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ORIGINAL ARTICLE

Stringent fluid management might help to prevent postoperative ileus after loop ileostomy closure

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Abstract

Purpose The present study aimed to analyze the impact of perioperative fluid management on postoperative ileus (POI) after loop ileostomy closure.

Methods Consecutive loop ileostomy closures over a 6-year period (May 2011–May 2017) were included. Main outcomes were POI, defined as time to first stool beyond POD 3, and postoperative complications of any grade. Critical fluid management–related thresholds including postoperative weight gain were identified through receiver operator characteristics (ROC) analysis and tested in a multivariable analysis.

Results Of 238 included patients, 33 (14%) presented with POI; overall complications occurred in 91 patients (38%). 1.7 L IV fluids at postoperative day (POD) 0 was determined a critical threshold for POI (area under ROC curve (AUROC), 0.64), yielding a negative predictive value (NPV) of 93%. Further, a critical cutoff for a postoperative weight gain of 1.2 kg at POD 2 was identified (AUROC, 0.65; NPV, 95%). Multivariable analysis confirmed POD 0 fluids of > 1.7 L (OR, 4.7; 95% CI, 1.4–15.3; $p = 0.01$) and POD 2 weight gain of > 1.2 kg (OR, 3.1; 95% CI, 1–9.4; $p = 0.046$) as independent predictors for POI.

Conclusions Perioperative fluid administration of > 1.7 L and POD 2 weight gain of > 1.2 kg represent critical thresholds for POI after loop ileostomy closure.

Keywords Loop ileostomy · Fluid management · Weight gain · Postoperative ileus · Complications

Abbreviations
ERAS enhanced recovery after surgery

Introduction

Loop ileostomy closure (LIC) as a seemingly simple procedure was repeatedly associated with considerable morbidity, with overall complication rates of up to 45% and reoperation rates of up to 7% [1–3]. More recently, several authors advocated LIC as a same-day procedure in selected patients [4, 5]. However, only a few patients were eligible for an ambulant hospital management in a recent analysis [6]. One reason for delayed recovery is postoperative ileus (POI), which occurs in about 20% of patients [7, 8]. Stringent fluid management within enhanced recovery protocols has been identified as a way to decrease ileus rates after colorectal resections [9]. However, it is quite unknown what "fluid overload" means in concrete terms, and little is known about perioperative intravenous (IV) fluid management during LIC.

The present study aimed to define IV fluid management–related thresholds associated with POI after LIC.

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Material and methods

Patients

Consecutive patients undergoing LIC over a 6-year period (May 2011–May 2017) at Lausanne University Hospital

(CHUV) were included. Patients were treated within a standardized enhanced recovery (ERAS) pathway for LIC [7]. Data were prospectively entered in an institutional ERAS database by a dedicated clinical nurse and data entry cross-checked through hebdomadal audit sessions by the institutional ERAS care team. Baseline demographic data and surgical details that were retained for the present analysis are displayed in Table 1. Index surgeries were carried out for malignant and benign indications. According to institutional policy, pretreated patients (neoadjuvant chemotherapy) were temporarily diverted, as were patients with low rectal cancers with an anastomosis below 4 cm. In our institution, LIC was performed 6 weeks after the index procedure or after completion of chemotherapy (usually 3 months).

LIC was performed in a standardized matter by the institutional colorectal surgical team [7]. Type of anastomosis (hand sewn vs. stapled), duration of the procedure, and overall compliance to ERAS items (stratified as 70%) were assessed [10]. This study was conducted as part of an institutional quality improvement project, and data extraction was approved by the Institutional Review Board (Commission cantonale d'éthique de la recherche sur l'être humain CER-VD # 2017-01971).

Fluid management–related parameters

Two parameters were assessed to define critical thresholds: total intravenous (IV) volume administration at the day of surgery (postoperative day (POD) 0), composed of intraoperative fluids including crystalloids, colloids, and blood products and postoperative IV fluids until midnight, based on anesthesia chart review. The second parameter was weight gain at POD 2, assessed by a staff nurse using standard balances.

Outcomes/study endpoints

The primary endpoint was POI, which was defined as time to delayed passage of stool beyond POD 3, according to ERAS recommendations and two expert consensus statements [11, 12].

Further were assessed overall complication rate (Clavien grade I–V) [13] and length of hospital stay.

Statistical analysis

Thresholds were identified through receiver operator characteristics (ROC) analysis to yield jointly optimal sensitivity and specificity of each ROC curve. ROC curves were calculated with the Statistical and Machine Learning Toolbox of MATLAB R2018a (Mathworks, Natick, MA, 01760, USA). Negative predictive values (NPVs) were calculated for both thresholds. Descriptive statistics for categorical variables were reported as frequency (%), while continuous variables were reported as mean (standard deviation) or median (interquartile range). Chi-square was used for comparison of categorical variables. All statistical tests were two-sided, and a level of 0.05 was used to indicate statistical significance. Data analysis was performed with the Statistical Software for the Social Sciences SPSS Advanced Statistics 22 (IBM Software Group, 200 W. Madison St., Chicago, IL, 60606, USA).

Results

Patients

The study cohort included 238 consecutive patients, with demographic and surgical details displayed in Table 1. Thirty-three patients (14%) presented with POI, while overall 30-day

Table 1 Demographic and surgical items

	All patients ($n = 238$)	Ileus ($n = 33$)	No ileus ($n = 205$)	p
Age (mean ± SD)	60 ± 15	64 ± 12	59 ± 16	*0.049*
Age ≥ 70 years (%)	44 (36)	13 (39)	59 (29)	0.226
Gender (m:f)	144:94	123:82	21:12	0.848
Smoker (%)	49 (21)	8 (24)	41 (20)	0.643
BMI (kg/m^2) (mean ± SD)	25 ± 5.3	24.4 ± 5.1	25.1 ± 5.3	0.489
ASA group (1–2:3–4)	182:56	18:15	164:41	*0.003*
Malignancy (%)	147 (62)	17 (52)	130 (63)	0.247
Hand sewn anastomosis (%) operation duration (min) (mean ± SD)	194 (82) 100 ± 50	25 (76) 140 ± 60	169 (82) 100 ± 40	0.213 < *0.001*
Operation duration > 90 min (%)	122 (51)	25 (76)	97 (47)	*0.003*
IV fluid administration at POD 0 (mL) (mean ± SD)	1700 ± 800	2300 ± 1200	1700 ± 600	*0.007*
Weight gain at POD 2 (kg) (mean ± SD)	1.6 ± 2.8	3.4 ± 3.8	1.3 ± 2.5	*0.015*

Baseline demographic and surgical parameters of patients with postoperative ileus ($n = 33$) and patients without postoperative ileus ($n = 205$)

BMI, body mass index; *ASA*, American Society of Anesthesiology; *POD*, postoperative day

Italic characters indicate significant values ($p < 0.05$)

complications occurred in 91 patients (38%). Median length of stay was 4 days (IQR, 3–10). On univariate analysis, age, ASA group, operation duration, perioperative fluid administration, and postoperative weight gain were higher in patients with POI as compared to those without (Table 1). Overall ERAS compliance of > 70% was observed in 79% of patients with POI and in 91% of patients without POI ($p = 0.089$).

Thresholds

1.7 L IV fluids at postoperative day (POD) 0 was determined a critical threshold for POI (AUROC, 0.64), yielding a negative predictive value (NPV) of 93%. Further, a critical cutoff for a postoperative weight gain of 1.2 kg at POD 2 was identified (AUROC, 0.65; NPV, 95%). ROC curves are displayed as online appendix.

Figure 1 illustrates different clinical outcomes in the patient group below and above thresholds. Fluid administration of > 1.7 L was associated with increased length of stay (5 vs.4 days, $p = 0.001$). Similarly, patients with weight gain of > 1.2 kg at POD 2 had a longer length of stay (5 vs.4 days, $p = 0.015$) compared to patients below the threshold.

Independent risk factors for POI

Multivariable analysis identified POD 0 fluids of > 1.7 L (OR, 4.7; 95% CI, 1.4–15.3; $p = 0.01$) and POD 2 weight gain of > 1.2 kg (OR, 3.1; 95% CI, 1–9.4; $p = 0.046$) as independent predictors for POI (Fig. 2).

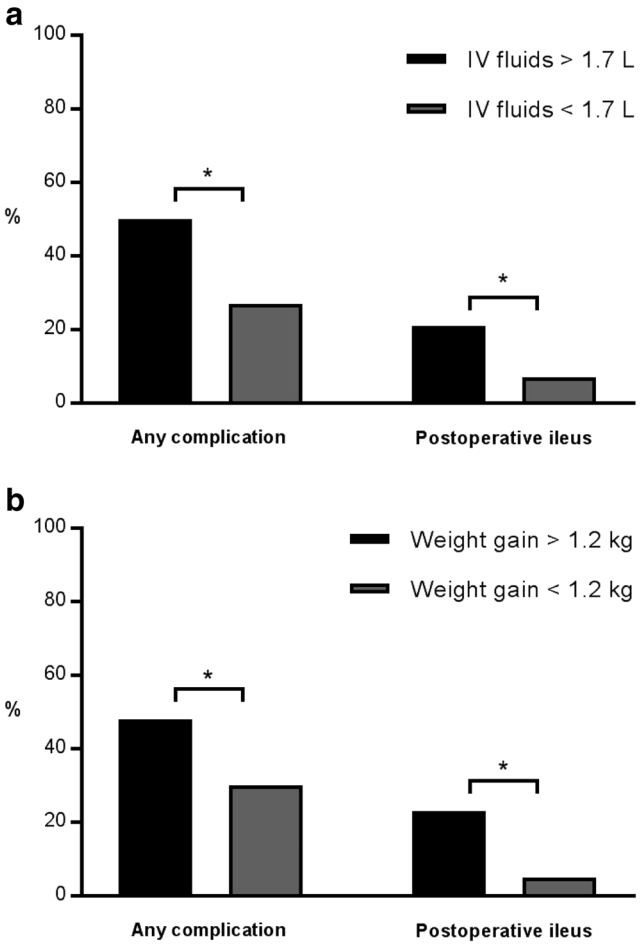

Fig. 1 Outcomes of patients above and below thresholds. **a** IV fluids. **b** Weight. Comparison of percentages of patients with overall complications ($n = 91$) and POI ($n = 33$) in patients receiving > 1.7 L of total fluids at POD 0 and patients receiving < 1.7 L (**a**) and patients gaining > 1.2 kg of body weight at POD 2 and patients gaining < 1.2 kg (**b**). * indicates statistical significance ($p < 0.05$). POI, postoperative ileus; IV, intravenous; POD, postoperative day

Discussion

The present study suggested perioperative IV fluid administration > 1.7 L on POD 0 and weight gain of 1.2 kg on POD 2 as critical thresholds for the development of postoperative ileus in a consecutive cohort of patients undergoing loop ileostomy closure. Stringent intravenous fluid management might help to decrease postoperative complications after this frequently performed routine procedure.

Recent evidence suggested higher rates of acute kidney injury in patients with stringent fluid management [14]. However, it is important to mention that this effect was not observed in patients treated within enhanced recovery protocols [14]. Defunctioning loop ileostomies after low anterior rectum resections have been repeatedly associated with decreased clinical anastomotic leak rates and lower reoperation rates [15, 16]. However, published morbidity rates after LIC are considerable, and particularly, POI has been identified as an important drawback for quick recovery and short hospital stay [17]. Several techniques were suggested to promote recovery of bowel function after LIC. In a recent randomized trial, daily stimulation of defunctioning stoma segments 2 weeks before LIC using a thick solution allowed for a significant decrease in POI and hospital stay [17]. These results need independent confirmation by larger studies, such as a recently launched pan-Canadian multicenter trial [18]. While the multicenter randomized HASTA (hand suture versus stapling) trial revealed no significant difference in bowel obstruction rate within 30 postoperative days between the two groups [19], a meta-analysis by the same group showed decreased obstruction rates after stapled anastomosis [20].

Stringent perioperative fluid management as part of enhanced recovery (ERAS) protocols promotes functional recovery including faster return of bowel function [21]. However, uncritical extrapolation of the institutional colorectal ERAS pathway to LIC led to initial difficulties and needed corrections to achieve shorter length of stay in the present institution [7]. The present study analyzed in more detail the impact of perioperative IV fluid management on POI rates in a cohort of 238 LIC procedures to identify critical fluid-related

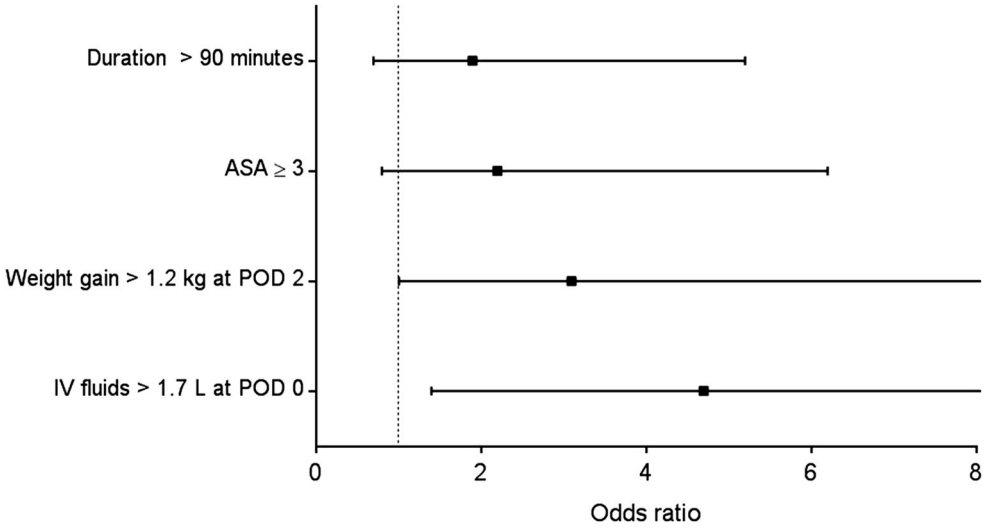

Fig. 2 Multivariable analysis of factors associated with POI. Multivariable analysis of univariate factors with $p < 0.05$ associated with postoperative ileus (POI, $n = 33$). An odds ratio of more than 1 increases the risk of ileus. ASA, American Society of Anesthesiology; POD, postoperative day; IV, intravenous. Odds ratio, 95% confidence interval

thresholds (POD 0 IV fluids of 1.7 L and POD 2 weight gain of 1.2 kg) through ROC analysis. Patients below thresholds presented with significantly less POI and overall complications and had a shorter length of stay, and exceeding of either threshold was independently associated with POI after multivariable analysis. Both thresholds might serve as "red flags" and points of reference to guide anesthetists and surgeons likewise through perioperative care in these elective procedures. Patients exceeding the thresholds may need particular attention to avoid further fluid overload and weight gain through fluid restriction, promotion of mobilization, and diuretics.

Several limitations of this study need to be addressed. First, this is a retrospective single-center study with a limited number of patients. The consecutive and unselected study cohort is heterogeneous in an attempt to picture the real-world situation ("all-comers"). Intravenous fluid management was targeted since it is easily assessable for monitoring and modifiable. However, interstitial fluid retention may vary among patients [22, 23]. Second, further fluid management–related measures, such as urine output with potential impact on postoperative weight gain, were not measured in the setting of these routine procedures. Finally, some residual confounding may exist due to the limited number of available items, including biomarkers. The results thus need to be interpreted with caution, and the suggested thresholds need to be considered as a help in guidance rather than dogmatic cutoffs. Furthermore, the suggested thresholds therefore need independent validation, with joint data on cumulative fluid balance and eventually, urine output. Furthermore, definitions and grading of POI vary widely in the literature, impeding uncritical comparison. The definition of POI in this present study was based on two expert consensus statements and on ERAS recommendations.

In conclusion, the present study emphasizes the importance of stringent intravenous fluid management in LIC. Prevention of fluid overload is likely to prevent POI and to allow earlier patient discharge.

Authors' contribution FG, BP, JS, and MH: study conception and design; FG, BP, FB, and JS: acquisition of data; FG, BP, FB, DH, ND, and MH: analysis and interpretation of data; FG, BP, FB, DH, ND, and MH: drafting of manuscript; FG, BP, FB, JS, DH, ND, and MH: critical revision of manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent This study was conducted as an institutional quality improvement project. Therefore, no informed consent was needed, after approval of the Institutional Review Board (Commission cantonale d'éthique de la recherche sur l'être humain CER-VD # 2017-01971).

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