Substantial variation of both opinions and practice regarding perioperative fluid resuscitation

Peter C. Chong, MD*
Elisa F. Greco, MD*
Danielle Stothart, MD*
Donna E. Maziak, MD, CM*
Sudhir Sundaresan, MD*
Farid M. Shamji, MD*
David Neilipovitz, MD*
Lauralyn McIntyre, MD†
Paul Hébert, MHSc, MD†
Andrew J.E. Seely, PhD, MD*†

From the *Division of Thoracic Surgery, Department of Surgery, and the †Division of Critical Care, University of Ottawa, Ottawa, Ont.

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Correspondence to:
Dr. A.J.E. Seely
Department of Thoracic Surgery
The Ottawa Hospital
501 Smyth Rd.
Ottawa ON K1H 8L6
aseely@ottawahospital.on.ca

Background: There are no current standards of care guiding perioperative fluid administration, and clinicians continue to debate restrictive versus liberal fluid administration. We sought to simultaneously evaluate the opinions and practice of surgeons, intensivists and anesthesiologists in a single centre regarding perioperative fluid resuscitation.

Methods: A postal survey sent to surgeons, intensivists and anesthesiologists in a single academic health care centre presented case-based scenarios followed by questions on fluid requirements and 5-point Likert scales involving statements about resuscitation. We performed a retrospective chart review to evaluate amount and type of intra- and postoperative (72-h) fluid administration, urine output and postoperative ventilation time in patients undergoing uncomplicated esophagectomy or pneumonectomy.

Results: Seventy-four of 77 respondents (96%) agreed that precise fluid resuscitation diminishes the risk of adverse events. Surgeons overall gave less fluids than anesthesiologists or intensivists and used fewer resuscitation end points to estimate fluid requirements perioperatively. For right hemicolectomies, only 3% of surgeons chose a fluid rate greater than 150 mL/h, compared with 55% of intensivists. We reviewed 49 patients' charts (25 who had pneumonectomies, 24 who had esophagectomies) retrospectively. The coefficient of variation (COV = standard deviation divided by its mean) of fluid administration intraoperatively was 0.56 for pneumonectomy and 0.35 for esophagectomy; postoperatively, the COV was greater than 0.50 for the first 24 hours, but less than 0.50 after 24 hours postoperatively.

Conclusion: The presence of substantial variability of both opinion and practice of perioperative fluid resuscitation in a single centre supports the need for further research to identify objective methods to define perioperative fluid requirements and standards of perioperative resuscitation.

Contexte : Il n'existe actuellement aucune norme thérapeutique établie pour guider l'administration de liquides périopératoires et le débat se poursuit entre les médecins qui prônent une administration liquidienne respectivement restrictive et libérale. Nous avons voulu évaluer simultanément les opinions et la pratique des chirurgiens, des intensivistes et des anesthésiologistes attachés à un même centre en ce qui concerne la réanimation périopératoire.

Méthodes : Dans un sondage envoyé par la poste aux chirurgiens, intensivistes et anesthésiologistes d'un hôpital universitaire, nous avons présenté des histoires de cas accompagnées de questions relatives aux besoins liquidiens et d'échelles de Likert en 5 points reposant sur des énoncés ayant trait à la réanimation. Nous avons procédé à un examen rétrospectif des dossiers afin de noter les quantités et les types de liquides administrés durant et après les interventions (72 heures), le débit urinaire et la durée de la ventilation post-opératoire chez des patients devant subir une œsophagectomie ou une pneumonectomie non compliquées.

Résultats : Parmi 77 répondants, 74 (96 %) ont convenu qu'une réanimation liquidienne précise réduit le risque de réactions indésirables. Dans l'ensemble, les chirurgiens ont administré moins de liquides que les anesthésiologistes ou les intensivistes et ont utilisé moins de paramètres associés à la réanimation pour estimer les besoins liquidiens périopératoires. Dans les cas d'hémicolectomie droite, seulement 3 % des chirurgiens ont choisi un débit supérieur à 150 mL/h, contre 55 % des intensivistes. Nous avons passé en revue rétrospectivement les dossiers de 49 patients (25 ayant subi une pneumonectomie et 24, une œsophagectomie). Le coefficient de variation (COV = écart-type divisé par sa moyenne) de l'administration peropératoire de liquides se chiffrait à 0,56 dans les cas de pneumonectomie et à 0,35 dans les cas d'œsophagectomie; en post-opératoire, le COV a été supérieur à 0,50 pendant les 24 premières heures suivant l'intervention, mais inférieur à 0,50 après les 24 premières heures.

Conclusion : L'existence d'opinions et de pratiques substantiellement divergentes de réanimation liquidienne périopératoire dans un seul centre milite en faveur d'un approfondissement de la recherche afin d'établir des méthodes objectives pour définir les besoins liquidiens et établir les normes de réanimation en contexte périopératoire.

Perioperative fluid administration is integral to surgical care. Intravenous fluids maintain hydration while patients are unable to drink and replace losses that occur as a result of surgery. Severity of illness, magnitude and duration of surgery, comorbidities and the host response to injury all influence perioperative fluid needs. Although the principle goal of fluid administration is to maintain adequate tissue perfusion and the perils of over- and under-resuscitation are well documented, there are no standards of care guiding perioperative fluid administration. Investigators continue to debate restrictive versus liberal perioperative fluids.[1–8]

Inadequate perioperative fluid resuscitation can lead to organ failure owing to decreased intravascular volume and inadequate interstitial space resuscitation with deleterious effects on cardiac, pulmonary, gastrointestinal and renal function. This is particularly relevant after surgery, when good blood flow to a surgical anastomosis is critical to good outcomes.[9,10] Supplemental fluid administration has been shown to increase tissue oxygen pressure,[2,11] increase the amount of collagen in healing wounds[12] and quicken recovery after laparoscopic cholecystectomy.[5] Under-resuscitation has also been linked to postoperative nausea and dizziness in amubulatory surgery.[13]

Conversely, over-resuscitation can result in morbidity following major surgery. Fluid accumulation in the extravascular space may result in pulmonary edema, which can be disastrous in patients having undergone pulmonary resection.[14] Over-resuscitation has been implicated in abdominal compartment syndrome[15] and postoperative coagulopathy.[16] Evidence suggests that over-resuscitation can lead to cardiopulmonary events and decreased tissue healing in patients undergoing colorectal surgery.[1,17] Evidence from Lobo and colleagues[18] suggests that a more restrictive postoperative fluid regime after colonic resection allows earlier return of gastrointestinal function than standard fluid therapy. Further complicating the issue is a recent trial showing that the use of a pulmonary artery catheter and dobutamine in high-risk surgical patients decreased postoperative complications compared with fluids alone.[19]

Although a recent survey in the United Kingdom revealed that most consultant surgeons believe that perioperative fluid is inappropriately managed,[20] there has been no formal evaluation of what constitutes an acceptable level of variability in perioperative fluid requirements. The purpose of our investigation was to characterize variation both in terms of estimation perception and actual performance of fluid administration. Our objective was to evaluate opinions and practice regarding perioperative resuscitation for major surgery in a single tertiary care centre. The simultaneous evaluation of practice and opinion allows a determination of physician- versus patient-related factors that contribute to variation in resuscitation. We hypothesized that considerable variation exists in both practice and opinion, even in a single centre.

Methods

Evaluation of opinion

We constructed a survey consisting of case-based scenarios followed by quantitative and qualitative questions on perioperative fluid resuscitation (a sample question is available in Appendix 1). We developed our survey via peer reviews from various disciplines involved in the management of major surgeries (general surgery, thoracic surgery, vascular surgery, anesthesiology, and critical care). We included in the survey cases pertaining to the management of patients undergoing hemicolectomy, esophagectomy, pneumonectomy and abdominal aortic aneurysm (the complete survey is available on request). Each case presented information on the type of surgery, whether it was elective or emergent, patient status and comorbidities. We included questions pertaining to types and amounts of fluid as well as the best measure of resuscitation (central venous pressure, urine output, vital signs and physical examination findings). The questionnaire included questions on resuscitation end points that were scored using a 5-point Likert scale. Demographic information collected from participants included their level of training and discipline(s) of practice.

We mailed the questionnaire to 164 faculty and resident members of the departments of general surgery, thoracic surgery, vascular surgery, anesthesiology and critical care at the University of Ottawa. Seventy-seven surveys were completed anonymously on a voluntary basis. We asked participants to declare their disciplines and level of training and to only evaluate scenarios with which they had clinical experience. We compared variation among the respondents with respect to the type and amount of fluid administered as well as the means of measuring adequacy of resuscitation.

Evaluation of practice

The second phase of our study included the evaluation of fluid administration practices for major surgery. After obtaining approval from The Ottawa Hospital Ethics Review Board, we performed a retrospective chart review. We identified adult patients having undergone elective esophagectomy or pneumonectomy surgery at The Ottawa

Hospital, General campus, between June 2002 and March 2005 using operating room (OR) records. As our investigation was focused on perioperative care for routine major surgery, we excluded patients who had abnormally complicated or lengthy procedures (i.e., carinal sleeve pneumonectomy, chest wall resection, colon interposition esophagectomy, etc.). We gathered data from OR notes, clinical progress notes and nursing notes.

The demographic information that we collected included age, sex, length of stay in hospital, previous surgeries and comorbidities. We recorded fluid loss and administration from the intraoperative start time to 72 hours postoperatively. Perioperative monitoring included the use of central venous pressure and continuous arterial line monitoring. The intraoperative parameters that we recorded included type of incision; urine output; epidural use; surgery time; incidence and duration of episodes of hypotension (systolic blood pressure < 90 mm Hg), tachycardia (heart rate > 90 beats/min) and hypoxemia (SpO_2 < 85%); and estimated blood loss. The postoperative data that we collected included site of recovery (postanesthesia care unit, intensive care unit [ICU], ward), amount and type of fluid administration, urine output, oxygen requirements, presence and duration of postoperative ventilation time, serum creatinine, epidural use and oliguria (< 30 mL/h).

RESULTS

Survey

Respondents

The overall response rate from the surveys was 47% (77/164), including attending and resident physicians; this represented a 65% response rate (34/52) from surgeons, 65% (11/17) from intensivists and 24% (32/133) from anesthesiologists. We had an equal rate of response from attending and resident physicians (48%). There were similar rates of responses from the various disciplines for attending physicians, whereas resident respondents were mostly from surgery followed by anesthesiology.

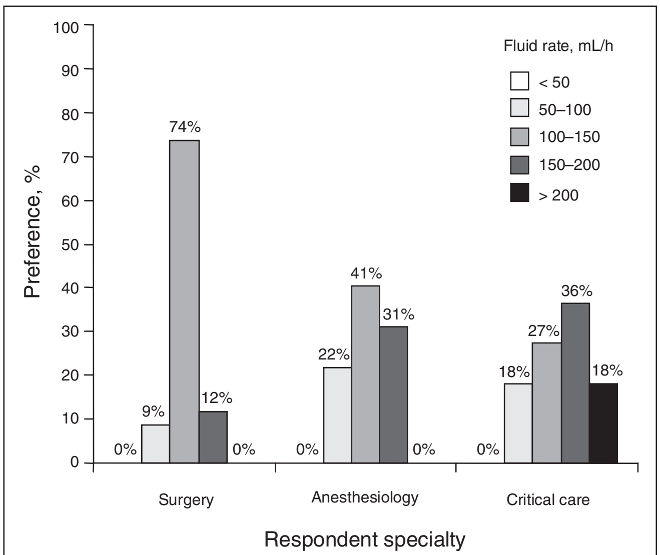

Fig. 1. Respondents had a choice of 5 different fluid rate ranges (e.g., 50–100 mL/h) for the first 24 hours after an elective esophagectomy for cancer in a 60-kg man with no other comorbidities.

Importance of resuscitation

Ninety-six percent of respondents either partially or fully agreed with the statement that "precise fluid control diminished adverse events" in the postoperative period.

Fluid amounts

Overall, surgeons (including surgical residents) chose less fluid for postoperative resuscitation than intensivists and anesthesiologists. Given a clinical scenario for an elective esophagectomy in a patient with no comorbidities, 83% of surgeons chose a 24-hour fluid rate less than 150 mL/h compared with 45% and 63% of intensivists and anesthesiologists, respectively (Fig. 1). The same results were mirrored for right hemicolectomies; 88% of surgeons chose a fluid rate less than 150 mL/h compared with 45% of intensivists (Fig. 2).

Responses to the Likert scale question, "Are you more concerned with over- or under-resuscitation in the postoperative period?" demonstrated that surgeons were more concerned with over-resuscitation than under-resuscitation compared with anesthesiologists or intensivists. For pulmonary surgery, 82% of surgeons were more concerned with over-resuscitation than under-resuscitation compared with 45% of intensivists.

Fluid choices

Surgeons chose normal saline and Ringer lactate in equal numbers for postoperative fluids, whereas anesthesiolo-

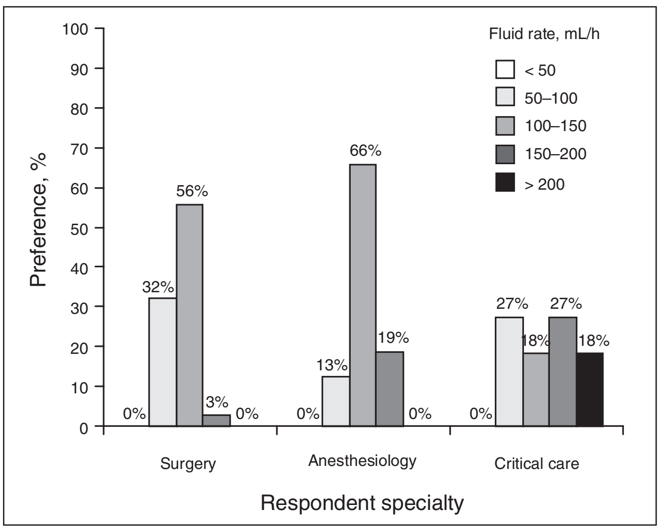

Fig. 2. Respondents had a choice of 5 different fluid rate ranges (e.g., 50–100 mL/h) for the first 24 hours after an elective right hemicolectomy in a 65-kg man with a history of coronary artery disease.

gists and intensivists favoured Ringer lactate. Surgeons were less inclined to prescribe a colloid (pentastarch) in the postoperative period (Fig. 3 and Fig. 4). Overall, respondents chose crystalloids as the standard postoperative fluid, with colloid being added depending on the type of surgery. Respondents chose colloids more often for abdominal aortic aneurysm repair and least often for pulmonary surgery.

Estimators of resuscitation

We observed differences among disciplines in choosing the best measurements of adequacy of resuscitation. Few surgeons relied on physical examination to guide resuscitation in contrast to anesthesiologists and intensivists. Although all clinicians used urine output to estimate resuscitation adequacy, most surgeons chose this marker exclusively. More than 90% of surgeons fully or partially agreed that urine output was the single best measure of perfusion compared with 40% of anesthesiologists and 39% of intensivists. When asked about confidence in current monitoring technology, 62% of surgeons believed that the status quo is adequate compared with 27% of intensivists.

Level of training

We noted no differences between residents and staff within each specialty in terms of fluid choices and postoperative fluid amounts.

Retrospective chart review

Demographics

We reviewed the records of 25 patients who had pneumonectomies and 24 patients who had esophagectomies. The clinical and demographic characteristics of both groups are shown in Table 1.

Intraoperative period

During the operation, patients having esophagectomies received on average 4783 (standard deviation [SD] 1705) mL of crystalloid and 687 (SD 485) mL of colloid compared with patients having pneumonectomies who received 1576 (SD 778) mL of crystalloid and 164 (SD 688) mL colloid. Intraoperative administration of blood products was 177 (SD 180) mL for patients having esophagectomies and 152 (SD 164) mL for patients having pneumonectomies. The estimated blood loss by the surgical team was similar for both types of surgery.

Postoperative period

For the first 72 hours postoperatively, patients who had pneumonectomies received on average, 5.9 (SD 3.0) L of fluids and patients who had esophagectomies received 11.4 (SD 5.6) L during the same period. At 72 hours postoperatively, patients who had esophagectomies remained in a positive fluid balance, whereas those who had

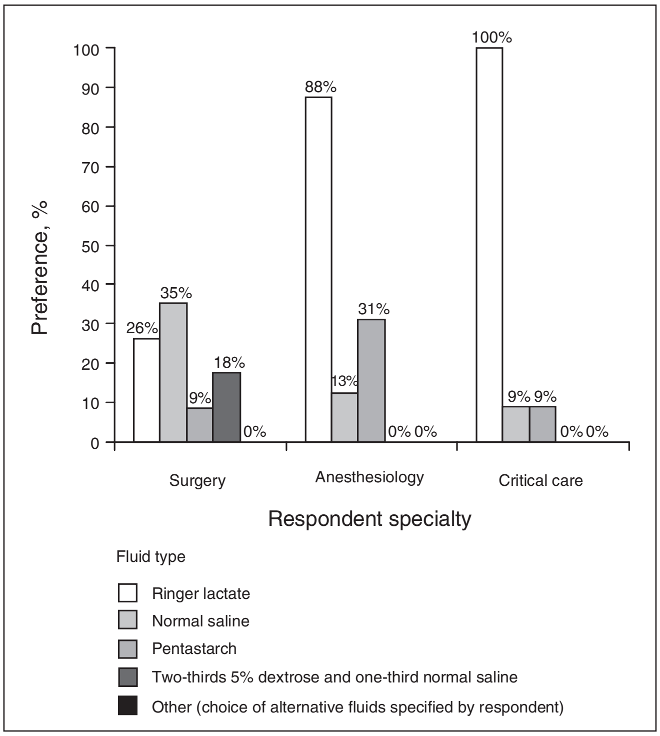

Fig. 3. Postoperative fluid choices for an elective right hemicolectomy. Respondents were allowed to choose more than one fluid type.

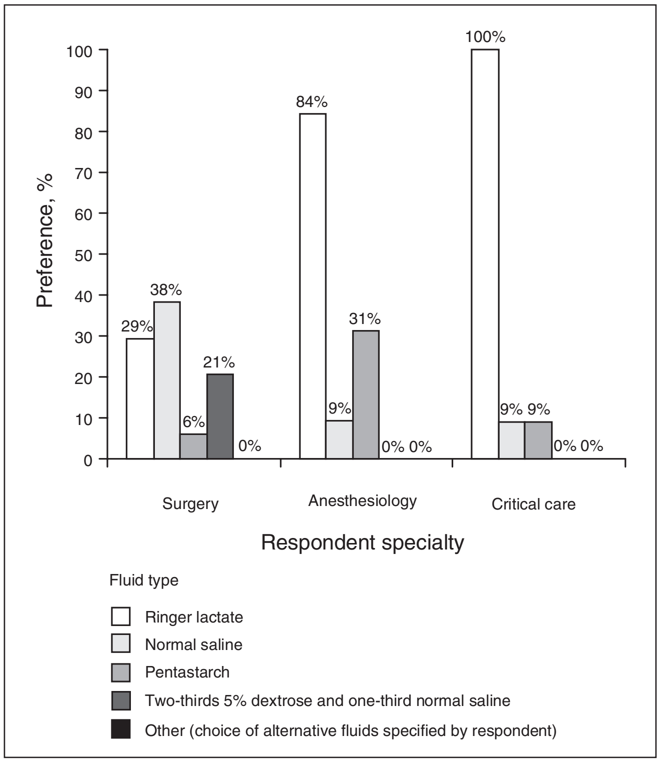

Fig. 4. Postoperative fluid choices for an elective esophagectomy. Respondents were allowed to choose more than one fluid type.

pneumonectomies were in negative fluid balance. In the ICU, intensivists from various disciplines (surgery, anesthesiology and internal medicine) clinically estimated postoperative evaluation of patient volume status via urine output, blood pressure and heart rate. Patients subsequently transferred to the ward had their volume status measured exclusively by the surgical team. In the first 72 hours postoperatively, 44% of patients who had pneumonectomies were estimated to be hypovolemic based on clinical markers compared with 25% of those who had esophagectomies. About 20% of patients who had pneumonectomies and 12.5% of those who had esophagectomies were thought to be hypervolemic. In the first 24 hours, oliguria (< 30 cc/h) occurred for an average of 170 minutes in patients who had pneumonectomies and 72 minutes in those who had esophagectomies. The net fluid balance for both groups of patients in the first 72 hours is shown in Figure 5.

Table 1.Demographic characteristics of 49 patients who underwent pneumonectomy or esophagectomy at The Ottawa Hospital, General campus, between June 2002 and March 2005

Characteristic	Patient group: Pneumonectomy n = 25	Patient group: Esophagectomy n = 24
Age, mean (range) yr	59 (34–78)	58 (17–84)
Male:female ratio	2:3	1:5
Length of stay in hospital, mean d	11	22
Comorbidities, %		
Coronary artery disease	0	12
Angina	8	21
Hypercholesterolemia	28	21
Chronic obstructive pulmonary disease	12	0
Congestive heart failure	0	0
Type 2 diabetes mellitus	4	8
Peripheral vascular disease	0	0
Gastresophageal reflux disease	20	46
Hypertension	20	25
Chronic renal failure	0	0
Past abdominal surgery	40	21
Past thoracic surgery	24	17

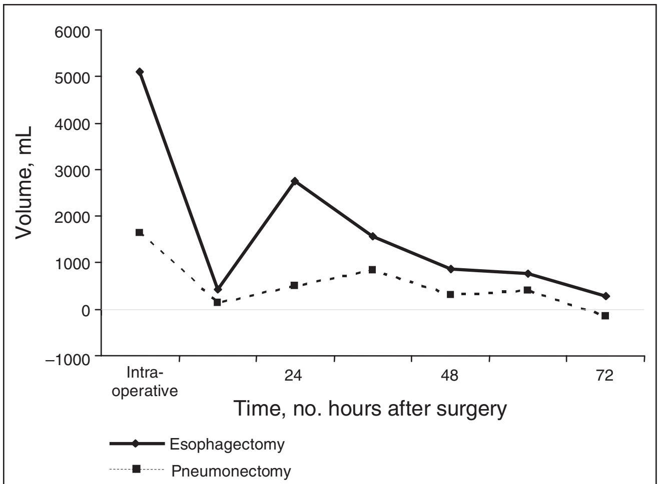

Fig. 5. Net fluid balance in the first 72 hours postoperatively among patients who had esophagectomies or pneumonectomies.

Variation

We used the coefficient of variation (COV) to assess the variation in practice of fluid administration. The COV is a measure of dispersion calculated by dividing the standard deviation of a distribution by its mean. It gives a unitless measurement, with a value of 0 representing no variation. It is useful in comparing 2 groups that have different means (which is true in our case), as the standard deviation will differ based on the mean.[21] Four different fluid regimens of 100 mL/h, 200 mL/h, 300 mL/h or 400 mL/h give a COV of 0.51. Intraoperatively, the COV was 0.56 for patients who had pneumonectomies and 0.35 for those who had esophagectomies. Postoperatively, the COV was above 0.50 at 12, 24 and 72 hours for patients who had pneumonectomies (0.90, 0.55 and 0.70, respectively). For those who had esophagectomies, the COV was above 0.50 at 12 and 24 hours (0.80 and 0.60, respectively). The greatest amount of variance in fluid administration for both groups was seen in the first 12 hours postoperatively (Fig. 6).

Discussion

Given the well-recognized importance of perioperative fluid resuscitation to surgical outcomes, we sought to evaluate the opinions and practice at a single institution to help distinguish patient- and physician-related factors. Survey respondents chose a broad range of fluid administration in theoretical case-based scenarios despite the respondents being from the same institution. For example, roughly equal numbers of intensivists chose 4 different fluid administration rates varying from 50–100 mL/h to more than 200 mL/h following uncomplicated right

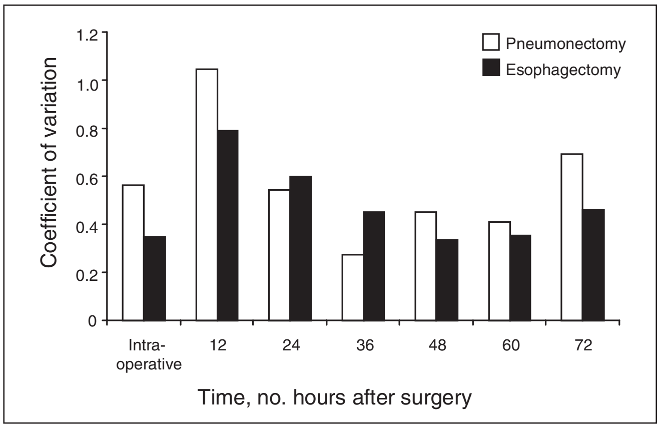

Fig. 6. Coefficient of variation in the first 72 hours postoperatively among patients who had esophagectomies or pneumonectomies.

hemicolectomy (Fig. 2). Variation in opinion was demonstrated among and within specialties. Despite taking care to ensure the pneumonectomies and esophagectomies represented standard, uncomplicated operations, we observed variation in practice (COV > 50%) for patients having had these procedures. A COV greater than 50% indicates that 95% of the data (2 units of SD) vary over 100%. Although this represents an arbitrary threshold and some variation in fluid management is expected, we conclude that our observation indicates marked variation in practice.

Accounting for this variation is multifactorial. Differences in characteristics relating to the patient, their conditions or the operation, including age, comorbidities and duration of surgery, account for substantial variation. However, when we surveyed clinicians using identical case-based scenarios, substantial differences in the amounts of fluids prescribed persisted, and we observed considerable variation in practice despite our evaluation of similar procedures. Although no prior description of an acceptable level of variation of resuscitation practice has been defined, our observations indicate lack of consensus among physicians in a single institution.

We noted differences among disciplines in the administration of fluid. Surgeons overall were more restrictive in fluid therapy than intensivists and anesthesiologists. Several reasons may account for these differences. The fluid avidity of intensivists could be influenced by the trial by Rivers and colleagues,[22] which advocated early and aggressive fluid resuscitation using central venous oxygen saturation to guide goal-directed management of early septic shock. Chronological incidences of complications might also influence clinicians. Physicians might be biased toward preventing either early or late complications depending on where they traditionally participate in perioperative fluid resuscitation. Judging adequacy of fluid management also varied among disciplines. Surgeons relied solely on urine output, whereas intensivists chose more variables to estimate fluid requirements.

In contrast to fixed-volume fluid resuscitation, individualized or "goal-directed" resuscitation has increasingly been evaluated. Shoemaker and colleagues[23–25] have shown that tissue oxygen debt is associated with poorer outcomes in surgical patients. Goal-directed therapy to obtain a preset oxygen delivery index has been shown to decrease postoperative complications and length of stayin hospital among high-risk patients undergoing general surgery.[26] Fluid administration based on achieving an optimal left ventricular stroke volume appears promising;[27] an investigation by Gan and colleagues[28] showed that fluid administration based on maximizing left ventricular stroke volume, as assessed by esophageal Doppler ultrasonography, led to a more rapid return of bowel function and shorter hospital stays. A Cochrane review on fluid optimization after femoral fractures showed that invasive monitoring (using either central venous pressure or esophageal Doppler ultrasonography) led to decreases in fluid volumes infused and reductions in hospital stay.[29] Although total amounts of fluid given during goal-directed therapy might not be dissimilar to that in conventional treatments, the timing of fluid administration is likely to play an important role.[30]

In addition to optimization of macrocirculation, microcirculatory perfusion is increasingly being investigated. New technologies to evaluate microcirculation are experimental but show some promise.[31] Gastric tonometry is a potential adjunct that has been used to demonstrate changes in perfusion during esophagectomy;[32] there has been no published evaluation on whether a device such as this can change patient morbidity and mortality. Clearly some pieces of the fluid resuscitation puzzle are still missing. Our study highlights that methods of estimating adequacy of resuscitation are variable from physician to physician and supports the need for further evaluation of means to monitor adequacy of resuscitation.

A recent review by Holte and colleagues[33] examined evidence from randomized controlled trials concerning the effects of fluid therapy on surgical outcomes. Although the review included 80 trials, there was little conclusive evidence to gain from the synthesis of these trials. Our findings at a single tertiary care centre mirror those found in the literature; despite ongoing research and debate on fluid therapy no consensus or reliable guidelines on how much fluid to give to surgical patients exist.

There are several limitations to our study. Both the survey and the retrospective evaluation of practice were from a single academic centre, therefore we showcased opinions and practice from a limited number of clinicians. However, given that different institutions have different experiences and biases regarding resuscitation, we would expect the variation of practice and opinion to increase if we evaluated other centres. Although the 47% response rate represents a survey return rate equivalent to most physician survey evaluations, the response rate was not equivalent for each of the disciplines queried. We did not evaluate responders for baseline knowledge equivalency; however, the variability in their opinions represents those of practising physicians who deal with perioperative resuscitation on a day-to-day basis. We were unable to match individual physician practice patterns with opinions on fluid management; nonetheless, both were drawn from the same institution and demonstrated marked variability. Data gleaned from our study of simultaneous evaluation of opinions and practice are mostly qualitative in nature, highlighting the present lack of consensus.

Conclusion

Simultaneous evaluation of opinions and practice regarding perioperative fluid resuscitation at the same centre demonstrate marked variation in fluid administration after major surgery, particularly in the immediate perioperative period, in conjunction with substantial variation of opinions regarding resuscitation among surgeons, intensivists and anesthesiologists. We highlight the need to develop rational evidence-based guidelines for the delivery and monitoring of individualized fluid administration during and after major surgery.

Competing interests: None declared.

Contributors: Drs. Maziak, Sundaresan, Neilipovitz, McIntyre, Hébert and Seely designed the study. Drs. Chong, Greco and Stothart acquired the data, which Drs. Chong, Neilipovitz, McIntyre, Hébert and Seely analyzed. Drs. Chong and Seely wrote the article, which all authors reviewed and approved for publication.

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Appendix 1. Sample question from a survey on perioperative fluid administration sent to faculty members and residents in the departments of general surgery, thoracic surgery, vascular surgery, anesthesiology and critical care at the University of Ottawa

A 50-year-old man is undergoing an elective lobectomy for lung cancer. He is moderately obese, weighing 90 kg, and is otherwise healthy with no comorbidities. Surgery is at 8 am; he has been NPO since midnight. A thoracic epidural catheter is placed for perioperative analgesia. The left lower lobe is resected with minimal blood loss (< 150 mL), and the surgery lasts 2 hours and 20 minutes. No transfusion is given intraoperatively. Please check the appropriate boxes for the management you would select (you may check more than one per row).

Preoperative preparation:					
Preoperative vascular access?	• central IV	• arterial line	• pulmonary artery catheter	• other ____________	
Fluid bolus prior to induction?	• crystalloid (amount ______ L)		• colloid (amount ______ L)		
Intraoperative management:					
Your choice of fluid?	• RL	• NS	• Pentaspan	• albumin	• other _______
Estimate the total fluid requirements.	• < 500 mL	• 0.5–1 L	• 1–3 L	• 3–5 L	• > 5 L
The best intraoperative measure of adequacy of resuscitation?	• CVP	• U/O	• vital signs	• physical exam	• other _______
Postoperative management (first 24 hours):					
Your choice of fluid?	• RL	• NS	• Pentaspan	• 2/3 1/3	• other _______
Estimate the average iv fluid rate required for the first 24 hours?	• <50 mL/h	• 50–100 mL/h	• 100–150 mL/h	• 150–200 mL/h	• > 200 mL/h
The best postoperative measure of adequacy of resuscitation?	• CVP	• U/O	• vital signs	• PE	• other _______
Is there a need for postoperative ventilation?	• none	• 4 hours	• overnight	• longer _______days	

CVP = central venous pressure; IV = intravenous; NPO = nil per os; NS = normal saline; PE = physical examination; RL = Ringer lactate; U/O = urine output.