l)</td>
<td>291</td>
<td>308</td>
<td>273</td>
<td>309</td>
<td>295</td>
<td></td>
</tr>
<tr>
<td>Actual or measured osmolality (mosmol/kg H₂O)</td>
<td>287</td>
<td>286</td>
<td>256</td>
<td>270</td>
<td>Not stated</td>
<td>271</td>
</tr>
<tr>
<td>pH</td>
<td>7.35–7.45</td>
<td>4.5–7</td>
<td>5.0–7</td>
<td>6.9–7.9</td>
<td>5.1–5.9</td>
<td>4–8</td>
</tr>
</tbody>
</table>

Plasma Lyte 148 (Baxter Healthcare, Toongabbie, NSW, Australia); Ringer’s Lactate (Baxter Healthcare, Deerfield, IL, USA); Ionosteril (Fresenius Medical Care, Schweinfurt, Germany); Sterofundin ISO (Braun Melsungen AG, Melsungen, Germany).
Perioperative fluid therapy plan

A near zero fluid balance is the goal for maintenance fluid therapy

- Preoperative insensible losses are usually overestimated
- Impact of preoperative fasting is usually overestimated
- Long fasting periods must be avoided
- Routine bowel preparation must be avoided
- If performed, iso-osmotic agents are preferred
- Intaborative insensible fluid losses by body exposures are usually overestimated
- The so called “third space” do not exist
- Hypervolemia must be avoided

Optimization reduced the incidence of major complications by 52%. In both trials, the restrictive group would be considered liberal according to today’s criteria. This illustrates the difficulty of comparing different fluid therapy strategies using different haemodynamic targets, different monitoring technique, and different therapies. However, there is indirect evidence that a liberal maintenance fluid therapy together with GDHT is less effective than GDHT accompanied by a restrictive maintenance fluid therapy.

The controversy regarding the choice of fluids in relation to stroke volume (SV) optimization persists. Nevertheless, because there are few RCTs conducted in the perioperative period comparing colloids versus crystalloids, we need to keep the focus on the pathophysiology. It is accepted that colloids have a higher plasma-expanding property than crystalloids, as they remain in the intravascular compartment due to large molecular weight and difficulty crossing the endothelium. In the specific setting of acute bleeding, colloids have a volume...
effect of more than 90%. However, a colloid only behaves like a colloid when the glyocalyx is intact and the patient is in need of intravascular expansion. The benefit of colloids in the setting of an intact glyocalyx in a patient undergoing volume optimization during major surgery or after major haemorrhage may be very different from the risk of colloids during the stabilization phase of severe sepsis with glyocalyx shedding and disruption. Hypervolaemia degrades the glyocalyx and allows colloids to escape from the intravascular compartment.

In the setting of GDHT, less fluid should be required to achieve specific haemodynamic goals (Fig. 4). Recently, Kanda et al. showed that colloid infusion was associated with significant increases in systolic blood pressure, left ventricular end-diastolic volume, SV, and cardiac output (CO). Wu et al. demonstrated no difference between crystalloids or colloids, in macro-haemodynamic terms, when resuscitating animals with haemorrhagic shock, while only synthetic colloids improved intestinal perfusion, which it is seriously compromised in patients with haemorrhage. An ideal resuscitation fluid should not only be effective in restoring both macrocirculation and microcirculation, but should also cause less reperfusion injury. Chen et al. reported that the exchanger that came closest to this definition was 6% HES 130/0.4. This solution was associated with less oxidative stress and a milder inflammatory response in the liver, intestine, lungs, and brain compared with gelatines and HES 200/0.5, after resuscitation from haemorrhagic shock. HES 130/0.4 has positive effects on ischaemia/reperfusion injury, microcirculation, tissue oxygenation, and immunity; it also impairs endothelial and epithelial barrier integrity, and the haemodynamic balance. Administration of colloids within GDHT is known to reduce the amount of perioperative fluids administered, which is closely related to volume overload and postoperative complications. Considering existing evidence, (patho)physiology, and findings from trials, there is no justification for increasing crystalloid infusion rates in patients that appear to be clinically hypovolaemic during surgery, despite a good extracellular fluid balance, particularly because the colloid controversy stems from the septic patient, who differs from the perioperative patient in so many ways. Moreover, the association between infusion of colloids and AKI in the perioperative setting has not been proved.

Conclusions

Fluid therapy is a key element in perioperative patient management. An adequate understanding of pathophysiology will guide fluid administration in terms of quantity and type. Maintenance fluid therapy should be restricted, as volume overload leads to an increase in perioperative complications.

Ethical disclosures

Protection of human and animal subjects. The authors state that no experiments have been performed on humans or animals for this research.

Confidentiality of data. The authors state that no patient data appears in this article.

Right to privacy and informed consent. The authors state that no patient data appears in this article.

Conflict of interest

JRM received travel funding from Deltex Medical and honoraria for lectures from Fresenius Kabi, Edwards Lifesciences, Deltex Medical and Merck Sharp & Dohme. DC Honoraria for lectures and academia studies from BBraun, Fresenius Kabi, Grifols, and LFB Biomedikaments. MM is a member of the Editorial Board of the BJA; Co-Editor-in-Chief of Perioperative medicine and a paid Consultant for Deltex Medical and Edwards Lifesciences. MM has run educational meetings that have received grants from Deltex Medical, Edwards Lifesciences, LidCo, Cheetah and Pulsion (www.epom.org). MM’s University Chair is sponsored by Smiths Medical. MM is a Director of The Bloomsbury Innovation Group. RCF: received honoraria and travel funding for lectures from Merck Sharp & Dohme and Deltex Medical. JMCV received honoraria and travel funding for lectures from Merck Sharp & Dohme, Deltex Medical and Fresenius Kabi. AE, AAG, SB state no conflict of interest.

Funding

None declared.

Acknowledgements

Professor Jean-Louis Vincent, Professor of Intensive Care Medicine (Université Libre de Bruxelles,) Depart. of Intensive Care, Erasme University Hospital, Brussels, Belgium. Professor Can Ince, Dept. of Intensive Care, Erasmus Medical Center. Erasmus University of Rotterdam, the Netherlands. Bernard M. van den Berg, Ph.D. Depart. of Internal Medicine (Nephrology) Leiden University Medical Center, Leiden, the Netherlands. Professor Hans Vink, Cardiovascular Research Institute Maastricht (CARIM), Depart. of Vascular Medicine at the Academic Medical Center, Amsterdam, the Netherlands. Professor Ignacio Garcia Monge, Dept. of Intensive Care, Hospital SAS de Jerez, Experimental Research Unit of Hospital SAS de Jerez, Spain. Professor Susana González Suárez, Dept. of Anesthesiology, Vall d’Hebrón University Hospital, Barcelona, Spain. Eugenio Martínez Hurtado, Infanta Leonor University Hospital, Madrid, Spain. Professor Vladimir Cerny, Dept. of Anesthesiology, Perioperative Medicine and Intensive Care J.E. Purkinje University, Masaryk Hospital Usti nad Labem, Czech Republic. Professor José Manuel Ramirez Rodríguez, Depart. of Colorectal Surgery, Lozano Blesa University Hospital, Zaragoza, Spain. Alix Zuleta-Alarcón, Dept. of Anesthesiology and Critical Care, The Ohio State University Hospital, Columbus, USA. Teresa de la Torre Aragonés, professional librarian, Infanta Leonor University Hospital, Madrid, Spain. GERM: Grupo Español de Rehabilitación Multimodal; Enhanced Recovery After Surgery (ERAS) Spain Chapter; and EAR Group (Evidence Anesthesia Review Group).
References


Perioperative fluid therapy recommendations for major abdominal surgery

