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Improving Fluid Management in the Enhanced Recovery after Surgery: A Plan-Do-Study-Act Cycle

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Abstract

Objective: Judicious fluid management, being an important intervention in Enhanced Recovery after Surgery (ERAS) for colorectal surgery, emphasizes on zero-balance fluid management. However, this concept can be difficult to translate to practice. In our plan-do-study-act cycle, we aimed to study the perioperative fluid usage and also set out to study its impact on outcomes.

Methods: We performed a retrospective baseline audit on all elective major colorectal surgical patients in 2015, made recommendations for improvement and repeated the audit in 2016. Data were collected from existing electronic medical records and analyzed. The rate of intraoperative fluid given was calculated using amount of fluid adjusted for patient's weight and duration of surgery. Outcome measures such as length of stay, surgical complications and acute kidney injury were collected.

Results: The adjusted median rate of intraoperative fluid administered was reduced from 8.44 (IQR 5.49, 11.04) $mlkg^{-1}hr^{-1}$ to 2.67 (IQR 1.69, 4.07) mlkg-$1hr^{-1}$ ($p<0.001$). The adjusted total fluid given in the 1st 24 hours also reduced from 2.28 (IQR 1.81, 3.10) ml/kg/hr to 1.26 (IQR 0.90, 1.63) $mlkg^{-1}hr^{-1}$ ($p<0.001$). The length of stay and incidence of surgical complications were similar. 12 patients (10.3%) in the 2016 group compared to only one in the 2015 group developed acute kidney injury with no patients requiring renal replacement therapy.

Conclusion: Compliance to appropriate fluid management for ERAS improved after raising awareness, implementing a fluid management algorithm and the use of a fluid infusion pump. These simple recommendations may be considered if any ERAS program finds ensuring fluid management a challenge. The clinical significance of acute kidney injury needs further exploration.

Keywords: Enhanced Recovery after Surgery; Postoperative recovery; Fluid management

Introduction

Enhanced Recovery after Surgery (ERAS) refers to a set of evidence-based perioperative interventions to improve overall patient outcomes. These interventions aim to maintain physiological function, minimize surgical stress and encourage processes to enhance the postoperative recovery [1].

Judicious fluid management is one of the important interventions in ERAS for colorectal surgery [1]. Perioperative fluid overload is associated in bowel edema [2], gastrointestinal ileus and delayed hospital discharge [3]. In the setting of ERAS with no bowel preparation, limited preoperative fasting with administration of carbohydrate drinks, the requirements for fluid loading intraoperatively has decreased.

After numerous comparative studies on restrictive versus liberal fluids and debates on goal-directed fluid therapy [4,5] with hemodynamic monitoring devices, the term "zero balance" fluid management is now the goal [6]. Maintenance fluid of 1-3 $mlkg^{-1}hr^{-1}$ has been advocated with volume replacement as required for blood losses [7,8].

ERAS protocol was introduced in our institution in 2013. This incorporated restrictive fluid therapy with the aim of zero-balance in perioperative period. Despite awareness and implementation, poor compliance to ERAS interventions often leads to poor outcomes [9]. Zero-balance fluid management is a concept that can be difficult to translate to practice. Hence, we undertook a plan-do-study-act (PDSA) cycle starting in 2015 aiming to improve fluid management in our institution.

We aimed to study the perioperative fluid usage in the first 24 hours adjusted for surgical duration and associated blood loss in the intra-operative fluid. We also set out to study the impact of the amount of fluid administered intra-operatively on the length of hospital stay and surgical complications.

Patients and Methods

Ethical approval for this study was provided by the Domain Specific Review Board of National Healthcare Group, Singapore (Reference number: 2015/01202, Chairperson A/Prof Low Yin Peng) on 17 December 2015.

We performed a retrospective baseline audit on patients undergoing elective major colorectal surgery in Khoo Teck Puat Hospital from Jan 2015-Dec 2015. Emergency surgeries were excluded. Baseline

characteristics of patients, surgical procedures, duration, estimated blood loss, urine output were obtained from the existing electronic database-OT System 2.0 and Sunrise Clinical Manager. The amount of fluid given intraoperatively and up to 24 hours postoperatively was recorded. The rate of fluid given intraoperatively was then adjusted for patient's weight and duration of surgery.

Outcome measures such as length of stay and surgical complication rate were recorded. The presence of postoperative Acute Kidney Injury, according to the criteria by Kidney Disease; Improving Global Outcomes [10], and the need for renal replacement therapy during the perioperative period were noted.

Following the first audit, the results were presented to the department and recommendations were made for improvement in fluid administration. A fluid management algorithm (Figure 1) was implemented and the use of the volumetric fluid infusion pump (B Braun infusomat) for intra-operative maintenance fluid administration was recommended. The same audit was repeated from April 2016 to March 2017.

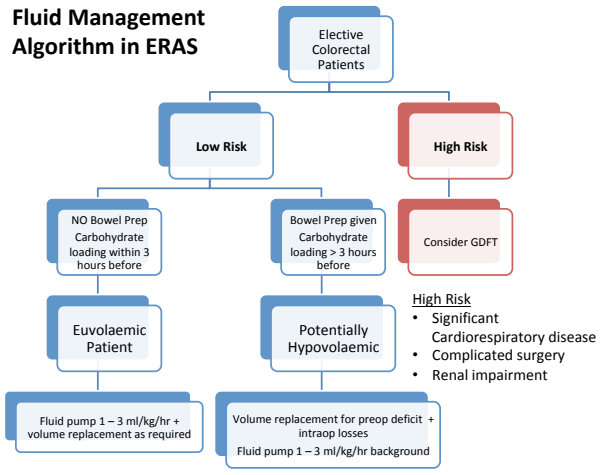

Figure 1: Fluid management algorithm implemented after dissemination of audit results. GDFT=Goal-Directed Fluid Therapy, Prep=Preparation, preop=preoperative, intraop=intraoperative.

The data was analyzed using IBM SPSS Statistics. For continuous variables, Mann-U Whitney tests were used for non-parametric data and student t test was used for parametric data. For categorical data, chi square test was used. A p value of 0.05 and below was used for statistical significance.

Results

Results from 112 patients in the 2015 group were analyzed and after the recommendations for improvement were made, 116 patients in the 2016 group were analyzed.

The adjusted median rate of intraoperative fluid administered was reduced from 8.44 (interquartile range=5.49, 11.04) $mlkg^{-1}hr^{-1}$ to 2.67 (interquartile range=1.69, 4.07) $mlkg^{-1}hr^{-1}$ (p<0.001). The adjusted total fluid given in the 1st 24 hours also reduced from 2.28 (1.81, 3.10) $mlkg^{-1}hr^{-1}$ to 1.26 (0.90, 1.63) $mlkg^{-1}hr^{-1}$ (p<0.001) (Table 1).

Fluid administration	2015 group (n=112)	2016 group (n=116)	p value
Adjusted rate of fluid intraoperatively ($mlkg^{-1}hr^{-1}$)	8.44 (IQR 5.49, 11.04)	2.67 (IQR 1. 69, 4.07)	p<0.001
Adjusted rate of fluid given over first 24 hours ($mlkg^{-1}hr^{-1}$)	2.28 (IQR 1.81, 3.10)	1.26 (IQR 0.90, 1.63)	p<0.001
Median and interquartile range shown, Mann U Whitney test used			

Table 1: Comparison of fluid administration between 2 groups.

When comparing the baseline characteristics of the 2 groups (Table 2), the 2016 group had more ASA 1 patients and less ASA 2 and 3 patients (p<0.001) and mean duration of surgery was longer (4.93 ± 1.87 versus 3.96 ± 1.35, p<0.001).

The mean age, body mass index (BMI), gender distribution, type of surgery and estimated blood loss were similar between 2 groups.

Baseline characteristics	2015 group (n=112)	2016 group (n=116)	p value
Mean age (years)	65.6 ± 11.3	65.2 ± 12.0	p=0.803
Mean BMI (kgm^{-2})	24.19 ± 5.94	23.01 ± 4.62	p=0.110
Gender			p=0.709
Male	60 (46.4%)	65 (56.0%)	
Female	52 (53.6%)	51 (44.0%)	
ASA status			P<0.001
1	0	19 (16.4%)	
2	78 (69.6%)	73 (62.9%)	
3	18 (33.3%)	24 (20.7%)	
Type of surgery			p=0.123
Open	39 (34.8%)	52 (44.8%)	
Laparoscopic	73 (65.2%)	64 (55.2%)	
Mean duration of surgery (hr)	3.96 ± 1.35	4.93 ± 1.87	p<0.001
Estimated blood loss			p=0.650
<50 ml	29 (25.9%)	32 (27.6%)	
50-200 ml	46 (41.1%)	51 (44.0%)	
201-500 ml	32 (28.6%)	29 (25.0%)	
>501 ml	5 (4.5%)	4 (3.5%)	
Average adjusted urine output intraoperatively ($mlhr^{-1}$)	70.1 (IQR 45, 104.2)	44.4 (IQR 25.9, 62.8)	p< 0.001
BMI: Body mass index; ASA: American Society of Anesthesiology			

Table 2: Baseline characteristics of both groups.

There was no statistical difference between the 2 groups for the outcome measures (Table 3) such as length of stay (p=0.750) for all patients, length of stay for open surgery (p=0.309), length of stay for laparoscopic surgery (p=0.648) and incidence of surgical complications (p=0.172).

Outcome measures	2015 group (n=112)	2016 group (n=116)	p value
Median length of stay (days)			
All	5 (4,7)	5.5 (4,8)	p=0.750
Laparoscopic	5 (4,6)	4 (3,6.75)	p=0.648
Open	7 (5,8)	7 (5,9.75)	P=0.309
Incidence of surgical complications	24 (21.4%)	34 (29.3%)	p=0.172
Incidence of postoperative acute kidney injury	1 (0.9%)	12 (10.3%)	p=0.002

Table 3: Outcome measures between 2 groups.

One patient in the 2015 group developed acute kidney injury in the immediate postoperative period compared to 12 patients (10.3%) in the 2016 group. Of the 12 patients in the 2016 group, 11 had grade 1 acute kidney injury and only 1 patient developed grade 2 acute kidney injury. None of the patients required renal replacement therapy.

Discussion

In our PDSA cycle, our initial results in 2015 showed that zero-balance fluid management was difficult to achieve with majority of our patients receiving fluids in excess of the recommended 1-3 $mlkg^{-1}hr^{-1}$. The variation in amount of fluid administered was also large in 2015. This occurred despite introduction and awareness of the ERAS protocols since 2013. Subsequently, following a set of recommendations which included the fluid management algorithm and use of a fluid pump, the median adjusted intraoperative fluid administered reduced to 2.67 $mlkg^{-1}hr^{-1}$ with less variation.

In general, there is a large amount of variation in the way anesthetists administer fluids intraoperatively [11]. Even in existing literature on ERAS, the terms "restrictive" and "liberal" are not defined clearly [12]. For most surgeries in the adult population, the amount of fluid given is often calculated based on a per-bag basis rather than actual millilitres administered. The rate of fluid being administered is often not precise as it depends on the regulating clip on the dripset and dimensions of the intravenous cannula. Hence, the amount of fluid given intraoperatively is often arbitrary and based on individual clinical experience. This clinical experience however stems from an era where patients are fasted for prolonged periods preoperatively before undergoing open abdominal surgery. In the setting of ERAS where patients are kept euvolaemic preoperatively with carbohydrate drinks, lack of bowel preparation and undergo minimally invasive surgery, copious amounts of intraoperative fluids actually do more harm [13,14].

Goal-directed fluid therapy aims to reduce such variations by providing measurable parameters to guide fluid administration. It is likely that for high-risk patients undergoing complicated open abdominal surgery, the additional guidance on fluid management can make a difference [15]. However, recent studies show that the use of these high-end devices with expensive consummables in low-risk patients undergoing minimally invasive surgeries does not necessarily improve outcomes [6,16,17]. Hence implementing goal-directed fluid therapy on every ERAS patient cannot be the answer to better compliance.

As mentioned, improvement in outcomes has always been proportional to the rates of compliance to the ERAS protocol elements [9]. Although awareness is the first step towards compliance, eventual actions in practice still requires complete "buy-in" and also the implementation of simple practical processes. The processes need to be easily available and does not involve perceived costs economically as well as in terms of potential complications. In our PDPA cycle, the use of a volumetric fluid infusion pump provides a simple yet effective solution for anesthetists to regulate and monitor the actual fluid amount.

In the Relief trial [18], a restrictive fluid regimen in a heterogeneous group of abdominal surgical patients was found to be associated with higher rate of acute kidney injury. Although our study, which involved only colorectal surgeries in the ERAS setting, yielded similar findings, majority of the patient developed only grade 1 acute kidney injury with no requirements for renal replacement therapy. The only patient who had grade 2 acute kidney injury had prior renal impairment and subsequent creatinine levels returned to her baseline. The clinical significance of this transient mild acute kidney injury beyond the first 48 hours postoperatively is still questionable and remains to be answered by future prospective studies with longer follow-up period.

The length of hospital stay and incidence of surgical complications were not statistically significantly different and this is possibly because our study is underpowered. Due to the retrospective nature of the study, the interplay of other elements in the ERAS, which may have affected the outcome measures, was not explored in our study. Subsequent repeated audits will also need to be performed to find out the sustainability of the recommendations and results.

Conclusion

Initial compliance to zero-balance fluid management was poor despite the introduction of ERAS protocol in our centre in 2013. Following dissemination of the results, raising awareness, implementing the fluid management algorithm and the use of a fluid infusion pump, fluid management improved and became more appropriate. These simple recommendations may be considered if any ERAS program finds ensuring fluid management compliance a challenge.

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