World Journal of Critical Care Medicine

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DOI: 10.5492/wjccm.v4.i3.192

World J Crit Care Med 2015 August 4; 4(3): 192-201
ISSN 2220-3141 (online)

REVIEW

Postoperative fluid management

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Author contributions: Kayilioglu SI, Dinc T and Coskun F designed the review; Kayilioglu SI, Dinc T, Sozen I, Bostanoglu A and Cete M conducted the literature review; Kayilioglu SI, Dinc T and Coskun F wrote the article; Cete M and Coskun F supervised all the process.

Conflict-of-interest statement: Authors have no conflict of interest.

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Received: November 28, 2014
Peer-review started: November 29, 2014
First decision: January 20, 2015
Revised: February 12, 2015
Accepted: April 1, 2015
Article in press: April 7, 2015
Published online: August 4, 2015

Abstract

Postoperative care units are run by an anesthesiologist or a surgeon, or a team formed of both. Management of postoperative fluid therapy should be done considering both patients' status and intraoperative events. Types of the fluids, amount of the fluid given and timing of the administration are the main topics that determine the fluid management strategy. The main goal of fluid resuscitation is to provide adequate tissue perfusion without harming the patient. The endothelial glycocalyx dysfunction and fluid shift to extracellular compartment should be considered wisely. Fluid management must be done based on patient's body fluid status. Patients who are responsive to fluids can benefit from fluid resuscitation, whereas patients who are not fluid responsive are more likely to suffer complications of over-hydration. Therefore, common use of central venous pressure measurement, which is proved to be inefficient to predict fluid responsiveness, should be avoided. Goal directed strategy is the most rational approach to assess the patient and maintain optimum fluid balance. However, accessible and applicable monitoring tools for determining patient's actual fluid need should be further studied and universalized. The debate around colloids and crystalloids should also be considered with goal directed therapies. Advantages and disadvantages of each solution must be evaluated with the patient's specific condition.

Key words: Body fluids; Body fluid compartments; Fluid therapy; Intensive care; Postoperative care

Core tip: Types of the fluids, amount of the fluid given and timing of the administration are the main topics that determine the fluid management strategy. Assessment of the patient's responsiveness to fluid resuscitation should determine the need of extra volume. Due to lack of evidence that supports central venous pressure (CVP) as an indicator of body fluid needs, we should not make our fluid resuscitation decisions based on CVP levels. On the other hand dynamic measures can be used to determine patient's fluid status. Among all fluid management strategies, goal directed strategy is the most rational approach to maintain optimum fluid balance.

Kayilioglu SI, Dinc T, Sozen I, Bostanoglu A, Cete M, Coskun F. Postoperative fluid management. *World J Crit Care Med* 2015; 4(3): 192-201 Available from: URL: http://www.wjgnet.com/2220-3141/full/v4/i3/192.htm DOI: http://dx.doi.org/10.5492/wjccm.v4.i3.192

POSTOPERATIVE FLUID MANAGEMENT

Fluid management is an important part of overall surgical therapy. Proper administration of fluids is critical, especially in patients who undergo major surgeries such as emergency laparotomies, bowel resections and hepatectomy procedures. Body fluid composition may change in minutes or hours, resulting in impaired wound healing and homeostasis. Briefly, choice of strategy in intraoperative and postoperative fluid management may be significant.

We will examine different postoperative fluid management strategies in this review. Postoperative management of patients, who undergo surgery, is carried out by intensive care specialists, anesthesiologists and general surgeons in postoperative care units, in all over the world[1]. On the other hand, intraoperative management is a quite different expertise, which is totally put into practice by anesthesiologists only, and is not covered in this article. Although postoperative care units are mostly managed by a team of both anesthesiologists and surgeons or only by anesthesiologists in Europe and Japan, surgeons' presence and co-leadership is of great importance in postoperative care. Harmonious with this view, surgeons play the largest role in North America[1,2].

Types of the fluids, amount of the fluid given and timing of the administration are the main topics that determine the fluid management strategy. Several debates have been continued about each of these topics. In early times of modern medicine, administering large amounts of fluids was favored, instead of facing the risk of hypovolemia[3]. In 1961, Shires *et al*[4] defined the "third space" fluid deficit as nonfunctional fluid which can be accounted as fluid loss and they suggested use of large quantities of fluids to substitute this functional loss. After this strategy becomes popular, reports of adverse effects of high volume states induced by excessive saline use began to arise. Today, exact amount of fluid to maintain ideal homeostasis is still controversial. Similarly, there are varying types of intravenous fluids and all vary in their biological and chemical properties which results in varying distribution forms and varying effects on homeostasis, vascular integrity, and other hemodynamic variables. Apparently, fluid management is admitted to be an art of medicine and based on personal judgments. Although this approach may not be totally wrong, plenty of evidence acquired by large volume studies should be considered wisely.

Postoperative fluid management plays a key role in providing adequate tissue perfusion, stable hemodynamics and reducing morbidities related with hemodynamics. Understanding body fluid physiology and possible outcomes of different fluid management strategies is crucial for all surgeons.

BODY FLUID COMPARTMENTS

Total body water is approximately 60% of total body weight. One third of this water is extracellular and it can be divided to as intravascular (20%) and extravascular (80%). The remaining two-third of body water is intracellular, which also exists in intravascular and extravascular compartments. From another perspective, intravascular fluid contains of both intracellular (40%) and extracellular (60%) compounds and plasma is the intravascular-extracellular compound of total body water (approximately 4% of body weight; in example, about 2.8 L in a 70 kg individual).

The endothelium is the separating wall between intravascular and extravascular compartments, thus it is the cell wall that separates the intracellular and extracellular compartments. There are various control mechanisms on these separating walls that regulate volumes of each compartment. Cell membrane is completely permeable to water, whereas it is selectively permeable to ions and organic molecules. It has also the Na^+/K^+-adenosine triphosphatase enzyme that actively expels Na^+ ions and maintains the Na^+ gradient between compartments. There are also endocrine mechanisms that control the cellular intake of certain molecules, such as glucose.

On the other hand, the earliest theory on vascular barrier by Ernest Starling declared that the hydrostatic pressure gradient in blood vessels creates a flow and the oncotic pressure of interstitial tissue allows only reasonable amount of fluid to cross through endothelium[5]. Later studies showed the intravascular osmotic pressure is significantly higher than interstitial osmotic pressure, however this doesn't result in interstitial edema[6]. As a result, this unexplained situation led researchers to look for another actor in this fluid distribution balance. The endothelial glycocalyx is a carbohydrate-rich coating over endothelial surface which is supported by proteoglycans and glycoproteins. It is a dynamic formation, consisting of membrane-bound and soluble molecules[7]. Existence of this glycocalyx layer forms a distinct space in the interior neighborhood of the endothelium, and there develops a notable oncotic pressure in this particular protein-free space. This definition brings out the "double-layer concept" for the vascular barrier[6,8,9]. This concept is quite capable of clarifying oncotic pressure balance between two compartments.

WHAT HAPPENS TO THE FLUID BALANCE IN SURGERY?

Homeostasis defines the tendency of the organism to maintain stability and balance. In this manner, body

fluid balance is controlled by previously described compartment mechanisms. On the other hand, any physical intervention may cause imbalance of the body fluids. During relatively long lasting major surgeries, which are performed with general anesthesia, whole intake is controlled by the anesthesiologist and fluid loss happens in numerous different ways such as bleeding, drainage of ascites, urination, insensible water loss and "third space losses". Intraoperative management of acute losses is not covered in this article. However, long term effects of these intraoperative events, such as possible over-hydrating by the anesthesiologist, dehydration, and bleeding should be considered in the postoperative care unit.

The third space is a term for spaces in which body fluids lose their function to affect fluid balance between intravascular and extravascular compartments. In other words, it can be called as non-functional extracellular volume. Bowel lumen, peritoneal and pleural cavities are thought to be the major examples of the third space. Studies that tried to explain the third space loss measured the extracellular volume (ECV) and functional ECV (fECV). fECV is defined as fluid accumulations within the interstitial space combined with plasma. Shires showed that, there is up to 28% loss in extracellular volume after two hours of operative time, during elective surgeries of thirteen adult patients[4]. Subsequent studies in 1960s support this finding and existence of the third space[10-12]. However, numerous trials with improved methodology proved that fECV levels do not decrease in or after surgery[13-16]. This correction of data couldn't be recognized well enough, but still, favored common belief is in the presence and importance of the third space. Current evidence supports that fECV is not negatively affected by surgery, however over-hydration with saline and surgical trauma cause endothelial dysfunction and interstitial edema due to fluid shift to ECV[13]. In conclusion, "the third space" term should only refer to anatomical cavities like bowel lumen, peritoneum and pleura, and should only be considered in certain cases. Moreover, possible endothelial glycocalyx dysfunction and fluid shift to ECV should be our guiding facts for determining the right strategy in postoperative fluid management.

MONITORING BODY FLUID STATUS

Mostly, the main goal of fluid resuscitation is to provide adequate tissue perfusion without harming the patient. It can be also said that fluid resuscitation is generally the first step in patients with inadequate tissue perfusion. However, it should be kept in mind that infusion of large volumes of fluids to patients who don't have enough preload reserves may result in unbalanced fluid shift to interstitial tissue, having no useful effect on tissue perfusion. Intravenous fluid administration will have no effect on tissue perfusion, unless it increases the stroke volume. Studies show that nearly half of the unstable patients are not hemodynamically responsive to fluid resuscitation[17,18]. This means that, fluid resuscitation may not always be the right way to provide adequate tissue perfusion, especially in unstable patients. Thereby, assessment of the patient's responsiveness to fluid resuscitation should determine the need of extra volume.

Thus, we need to determine the actual body fluid status of the patient and build a strategy accordingly. For this purpose, static measures of intravascular volume are being used for decades and central venous pressure (CVP) has been the most favorite tool[19,20]. CVP is widely believed to indicate general intravascular volume status of the patient. Moreover, many intensivists think that, CVP is directly correlated with right ventricle stroke volume and indirectly correlated with left ventricle stroke volume. However, a systematic review of 24 studies showed no relation between CVP and left ventricle stroke volume[21]. Due to lack of evidence that supports CVP as an indicator of body fluid needs, we should not make our fluid resuscitation decisions based on CVP levels. Similarly, pulmonary capillary wedge pressure is another static measure of intravascular volume and is incapable of predicting fluid responsiveness, in contrast to the common assumption[22]. Besides, the two even less favored static measures are left ventricular end-diastolic area and inferior vena caval diameter.

On the other hand, recent studies claim that monitoring of the interactions of heart and lung in mechanically ventilated patients, so called dynamic measures, can be used to determine patient's fluid status. According to Marik *et al*[18], non-invasive techniques such as the pulse pressure variation, the stroke volume variation, and systolic pressure variation can significantly predict fluid responsiveness in mechanically ventilated patients. These techniques are based on physiological facts. The patients, whose pulse pressures or stroke volumes are more dependent on intra-thoracic pressure variations provided by the ventilator, tend to be more responsive to fluid resuscitation.

The physiological principles underlying the pulse pressure variation (PPV) and the stroke volume variation (SVV) are based on the effects of increased pleural pressure. As the mechanical ventilator increases the pleural pressure, the increased resistance in the pulmonary system causes a decrease in the right ventricle preload and an increase in the right ventricle afterload. Meanwhile, the left ventricle preload and afterload are affected exactly the opposite way of right ventricle is: Left ventricle preload increases and afterload decreases at the end of inspiration. The pulse pressure and the left ventricle stroke volume are at their highest values at this moment. Afterwards, prolongation of blood transit time through pulmonary system results in a decrease in the left ventricle preload and reduction in the left ventricle stroke volume (and the pulse pressure) during expiratory period[23,24]. Echocardiographic evaluations of aortic flow velocity and stroke volume and vena caval diameter variation

are two other dynamic parameters based on similar physiological reactions.

Another technique for predicting fluid responsiveness is called the passive leg raising (PLR). While previously mentioned techniques are used for mechanically ventilated patients especially who has no spontaneous breathing, PLR can be used on any patient. Raising the legs to provide a better cardiac preload has been used for a long time in emergency patients. Recently PLR gained interest as a predictor for fluid responsiveness. Monnet pointed out that lifting the legs passively in a lying patient induces a significant blood flow towards the heart[25]. Therefore, Marik *et al*[17] called this physiologic condition as "autotransfusion". In a study on mechanically ventilated patients, PLR-induced changes have been found to be strongly similar with the effects of 300 mL colloid infusion. As a result, PLR simulates the state after fluid administration. In other words, if the patient has enough preload reserve, PLR will increase left ventricle preload and stroke volume correspondingly. It is also been reported that, these effects are reversible, and when legs are returned to their horizontal positions, this preload increasing effect disappears[25]. Another important point is that PLR reaches its maximal effect in 1 min and its effects disappear gradually in time[26]. Accordingly, when PLR is used to predict fluid responsiveness changes in arterial pulse pressure[27], descending aorta blood flow[28], pulse contour-derived stroke volume, or pulsed Doppler-derived velocity-time integral[29] should be monitored closely at the first minute[25].

Briefly, fluid management must be done based on the patient's body fluid status. Patients who are responsive to fluids can benefit from fluid resuscitation, whereas patients who are not fluid responsive are more likely to suffer complications of over-hydration.

Therefore, common use of CVP, which is proved to be inefficient to predict fluid responsiveness, should be avoided and attempts should be made to extend the use of techniques like PLR, pulse pressure variation and the stroke volume variation. Practical tools should be manufactured and made available for common use.

TYPES OF INTRAVENOUS FLUIDS: CRYSTALLOIDS AND COLLOIDS

Intravenous fluids are classified into two main types: Crystalloids and colloids. Each group has its very own characteristics and moreover, each particular solution has its unique properties.

Crystalloids

Crystalloids consist of glucose or sodium chloride (saline) solutions. Osmolarity of the solution determines if the solution is hypotonic, isotonic or hypertonic. Isotonic solutions have the closest osmolarity to plasma and the other solution types are named comparing to plasma osmolarity. Saline solution containing 0.9 g of NaCl in each liter of water is defined as isotonic saline, and it is the most popular intravenous fluid worldwide. Some widely used saline solutions also contain one or more of these components: potassium, calcium, bicarbonate, lactate, and glucose. Isotonic glucose solution contains 50 g glucose in each liter of water and it is defined as isotonic glucose. Glucose in these solutions is metabolized right after administration and solvent is mixed into total body water. On the other hand, saline solution's high NaCl concentration serves to keep its solvent water in the extracellular compartment. However, any crystalloid solution can freely pass through double barrier of endothelium. This condition causes up to four-fifth of the infused crystalloid to distribute directly into the interstitial compartment[13,30]. Accordingly, crystalloid infusion in high amounts is related with serious complications, such as pulmonary edema[31], and hyperchloremic acidosis[32]. Despite that, colloid solutions are generally imprisoned in intravascular compartment, unless double-barrier of endothelium is impaired. Major advantage of crystalloids to colloids is containing only ions or small sized molecules which can easily be metabolized in reasonable amounts.

Colloids

Colloids can be blood products, such as human albumin solution and fresh frozen plasma, or they can also be synthetic large molecules which are not able to distribute across vascular barrier such as gelatins, dextrans, and hydroxyethyl starches.

Colloids are, like crystalloids, widely used in fluid resuscitation[33]. Although colloids are thought to be more useful than crystalloids for increasing intravascular volume and providing osmotic pressure, they are both shown to be similarly effective on mortality[34,35]. Colloid solutions are prepared by dissolving colloid molecules in isotonic saline solutions, or more rarely in other crystalloids.

Endogenous albumin is primarily responsible for intravascular osmotic pressure in healthy subjects. Thus, albumin, as an intravenous colloid solution, makes perfect sense to maintain intravascular colloid pressure. However, like all blood products, it has significant disadvantages, like allergic reactions and (theoretically) infection risks, although it is generally considered safe. Molecular weight of albumin is around 69000 Dalton. Gelatins, dextrans and hydroxyethyl starches (HES) are other common colloid substances. Gelatins are products of biochemical processes executed on bovine collagen. Although there are some concerns about its relation with Creutzfeld-Jacob disease and bovine spongiform encephalitis, there is no solid evidence proving these concerns[36,37]. Dextrans are polysaccharides that can vary in size. Most common types of dextrans are dextran 70 and dextran 40, which are named after their average molecular weights: 70000 and 40000 Dalton, respectively. Lastly, HES is a nonionic starch derivative, which is synthetized from amylopectin. HESs

also vary in molecular weight, and can be classified as low (70000-130000 Dalton), medium, and high (450000-480000 Dalton) molecular weights. They are also classified by their molar substitution degree, which defines the proportion of glucose molecules that are replaced by hydroxyethyls. HESs are the most commonly used colloids in Europe. Commonly used examples of these colloids are Voluven® (Fresenius Kabi, Bad Homburg, Germany) which is a 130000 Dalton tetrastarch, dissolved in saline with substitution degree of 0.4 and HAES-steril® (Fresenius Kabi, Bad Homburg, Germany) which is a 200000 Dalton pentastarch, dissolved in saline with substitution degree of 0.5.

Each type of colloid solution has its unique features. Effect on plasma volume and plasma viscosity, adverse reactions, and side effects on the system are the main concerns while choosing colloid solutions. Every colloid substance has a concentration decrease rate (half-life) in plasma by being metabolized, or by a loss through endothelial barrier and glomerular filtration. Half-life of a colloid determines the amount and the duration of plasma volume expansion. Higher molecular weight colloids tend to stay longer in the intravascular compartment. Besides, some studies point that the dextrans and the HESs provide significantly better expansion of plasma volume than the gelatins[38-40]. Whereas, some studies indicate that only albumin has significant advantage over other colloids and saline; and none of the other colloids is superior to others regarding plasma volume expansion[41-43].

All colloids provide a level of expansion in plasma volume and this leads to hemodilution. Hemodilution causes a decrease in plasma viscosity. However, it is known that some colloids cause a total increase in viscosity due to red cell aggregation. High molecular weight dextrans and HESs cause a significant increase in viscosity, while low molecular weight dextrans HESs and albumin solutions decrease both red cell aggregation and plasma viscosity[44-47]. Colloids have various effects on hemostasis, such as impaired platelet function, decreased factor VIIIc and von Willebrand Factor levels, in addition to previously described hemodilution and altered red cell aggregation[44,48,49]. Particularly, dextrans are known with their significant antithrombotic effects[49-51].

Accumulation of colloid substances in the body is possible. Dextrans and gelatins can be metabolized in humans. On the other hand, HESs may also accumulate. Metabolism and filtration of HES is relatively slow and storage in reticulo-endothelial system is not well recognized yet.

All colloids are large molecules and can trigger anaphylaxis of anaphylactoid events. Colloids also have minor anti-inflammatory effects.

Although it has been argued for a long time, there are still no definite rules on "crystalloid *vs* colloids" issue. There are studies that show crystalloid infusion is related with interstitial edema and worse anastomotic healing[31,52,53]. On the other side, it is still arguable that colloid solutions are able to prevent consequences of these negative effects[54,55]. In a study on pancreaticoduodenectomy patients, who are resuscitated with lactated Ringer's solution (isotonic crystalloid solution; including lactate, potassium and calcium in addition to sodium chloride), the significantly increased interstitial edema in jejunum was shown[56]. However, colloid use has been reported to have an increasing effect on mortality, in some fairly criticized studies, especially on critically ill patients[57,58]. On the other hand, CRISTAL trial, which is a multicenter randomized study on critically ill patients, failed to demonstrate this effect on mortality. In contrast, fewer death rates were found within 90 d in colloids group[54].

Moreover, although colloids are proved to be capable of maintaining efficient plasma volume, they do not appear to have positive effects on renal function. Contrarily, reports had shown significant harmful effects of dextran 40 use on kidney function in the second half of 20th century[59-61]. Some of the subsequent studies on HESs also revealed negative effects of these solutions on kidneys[62,63]. Schortgen *et al*[64] also reported that the use of hyperoncotic colloids and human albumin is significantly associated with renal dysfunction. However, in a multicenter study on over 3000 intensive care patients, no significant relation was detected between HES use and renal dysfunction[65]. Similarly, in a review of studies with different HES products, no adverse effects on kidneys were reported[66]. In a randomized clinical multicenter trial, 6997 critically ill patients were randomized into two groups. One group was assigned to receive 4% of albumin and the other group was assigned to receive saline for intravenous resuscitation during 28 d. There was no significant difference between two groups, regarding to mortality, days spent in intensive care unit, days of mechanical ventilation, or days of renal replacement therapy[67]. In addition to all of these results, it should be taken into consideration that none of the colloid solutions is proved to be directly toxic to the kidneys[68].

Considering all pros and cons of each solution family, it is still not possible to make a strict evidence based statement about how to use colloids and crystalloids[57,69]. It should be kept in mind that, crystalloids have less negative effects on hemostasis, immune system and kidneys; whereas colloids may provide a better plasma volume expansion with less interstitial edema in elective surgery patients[69].

FLUID RESUSCITATION STRATEGIES

Although there has been various different strategies defined in literature in decades, none has been adopted alone by most of the clinicians as the superior strategy. We think that many clinicians tend to keep their accustomed strategy, despite the evidences in the literature. There are studies that compare outcomes

of different strategies of fluid management. Lately, "crystalloids *vs* colloids" debates are fading, while recent studies mostly focus on the amount of fluid given perioperatively.

Traditional approach to determine the fluid amounts is more likely to generate formulas based on parameters such as patients' body weights and duration of surgeries. However, there is an evidence that each patient has his/her own body fluid status depending on the type of surgery, comorbid conditions, fluid already administered before, and various other factors. In addition, each patient should be considered as unique and his/her unique status should be monitored closely in the correct ways. As stated before, the main goal of fluid management is to maintain adequate tissue perfusion, with minimized risks of complications of over-hydration, such as pulmonary edema, cerebral edema, and intestinal edema. Both inadequate and excessive fluid administration may increase the stress on the circulatory system, and can affect tissue healing after surgery. From this perspective, without decent monitoring of patient's current status, any strategy may fail.

Debates about fluid management strategies are gathered around liberal strategy, restricted (conservative) strategy and goal-directed strategy so far. Liberal and restricted strategies are defined by different authors with variable volume ranges. For example, in one study, restricted fluid volume is defined as 1000 mL plus loss through drains[70], while in another study, patients in restricted fluid volume group were subjected to over 2000 mL fluid on the day of surgery[71]. These variances make it difficult to consider these studies as a whole. Still, majority of authors studying this subject point out that restrictive strategy has positive effects on gastrointestinal function, wound healing and pulmonary function[44,70,72-74]. Brandstrup *et al*[70] stated that, excessive hydration with crystalloids is related with increased major complications, such as leakage, peritonitis, sepsis, pulmonary edema and bleeding in patients who underwent elective colorectal surgery. Also, intestinal edema is known to be related with increased bacterial translocation and multiple organ dysfunction syndrome rates[75,76]. It can be concluded that, staying closer to the dehydration level is more reasonable, because it is safer and more efficient than administering large volumes to avoid dehydration. On the other hand, the liberal strategy is superior to the restricted strategy for reducing postoperative nausea, headache, dizziness and vomiting[77,78].

However, the goal directed strategy (GDS) is totally based on patient's current data, obtained from monitoring methods (See section: Monitoring body fluid status). Rivers and colleagues, one of the pioneers of this strategy, monitored CVP, mean arterial pressure, serum lactate, and mixed venous oxygen saturation in order to manage therapy in sepsis patients[79]. Later studies were focused on monitoring hemodynamics, and the effects of administered fluids on patients. Now, GDS can be defined as an individualized fluid therapy, based on patient's fluid responsiveness; in other words, "fluid need". The extra volume, which won't be able to affect the left ventricle stroke volume is regarded as unnecessary; and as a matter of fact, hazardous. It makes perfect sense to totally evaluate patient's needs and replace what is needed. Still, efficiency of GDS is limited with the power of our monitoring tools, which is determined by accessibility, applicability of the tools and the quality of information we acquire from them.

PPV and SVV are defined to monitor the fluid need of the patient dynamically as it is stated above[18]. Esophageal Doppler monitoring of cardiac volumes and aortic flow are also one of the helpful tools in GDS. In a systematic review of esophageal Doppler guided GDS studies; reduced hospital stay, fewer ICU admissions, and less inotropes usage were detected in GDS group[80]. In a single center, blinded, prospective controlled trial, 128 patients who underwent colorectal resection were randomized into two groups. Each group was managed with esophageal Doppler or CVP guided fluid therapy during surgery. Intraoperative Doppler guided fluid management was associated with decrease in the duration of hospital stay[81]. A randomized controlled study on 108 elective colorectal surgery patients also showed shorter hospital stay and decreased morbidity in GDS group[82]. GDS is also advantageous in patients who undergo major surgery[79]. A systematic review and meta-analysis studies by Hamilton on major surgery patients state that preemptive hemodynamic monitoring reduces mortality and morbidity[83]. Similarly, Poeze *et al*[84] showed that efforts to achieve an optimized hemodynamic condition resulted in a decreased mortality rate, in their meta-analysis study in 2005. Another meta-analysis also shows that GDS reduces both major and minor gastrointestinal complications after surgery[85].

In contrast with these studies, in a multicenter study, which included 762 high risk patients in 56 intensive care units, no significant effects of GDS were found. In this study, patients were randomly assigned to cardiac-index group, mixed venous oxygen-saturation group and standard therapy group. Predetermined hemodynamic targets were reached significantly better in the control group. There were no significant differences among the three groups, regarding mortality at six months. Even the subgroup analysis of patients, whose predetermined hemodynamic targets have been reached successfully, showed similar mortality rates among the three groups. Moreover, the number of dysfunctional organs and the duration of stay in the intensive care unit were similar in all groups[86].

Despite these evidences, low accessibility and applicability of esophageal Doppler are the major disadvantages of this method. This leads researchers to search for a more accessible and applicable method for common use in postoperative care unit, such as non-

invasive pulse oximetry and invasive arterial pressure measurement. Thus, predictive value of pulse pressure variation, systolic pressure variation and stroke volume variation tests for fluid responsiveness are defined[17]. All of these tests are applicable in an average postoperative care unit. However, the true value of these tests should be evaluated by larger studies. After that, optimization of patient monitoring devices should be done accordingly. Moreover, even PLR alone can provide important information about fluid responsiveness and lead the intensivists for GDS.

Since there is still insufficient number of randomized controlled trials with standardized criteria, the fluid management debates are going on. A consensus on criteria for each fluid management strategy should be made. We think that the related studies from all around the world with defined criteria are going to reveal the true value of each strategy.

Each surgeon should keep in mind that the patient is totally managed by the anesthesiologist during the surgery, so depending on the anesthesiologist's preference on fluid strategy, patient's fluid status after surgery may vary widely. Besides, intraoperative bleeding and other causes of surgical fluid loss should also be considered. During or after the surgery, the blood loss in patients with low hemoglobin levels is generally managed with erythrocyte suspensions. However, in patients with reasonable hemoglobin levels, appropriate fluid strategy should be chosen to avoid complications of transfusion. We think that determining the actual fluid status and the needs of a postoperative patient, by using monitoring tools and examining the report of the anesthesiologist, is of great importance.

CONCLUSION

Postoperative care units can be managed by an anesthesiologist, a surgeon or a team composed of both. Management of postoperative fluid therapy should be done considering both patients' unique status and intraoperative events. Thus, surgeons must be aware of pros and cons of current fluid management strategies and their effects on surgical outcome. Although there has been a significant progress on fluid status monitoring and fluid management strategies, most clinicians still prefer their traditional approaches for postoperative fluid management. This tendency towards empirical fluid management can be replaced by evidence based strategies, only if significant benefits of new strategies are proved with multicenter randomized controlled trials which use standardized criteria. GDS is the most rational approach to assess the patient and maintain optimum fluid balance. However, accessible and applicable monitoring tools for determining patient's actual fluid need should be further studied and universalized. The debate around colloids and crystalloids should also be considered with goal directed therapies. Advantages and disadvantages of each solution must be evaluated with the patient's specific condition.

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P- Reviewer: Gurjar M, Wheeler DS **S- Editor**: Ma YJ **L- Editor**: A
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