Perioperative Fluid Management

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KEYWORDS

- Fluid therapy • Resuscitation • Perioperative medicine • Anesthesia • Surgery
- Geriatrics

KEY POINTS

- Age-related decline in organ-specific reserves leads to increased hemodynamic instability and greater vulnerability to fluid shifts and electrolytes imbalances, making optimal perioperative fluid management of the aging patient challenging.
- There is limited generalizable evidence to guide perioperative fluid management in the geriatric patient, with robust clinical judgment remaining at the center of optimal fluid management.
- Perioperative fluid management strategies need to be restrictive and dynamically tailored to patient characteristics, severity of the surgical procedure, and blood loss.

INTRODUCTION

Perioperative fluid management has evolved over the last 25 years, starting with liberal fluid use in the early 2000s, followed by a restrictive approach in the second decade, to the current more balanced approach over the last 5 years.[1] The latter emerged as decrease in the volume of crystalloids administered was linked to an increase in acute

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kidney injury (AKI) incidence, particularly with resultant increase in vasopressor use.[1,2] Not surprisingly, given these swings in the "*pendulum*" of fluid management, the current clinical practices of perioperative fluid management, including volume status assessment, fluid choice, fluid administration strategies, or blood product use are characterized by a high degree of interindividual and interinstitutional controversy, heterogeneity, and bias.

Establishing optimal fluid management is particularly challenging in the older adults due to combination of age-related physiological changes in organ function, increased comorbid burden, and larger fluid shifts frequently related to more complex surgical procedures.[3] Furthermore, many studies examining fluid management have focused on *critical care* patients and/or populations with a small to moderate geriatric cohort, thus limiting the generalizability of results for *perioperative* fluid management in the *geriatric* population.[4]

Thus, the goal of this manuscript was to review the available clinical evidence, followed by a concise, pragmatic, and critical appraisal of the data to answer several key questions relevant to everyday clinical practice when taking care of geriatric patients.

What Aspects to Consider in the Older Adults?

A major factor of perioperative fluid management in the older adults is the age-related decline in organ function.[2–5] Especially, the reduction in cardiac and renal reserves may expose this cohort to higher risk of fluid and electrolytes imbalances or inadequate tissue perfusion leading to increased morbidity and mortality.[2–5]

Structural changes in the cardiovascular system associated with normal aging may include stiffening of the arteries, increasing left ventricular wall thickness and stiffening, diastolic dysfunction, degenerative changes of the heart valves, or the cardiac conduction system.[2–5] Furthermore, autonomic nervous system undergoes age-related changes ("dysautonomia of aging") that may include overactive sympathetic nervous system activity (SNA) impaired beta adrenoreceptor responsiveness, or decreased sensitivity of arterial baroreceptor reflex.[4–8] As a result, older adults patients may be at risk for increased hemodynamic instability and inadequate tissue perfusion:[3–5,9]

- *At induction:* Severe hypotension, due to combination of pronounced pharmacodynamic sensitivity to anesthetics, acute decrease in SNA, vasodilatation, and limited cardiac reserve, is common in this population, especially, in patients with mild preoperative hypovolemia which is characteristic for this cohort.
- *Intraoperatively:* Labile hemodynamics with increased dependence on preload and sinus rhythm (atrial kick) is common. Aging patients are at higher risk for ectopic beats, intraoperative arrhythmias, myocardial ischemia, disproportionally large variations in blood pressure from small-to-modest changes in cardiac filling, contractility, or electrolytes.
- *Postoperatively*: Removal of anesthetic agents, return of SNA to baseline, combined with intraoperative fluids, and postoperative surgical pain frequently result in hypertension. In addition, some may be at risk for pulmonary edema given the limited ability of the stiffened cardiovascular system to buffer any increase in intravascular volume.

Three key changes in the renal system associated with advancing age include progressive decrease in renal mass, renal blood flow, and total body renin and aldosterone levels.[2,4,5] Consequently, older adults patients demonstrate decreased ability to clear medications, handle excess fluid, or maintain appropriate intravascular volume.

In summary: The natural age-related decline in organ-specific reserves lead to increased hemodynamic instability, greater vulnerability to fluid shifts and electrolytes imbalances making optimal perioperative fluid management of the aging patient challenging.

How to Assess Intravascular Volume Status?

Monitoring of intravascular volume status is an essential step in ensuring appropriate fluid management. Most surgeries can be safely and successfully performed using the well-established noninvasive approach to fluid monitoring, including.

- Preinduction assessment in the awake patient: thirst, skin turgor, capillary refill time, urine output, lethargy, and postural dizziness.
- The use of standard continuous hemodynamic monitors, such as blood pressure, heart rate, and electrocardiogram (ECG)
- The continuous measurement of intraoperative fluid losses, including urine output, blood loss, and insensible fluid losses.

Complex surgical procedures, surgical patients with high comorbid burden, or unexpected perioperative challenges may require additional, more invasive methods to *monitor intravascular volume status* and predict fluid responsiveness.

- *Static hemodynamic* (eg, central venous pressure, pulmonary artery pressure, systemic arterial pressure, urine output) and *laboratory parameters* (eg, lactic acidosis, elevated serum lactate, or base deficit) provide only a suboptimal and unpredictable representation of the clinical volume status.[10–12] For example, oliguria is not always a sign of hypovolemia in the intraoperative setting, as it can represent a side effect of certain anesthetics or surgical stress itself.[13,14] The same applies to blood pressure and heart rate, given lack of a consistent correlation between blood pressure and cardiac output.[15] Similarly, the intermittent nature of intraoperative measurements of lactate and mixed-venous oxygen saturation make them poor markers of acute changes in volume status. Having said that, rising serum lactate and decreasing mixed-venous oxygen saturation are excellent markers of global tissue hypoperfusion and are frequently used when there is clinical uncertainty about the presence of ongoing global malperfusion as well as to help better define its clinical severity.
- *Dynamic hemodynamic parameters* have been found to consistently provide better assessment of volume responsiveness than traditional static parameters:[16–23]
  - The continuous assessment of *respiratory variations in arterial and/or venous pressure waveforms* has emerged as one of the most widely adopted approaches to intraoperative monitoring of fluid status, given its simplicity and reliability.[21,23–27] Commonly used examples include pulse pressure variation (PPV), stroke volume variation (SVV), systolic blood pressure variation (SBPV), and changes in the diameter of the inferior vena cava. During mechanical ventilation, increased intrathoracic pressure during inspiration leads to reduced venous return and consequently stroke volume. Assuming constant arterial vasomotor tone and cardiac function, pulse pressure, and systolic blood pressure will vary with the respiratory cycle.[27] Variation between inspiratory and expiratory measurements of greater than 10% to 15% was found to represent a reliable marker of intravascular volume depletion.[28,29] PPV and SBPV can generally be visually assessed or manually or automatically calculated. Visual assessment and calculation have been found to nearly always lead to similar treatment decisions.[21,24] Although superior to static

hemodynamic parameters, PPV, and SVV reportedly have limited sensitivity and specificity,[30] suggesting that such dynamic indexes should be considered in the clinical context when making treatment decisions.[21] Another limiting factor is that measurements of respiratory variations in pressure waveforms can be inaccurate when a patient is spontaneously breathing, when the tidal volume is less than 8 mL/kg, when the PEEP is high (>15 cm H_2O), and/or when the chest is open.[21,31–33]

- ○ *Ultrasound* is another option for dynamic monitoring of intravascular volume status, particularly when PPV and SBPV are inaccurate. Transesophageal Doppler ultrasound can be used to measure blood flow through the descending thoracic aorta,[23,34,35] whereas transesophageal and transthoracic echocardiography can be used to directly assess the intravascular volume status.[36,37]
- ○ Finally, there is a growing number of *technologies that measure cardiac output noninvasively* (eg, pleth variability index, thoracic electrical bioimpedance) or take advantage of an existing *indwelling arterial catheter* (pulse waveform analysis).[38–41] Although the ease and noninvasiveness of these devices makes them very attractive, their use remains limited due to high inaccuracy in measurement of cardiac output.[42]

In summary: Although a wide range of different approaches, techniques, and technologies have been introduced over the years, none has emerged as the uniformly accepted "gold standard." Thus, even in the year 2023, the best monitor of intravascular volume status in the older adults seems to be the experienced clinician, who by continuously integrating a wide range of tools, monitors, and observations in real-time, can obtain an accurate and dynamic representation of intraoperative fluid status.[4]

What Type of Fluid Should Be Used for Volume Resuscitation?

The optimal choice of type of intravenous fluid remains controversial. Multiple fluid therapies with sound theoretical rationale for their use are available. Yet, little evidence exists of their benefits in clinical practice. Hence, several have been used in clinical practice without a rigorous evaluation of outcomes.

In the last decade, the safety of 0.9% saline (commonly known as "normal saline") has been questioned, with some authors labeling it "abnormal saline."[43,44] Although the tonicity of 0.9% NaCl is similar to physiological levels, its chloride concentration far exceeds that of plasma, affecting the strong ion difference and driving metabolic acidosis.[45,46] In a study with healthy volunteers, renal cortical perfusion fell significantly from baseline after 0.9% NaCl infusion, but not after a balanced electrolyte solution.[47] Further, prospective trials have reported potential harm with 0.9% saline resuscitation compared with balanced crystalloids.[48,49] On the other hand, the saline versus plasma-lyte for ICU fluid Therapy (SPLIT) trial comparing effects of 0.9% saline and a balanced crystalloid solution in intensive care units (ICUs) on renal complications demonstrated similar rates of AKI or failure in the two groups.[50] Other notable studies addressing this question were SALT-ED, which assessed patients outside of the ICU, and SMART, which included critically ill patients.[49,51] Although saline against lactated ringers or plasma-lyte in the emergency department (SALT-ED) was a negative trial, balanced crystalloids versus saline in critically ill adults (SMART)reported a lower rate of composite outcome of death from any cause, new renal replacement therapy (RRT), or persistent renal dysfunction in the group that received balanced crystalloids. More recently, two large randomized trials (balanced solution versus saline in intensive care study [BaSICS] and plasma-lyte versus saline study

[PLUS]) reported no differences in mortality between the two crystalloid solutions.[52,53] In a meta-analysis of randomized trials comprising over 35,000 patients, the investigators concluded that balanced crystalloids are most likely beneficial when compared with 0.9% NaCl, with an estimated effect that ranges from a 9% relative reduction to a 1% relative increase in the risk of death.[54]

In contrast to crystalloids, colloid solutions offer a theoretical advantage of requiring less volume to produce the same intravascular expansion. The saline versus albumin for fluid resuscitation in the critically ill (SAFE) trial evaluated albumin and saline as fluid therapies and demonstrated no difference in all-cause mortality at 28 days between the groups.[55] Similar results were noted in the volume replacement with albumin in severe sepsis (ALBIOS) trial in 28- and 90-day mortality.[56] Of note, the effects of albumin may differ depending on the subgroup of patient studied; in the SAFE trail, a nonsignificant trend of reduced mortality in the severe sepsis subgroup but a worse 28-day mortality in the traumatic brain injury (TBI) subgroup was observed with albumin, whereas a post hoc analysis of patients with septic shock in ALBIOS demonstrated a benefit only in 90-day mortality.[56–58] Additional studies found albumin to be harmful in patients with acute ischemic stroke, being associated with increased rates of intracerebral hemorrhage and pulmonary edema.[57]

With respect to synthetic colloids, high-quality randomized trials revealed the association of hydroxyethyl starch with an increased incidence of AKI, need for RRT, bleeding, and death.[58–62] Other synthetic formulations such as gelatins and dextrans have not been adequately tested for safety and they should be avoided due to concerns for adverse events.

In summary: (1) except for specific populations (such as patients with increased intracranial pressure, brain edema, or hyponatremia), the use of balanced crystalloids solutions is preferable; (2) current evidence does not support the use of albumin in critically ill patients and only suggest a potential benefit in patients with septic shock. Evidence advises against its administration in patients suffering from TBI or stroke; and (3) overall evidence advises against using synthetic colloids as volume expander therapy.

What Volume of Intravascular Fluids to Administer?

The expected blood loss, fluid shifts of the planned surgical procedure, and its complexity dictate the intraoperative fluid management strategy.

- In patients undergoing *brief minimally-to-moderately invasive surgery* who are expected to have rapid postoperative recovery (eg, outpatient or short floor stay), administration of 1 to 2 L of a balanced electrolyte solution over the course of the procedure has been found to decrease postoperative pain and nausea.[63,64] Naturally, this volume must be adjusted in patients at risk for volume overload.
- In patients undergoing *major invasive surgery*, there is inconsistent evidence as to what constitutes the best fluid management strategy, although there is a strong agreement on which strategies should not be recommended as they may *increase* the risk of perioperative complications:
  - Currently, recommended strategies, though the strength of evidence varies, include:
    - *Restrictive (zero-balance) strategy for patients* with an expected blood loss of less than a liter: only fluids lost during surgery are replaced at approximately 3 mL/kg per hour with a balanced crystalloid (replacement of sensible and insensible losses) as well as additional fluid for blood loss.[11,12] Although

many studies report superior outcomes with this approach,[11,12,65–68] there are some disconcerting data linking the restrictive fluid strategy with a higher risk of AKI,[69,70] highlighting the need for continuous intraoperative fluid monitoring to avoid hypovolemia.

- *Goal-directed therapy in patients undergoing major invasive surgery with expected significant blood loss:* In this approach, fluid is administered to reach a set-measured physiologic parameter, such as PPV/SBPV (estimated from intra-arterial waveform tracing), stroke volume (measured via esophageal Doppler), or left ventricle size (assessed via transesophageal echocardiography).[38] Similar to restrictive strategy, patients receive a continuous infusion of 3 mL/kg/h of a balanced crystalloid.[2,11] In addition, the patient's fluid responsiveness is assessed to maintain optimal intravascular volume status. This is typically accomplished using 250 to 500 mL boluses until the patient is no longer fluid responsive (ie, returned to the goal value of monitored physiologic parameter).[28,29] Although the data supporting goal-directed therapy have not been consistent,[71–77] the results of multiple meta-analyses suggest that the benefits of goal-directed therapy may be less in optimization of fluid responsiveness but more in optimizing tissue and organ perfusion.[78–80] Consistent with these results, a strategy that combined optimization of fluid responsiveness with optimization of cardiac output offered the biggest clinical benefit.[79,81,82]
- The *recommended ratios for blood loss replacement are 1.5:1 when using crystalloid and 1:1 when using colloid.*[2,55,83–87]
- *Vasopressors* should be considered to manage anesthesia-induced hypotension to avoid excess fluid administration.[88,89]

◦ Strategies that are currently NOT recommended, as they have been found to increase the risk of fluid overload and tissue and organ edema, ultimately leading to increased rates of adverse outcomes include:

- Traditional liberal or pre-calculated fixed volume strategies, which typically account for preoperative deficits from fasting as well as intraoperative losses, including the nonanatomic "third space" loss.[11,12,90–96]
- The administration of crystalloid in a 3:1 ratio to replace intraoperative blood loss.[83,87]
- Excessively deep anesthesia (eg, bispectral index values < 40), increasing the risk of vasodilation and unnecessary fluid administration
- Preloading with large volume of fluid before neuraxial blockade

In summary: Best perioperative fluid management strategies need to be restrictive and dynamically tailored to patient characteristics, the severity of the surgical procedure, and blood loss.[97–100]

When Is Blood Transfusion Indicated?

It is widely accepted that blood products are not to be considered as a volume expander therapy per se in non-hemorrhaging patients. The landmark TRICC trial demonstrated no mortality difference with a restrictive compared with liberal transfusion strategy in critically ill adult patients.[101] The trial was followed by multiple studies demonstrating non-inferior and in fact, some showing improved outcomes with a restrictive transfusion threshold of less than 7 to 8 g/dL.[102–104] However, optimal transfusion approaches in specific diseases and/or populations, such as older adults patients, have not been clearly established. Some data indicated increased risk of ischemia-related organ injury and mortality with restrictive transfusion, resulting in endorsement of a hemoglobin target of 9 g/dL in older adults patients undergoing hip fracture surgery.[105,106] Studies in oncologic patients showed mixed findings: some with survival trends favoring a higher hemoglobin threshold while others showing equal outcomes.[107,108]

With inconclusive or lacking evidence of optimizing transfusions of red blood cells based on hemoglobin levels, experts advocate basing the decision on the oxygen delivery/consumption balance.[109,110] Such approach would also take into consideration patient's characteristics (such as age, gender, and comorbidities) as well as underlying pathological processes. Studies describing cardiovascular and metabolic responses to isovolemic anemia offer a significant insight in assessing adequacy of oxygen delivery by using physiological and laboratory parameters such as stroke volume, heart rate, blood pressure, cardiac index, ECG changes, tissue oxygen saturation/cerebral oximetry, urine output, arterial and venous oxygen content, oxyhemoglobin saturation, and plasma lactate.[111,112] Two recent studies demonstrated that including mixed venous oxygen saturation into transfusion decision allowed for a more restrictive transfusion strategy without increasing the incidence of morbidity or mortality.[113,114] Another recent study examining the arterial-to-venous oxygen saturation (A-VO_2) difference as a surrogate for the oxygen delivery/consumption ratio indicated that transfusion in patients with higher A-VO_2 difference was associated with lower morbidity and mortality.[115]

In summary: A large proportion of hospitalized and critically ill patients receive transfusions. Guidelines that overall recommend restrictive red blood cell transfusion strategies are primarily based on hemoglobin concentration thresholds. However, in addition to hemoglobin concentration, decision to transfuse should be individualized and based on multiple other physiological and laboratory parameters with the ultimate goal of optimizing oxygen delivery.

When to Stop Fluid Resuscitation?

The goal of intravenous fluid therapy is to optimize intravascular volume and subsequently organ perfusion. The main indication for starting resuscitative fluid therapy is intravascular volume deficit or acute hypovolemia, though, duration of such therapy is frequently less clear.[116] Timely de-escalation of fluid therapy is of paramount importance to decrease the risk of fluid overload; excessive fluid can result in heart failure, worsening gas exchange, kidney function, and so forth and is associated with worse outcomes in critically ill patients.[117,118]

The decision on when to start and stop fluid therapy is not trivial in critically ill patients due to its dynamic nature, and some authors described it in four phases: resuscitation, optimization, stabilization, and de-escalation.[119]

- In the *resuscitation phase*, the focus is on lifesaving measures and correction of shock to obtain adequate organ perfusion. Early and rapid intravenous (IV) fluid administration is required in form of repeated boluses, which results in a *positive* fluid balance. A reasonable approach may entail administering a 3 to 4 mL/kg bolus over 10 to 15 min, repeated when necessary. The total amount of administered fluids is best individualized, rather than mandated by protocols.
- The second *optimization phase* is focused on organ rescue—optimization and maintenance of tissue perfusion and oxygenation. Fluid administration is more conservative, regularly reassessed with fluid challenge techniques, hemodynamic monitoring, and biochemical markers of perfusion. In this phase, a *neutral* fluid balance may be expected, with the goal of avoiding fluid overload.

- In the third *stabilization phase*, the focus is on organ support, with fluid therapy to ensure adequate water and electrolyte replacement. The aim is a *zero or negative* fluid balance with minimal maintenance infusion.
- Finally, the fourth *de-escalation phase* focuses on organ recovery. The main goal is mobilization of accumulated fluid, aiming for a *negative* fluid balance. If spontaneous diuresis is not adequate, active fluid removal with diuretics or ultrafiltration may be necessary.[119]

In summary: Fluid resuscitation is a dynamic process. Using a four-phase approach (resuscitation, optimization, stabilization, and de-escalation) emphasizes such dynamic nature of fluid resuscitation and particularly the importance of frequent reassessments and adjustments of therapies and therapeutic goals. It is recommended to reduce IV fluid therapy and consider stopping it during the optimization and stabilization phases, respectively.

Do Goal-Directed Fluid Management Strategies Make a Difference?

As discussed above, the aim of goal-directed fluid management is to improve organ perfusion and tissue oxygenation. Multiple factors can contribute to inadequate oxygen delivery (eg, reduced cardiac function, peripheral vascular resistance, or oxygen carrying capacity) and inadequate intravascular volume is only one of them. The relationship of intravascular volume contributing to the cardiac output is described by the Frank–Starling curve and may be considered the basis for goal-directed fluid resuscitation. Typically, fluid therapy is not the only therapy, but rather the first step in goal-directed approaches, which aims to achieve optimal volume status before adding inotropic or vasopressor therapy.

One of the first trials on the goal-directed therapy for treatment of severe sepsis and shock demonstrated decreased mortality with early goal-directed therapy.[120] However, besides fluid boluses, interventions included the use of vasopressors, dobutamine, and red blood cell transfusions, which makes it impossible to determine the impact of fluid therapies, regardless of other criticisms of that study. A randomized multicenter trial with patients who underwent major gastrointestinal surgery demonstrated that the use of cardiac output-guided hemodynamic therapy, which included IV fluids and inotropic medications, did not reduce complication or mortality rates.[72] This was in contrast to two trials: one in patients who underwent colorectal resection and another in low–moderate risk surgical patients that showed esophageal Doppler-guided goal-directed therapies were associated with reduced complications and hospital stay, with no mortality difference.[121,122] In these studies, the administration of fluids and vasoactive medications was guided by stroke volume, arterial blood pressure, and cardiac index. Interestingly, the studies found no difference in intraoperative or postoperative fluid or vasopressor administration. Therefore, the investigators speculated that the beneficial effects of esophageal Doppler-guided strategies were likely secondary to fluid administration at the right time.[121,122] A more recent trial showed that fluid management based on plethysmographic variability index in low-to-intermediate-risk orthopedic surgeries did not shorten hospitalization or improve complications.[41]

As the perioperative fluid therapy is considered one of the most important factors for postoperative outcomes, enhanced recovery after surgery (ERAS) protocols include multiple interventions that reduce the risk of intravascular fluid derangements. ERAS protocol-based studies failed to identify major benefits of goal-directed fluid therapy in abdominal surgery patients.[71] In addition to ERAS, another fluid management strategy—restricted fluid therapy—has been compared with goal-directed approaches. A meta-analysis of trials with patients who underwent noncardiac surgery concluded that it was uncertain whether restrictive fluid therapy is inferior to goal-directed fluid therapy.[123] The evidence was mainly based on studies including abdominal surgeries in a low-risk patient population.

In summary: Overall, variable benefits of goal-directed therapies have been reported, which may be attributed to heterogeneity between trials, study limitations, institutional differences in patient management, poorly defined endpoints, and difference in types of surgery. Evidence suggests that goal-directed fluid therapy may be beneficial only in certain populations; however, the treatment effect remains relatively small.[82] A recent systematic review and meta-analysis concluded that goal-directed hemodynamic therapy might reduce mortality and length of hospital stay with low certainty of evidence.[124] In regard to postoperative outcomes, only infection rate and anastomotic leakage reached moderate certainty of evidence.[124]

The "Third Space": Fact or Fiction?

The concept of the third space was proposed as a mechanism to explain reduction in extracellular fluid volume (ECV) commonly encountered during major surgical procedures or trauma that could not be accounted for by blood losses alone.[125,126] Third space losses have been further divided into anatomical and non-anatomical parts, though it is the non-anatomical extracellular space that is commonly considered as the "classic" third space. Given this separation from other spaces, third space has been described as a "*non-functional extra-cellular volume*".[126,127]

The concept of the third space was originally popularized by a 1961 study, in which plasma volume, red blood cell mass, and ECVs were measured in a control group of patients undergoing minor procedures and an experimental group undergoing elective major surgical procedures.[125] The experimental group demonstrated a marked reduction in functional ECV compared with the control group. The investigators explained this loss through an internal redistribution of fluid into an area that no longer equilibrated with the extracellular fluid. Ultimately, these results led to widespread adoption of the concept of the third space with resultant liberal use of intraoperative fluid management.[128]

In recent years, the concept of third space as an actively consuming compartment has been increasingly challenged.[129] For one, there is a growing appreciation of increased morbidity risks associated with liberal approaches to perioperative fluid management, including respiratory complications, kidney injury, and electrolyte abnormalities.[93,96,130] Second, the methodology behind the studies originally describing the third space has been brought into question: A 2006 systematic review of tracer studies of ECV loss found that studies using longer equilibration times between the compartments failed to support the existence of the third space.[131]

The question about third space is further complicated by the fact that a recent body of literature demonstrated a fluid shift into a "space" not equilibrating with the plasma, that is, a compartment consistent with the definition of the third space. In fact, this line of research suggests that up to a third of the infused crystalloid fluid during surgery enters such a third space. The third space itself is proposed to represent a protective mechanism against intravascular fluid overload,[126] with potential sites including the gastrointestinal track, skin, surgical wounds, and lymphatics.[132] These losses have been shown to increase with isoflurane but not mechanical ventilation, possibly suggesting a link between inhalational anesthetics and perioperative fluid retention.[14]

In summary: The mystery of the elusive "third space" currently remains unsolved, although most of the evidence to date does not support its existence.

SUMMARY

Despite the growing importance, the evidence to guide perioperative fluid management in the older adults is still very limited. What has become clearer over the years, however, is that the best perioperative fluid management strategies need to be restrictive and dynamically tailored to patient characteristics, the severity of the surgical procedure, and blood loss.[97–100] A robust clinical judgment remains the fundamental core to optimal fluid management in this cohort in the perioperative period.

CLINICS CARE POINTS

- The natural age-related decline in organ-specific reserves lead to increased hemodynamic instability, greater vulnerability to fluid shifts and electrolytes imbalances.
- Although a wide range of different technologies has been introduced to monitor intravascular volume status, none has emerged as the uniformly accepted "gold standard", with the experienced clinician remaining as the best monitor of intravascular volume status in the older adults.
- Except for specific populations, the use of balanced crystalloids solutions is preferable. Current evidence does not support the use of albumin in critically ill patients and only suggest a potential benefit in patients with septic shock.
- Best perioperative fluid management strategies need to be restrictive and dynamically tailored to patient characteristics, the severity of the surgical procedure, and blood loss.
- Guidelines on red blood cell transfusion strategies are primarily based on hemoglobin concentration thresholds. However, in addition to hemoglobin concentration, decision to transfuse should be individualized and based on multiple other physiological and laboratory parameters with the ultimate goal of optimizing oxygen delivery.
- Goal-directed fluid therapy may be beneficial only in certain populations; however, the treatment effect remains relatively small.
- The four-phase approach to fluid resuscitation (resuscitation, optimization, stabilization and de-escalation) emphasizes the dynamic nature of fluid resuscitation and the necessity for frequent reassessments and adjustments of therapeutic goals.

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