

Nurses' Indications for Administration of Perioperative Intravenous Fluid Therapy—A Prospective, Descriptive, Single-Center Cohort Study

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Purpose: To examine whether nurse anesthetists and postanesthesia nurses' administration of intravenous (IV) fluid therapy during surgery and in the postanesthesia care unit is based on evidence. Secondarily to investigate if providing indications for IV fluid administration changed nursing practice.

Design: Prospective, descriptive, single-center study in Scandinavia comparing two cohorts.

Methods: Descriptive, fluid volume, and type data were obtained in both cohorts. Cohort 1 ($n = 126$) was used as baseline data. In cohort 2 ($n = 130$), nurses recorded indications for type and volume of fluid therapy using a validated list. Analysis compared median volumes of crystalloid or colloid fluids of surgical types by cohort. Analysis compared frequency of given indication reasons for each IV fluid by surgical type.

Findings: Basic static variables were chosen most frequently for indications of IV fluid needed for all surgeries except high-risk abdominal surgery where dynamic variables were more frequent. Signs and symptoms of inadequate tissue perfusion were only sparsely indicated. The volume of intraoperative crystalloid fluids was statistically different for patients with hip fracture surgery in cohort 2. Volumes of both colloid and crystalloid fluids were significantly higher for high-risk abdominal surgery in cohort 2.

Conclusions: Nurse anesthetists and nurses in the postanesthesia care unit rely more on basic static parameters than signs of inadequate tissue perfusion when they make decisions about fluid administration. The indications cited for fluid administered to high-risk abdominal surgery and hip fracture patients did not always fit guidelines. This indicates the need

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Conflict of interest: None to report.

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of a stronger intervention to change practice to follow evidence-based clinical guidelines.

Keywords: *perioperative nursing, intravenous fluid administration, perianesthesia, nurse anesthetists, evidence-based nursing, clinical guidelines.*

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INTRAVENOUS (IV) FLUID ADMINISTRATION

is one of the most frequently used interventions in hospitals and plays a vital role in establishing and maintaining cellular homeostasis.^{1,2} Perioperative IV fluid administration has been shown to be extremely variable and provider dependent in some studies.^{3,4} Indications for IV fluid administration can be hypovolemia, sepsis, and perioperative correction of volume losses.⁵ For most surgical patients estimated fluid losses are replaced during surgery and oral intake of fluid is rapidly resumed after surgery.

Inadequate use of IV fluid can lead to reduced cardiac output and tissue hypoperfusion. Conversely, excessive use of IV fluid can lead to edema, acidosis, and severe electrolyte derangement. Consequently, patients may experience high levels of morbidity, prolongation of hospitalization, and even excess mortality.^{2,5,6} Current evidence shows that the adverse effects of fluid depend on the type and dose of fluid administered and the specific context in which it is given.^{1,5} Therefore, IV fluid administration should be considered analogous to drug delivery.⁷ Evidence suggests that optimization of flow-related variables (by using the principals of goal-directed therapy [GDT]) can reduce the number of postoperative complications and time spent in hospital.^{8,9}

However, despite clinical guidelines on how to provide IV fluid in the perioperative period, practices of health professionals vary.^{8,10} Development and dissemination of clinical guidelines are supposed to help health professionals to implement new knowledge and interventions into clinical practice. Despite this, many health professionals rely more on their expertise than on research.¹¹ Consequently, physicians often prescribe IV fluid therapy with limited knowledge or appreciation of its potential to cause harm.⁵ Therefore, it is important to raise

awareness of existing practice and the extent to which there may be automatically cued habits that are not conducive to evidence-based practice.¹¹

In Scandinavia, nurse anesthetists and nurses in the postanesthesia care unit (PACU) are responsible for administering IV fluid therapy based on delegated responsibility and grounded in their clinical observations, such as cold and pale skin, bleeding and other fluid losses, an increase in serum lactate, or stroke volume (SV) response. Therefore, knowledge of their IV fluid practices and the impact of their perceptions of indications for IV fluid therapy need to be explored to take necessary educational actions to assure that patients receive fluid according to current evidence.

Accordingly, the primary purpose of this study was to examine nurses' practice for IV fluid administration to identify if this practice was based on evidence and clinical guidelines to reflect evidence-based decision-making.

A secondary purpose was to investigate if nurses, when asked to provide indications for their IV fluid administration, would change their practice within this field.

Method

We performed a prospective, descriptive, single-center cohort study¹² with two cohorts following patients during surgery and in the PACU. Data in both cohorts on the amount and type of IV fluid administered by nurse anesthetists and nurses in the PACU were obtained. Cohort 1 was the unexposed group and served as baseline, because the participants in cohort 2 were aware of observation and potentially could change behavior due to this.¹³ In cohort 2, the exposure in the form of an intervention was made as we asked nurses

and nurse anesthetists to document rationale for their administration of IV fluid.

Participants and Patient Inclusion Criteria

All nurse anesthetists (n = 60) and nurses in the PACU (n = 32) in the present center were asked to take part in the study. In Denmark, nurse anesthetists have 2 years postgraduate education in anesthesiology and at least 2 years of experience as a nurse before they are employed in an anesthetic unit. Nurses in the PACU have no formal postgraduate education.

All patients meeting the following criteria were included in the study: 18 years or older undergoing high-risk abdominal surgery (defined as major abdominal pathology requiring emergency laparoscopy or laparotomy including reoperations after elective gastrointestinal surgery¹⁴), hip fracture surgery, lower limb amputation, revision arthroplasty, or elective colorectal surgery.

Setting

The study was conducted in the Department of Anaesthesiology, in a University Hospital in the capital region of Denmark, from December 2015 to June 2016. The center performs anesthesia 26,000 times each year, covering orthopaedic surgery, gastrointestinal surgery, and gynecology and obstetrics. The present center has local guidelines defining how to administer IV fluid intraoperatively for all included patient categories. These guidelines are developed by chief physicians employed in the present center and are updated every second year according to current evidence. Each time a guideline is written or updated all nurses and doctors receive an e-mail with information about the guideline. They are then expected to read it and use it in their daily practice. An exception is the guideline used for patients undergoing high-risk abdominal surgery. Here the present center offers a monthly 1-hour education in use of the monitor and GDT. The education is performed by chief physicians with experience in using GDT, and nurses and physicians are expected to participate. The education is offered because of the reality that GDT is a complex intervention and requires new skills. Nurse anesthetists, nurses in the PACU, and physicians have access to the guidelines through the hospitals intranet, which is available in the operating room and by each bed in the PACU.

During surgery, the principles of GDT are standard care for patients undergoing high-risk abdominal surgery¹⁵ according to the present center's guideline. Physicians and nurse anesthetists are intraoperatively expected to administer a bolus of 250 mL colloid solution from assessment of dynamic preload parameters based on SV measured via arterial waveform analysis. Infusions of crystalloids are based on the patient's weight and are also used for fluid bolus when colloids are contraindicated. After the induction of anesthesia, the physician leaves the operating theater and the nurse anesthetist is responsible for administering IV fluid according to the prescribed algorithm. The nurse anesthetist is also responsible for the patient care, to react on changes in the patients' condition, and to inform the physician about these changes.

According to the present center's guidelines, patients undergoing hip fracture surgery or revision arthroplasty should receive isotonic crystalloids 10 mL/kg/h in the first hours and 3 mL/kg/h for the remaining time. Patients undergoing lower limb amputation should receive isotonic crystalloids 5 mL/kg/h. Patients scheduled for elective colorectal surgery should receive isotonic crystalloid 20 to 30 mL/kg during the entire procedure. Colloid solutions are administered in the case of clinically suspected hypovolemia or bleeding unless colloid solutions are contraindicated.

In PACU, GDT is standard care for patients undergoing high-risk abdominal surgery and the principles and nurse responsibilities are the same as intraoperatively. There are no standardized guidelines with instructions for IV fluid therapy in the PACU for the other patient groups.

Measures and Data Collection

A list with 17 indications for administering IV fluid was developed by the first author from indications used in earlier studies on physicians' fluid management.^{1,16,17} The list was subsequently discussed with the coauthors of this article and a 1-week pilot study was conducted. This was done to determine if the list with indications was practical and understandable among nurse anesthetists and nurses in the PACU. Each indication on the list was numbered.

Patients eligible for inclusion were identified in the hospitals' electronic medical record and included consecutively by the first author. Demographic data collected for both cohorts included age, sex, length of stay (LOS) in surgery, LOS in the PACU, American Society of Anesthesiologists physical status, which indicates physical health to predict postoperative morbidity (0 [lowest risk] to 5 highest risk),¹⁶ and type of surgery. The amount and type of IV fluid administered were also collected. Data for cohort 1 was gathered prospectively and consecutively between December 7, 2015 and February 11, 2016. This was done to have baseline data of the amount and type of IV fluid administered.

In cohort 2, the intervention was introduced in the form of the aforementioned list with indications. Nurse anesthetists' and nurses in the PACU were asked to register their indications for administration of IV fluid. Nurses documented the indication(s) by writing the number(s) from the list in the patients' fluid chart each time they administered IV fluid (Table 1). The list was displayed in all operating rooms and bedside in the PACU to encourage registration of the indications. The first author called the responsible nurses at the time of change in shift, ensuring continued vigilance throughout all hours of the day. Data were collected prospectively and consecutively from the selected group of patients from February 10, 2016 to June 10, 2016. The data collection period in cohort 2 was prolonged compared with cohort 1 because of missing data in the nurse registered indications. Consequently, the data collection was continued until the number of patients with registered indications was comparable to the first cohort, resulting in a larger number of cases in cohort 2. The indications for administering IV fluid and the amount of IV fluid were registered from surgery start until PACU discharge.

Ethics

The Regional Committee on Health Research Ethics waived the need for informed consent because of the descriptive nature of the study (file number 15012245). This study was approved by the Danish Data Protection Agency (file number 2012-58-0004) and the heads of the present center. All nurse anesthetists and nurses in the PACU were

Table 1. Nurses' Indications for IV Fluid Therapy

Indication Number	Indications for IV Fluid Therapy
1	High pulse
2	Low blood pressure
3	Small urine production
4	Bleeding
5	Large output from stoma or drain
6	To keep the drip open
7	Fasting
8	Sepsis
9	Weaning from vasopressor
10	Increasing serum lactate
11	Patient cold and pale
12	According to prescribed plan
13	Fluid with medication
14	Routine*
15	SV response
16	Central venous saturation
17	Other

IV, intravenous; SV, stroke volume.

*A habitually and mechanically execution of a task.

informed about the study via e-mail and at the center's morning meetings.

Statistical Analysis

Indications for administering IV fluid are reported in number of times an indicator is reported. Data on the amount of IV fluid administered were screened for normal distribution by visual inspection and Kolmogorov-Smirnov test of normality. All non-normally distributed and categorical data are presented as median and interquartile range. Differences in the administered amount of crystalloid and colloid between cohorts were analyzed using Mann-Whitney test for non-normally distributed continuous variables. In results showing a tendency toward a significant difference in the amount of fluid administered, we used χ^2 test. This was done to investigate if there was a difference between the proportions of patients receiving more or less than 500 mL colloid solutions (one bag). The level of significance was set a priori at $P \leq .05$. All data analysis was performed using SPSS version 22.

Table 2. Comparison of Demographics of Cohort 1 and Cohort 2

Variables	Cohort 1 (n = 126)	Cohort 2 (n = 187)*
Age, median (IQR) (y)	72 (60-84)	74 (63-83)
Men, n (%)	58 (46)	83 (44.4)
High-risk abdominal surgery, n (%)	32 (25.4)	46 (24.6)
Elective colorectal surgery, n (%)	31 (24.6)	42 (22.5)
Lower limb amputation, n (%)	5 (4)	11 (5.9)
Revision arthroplasty, n (%)	12 (9.5)	17 (9.1)
Hip fracture, n (%)	46 (36.5)	71 (38)
ASA classification, n (%)		
1	7 (5.6)	13 (7)
2	57 (45.2)	71 (38)
3	55 (43.7)	90 (48.1)
4	7 (5.6)	7 (3.7)
LOS in surgery, median (IQR) (min)	181 (128-223)	194 (147-270)
LOS in PACU, median (IQR) (min)	165 (110-275)	190 (124-380)

ASA, American Society of Anesthesiologist Classification; IQR, interquartile range; LOS, length of stay; PACU, post-anesthesia care unit.

*Number of patients with missing values: ASA classification = 6.

Results

In cohort 1, 126 consecutive patients from surgery and the PACU were included in the study, whereas 187 consecutive patients from surgery and the PACU were included in the study in cohort 2 (Table 2). Of the 187 patients in cohort 2, indica-

tions were registered on 130 patients during surgery and 87 patients in the PACU. Numbers of nurses registering indications in cohort 2 were 58 nurse anesthetists and 31 nurses in the PACU. Most nurses (n = 87) registered indications on one to five patients, but two nurses registered indications on 12 patients each.

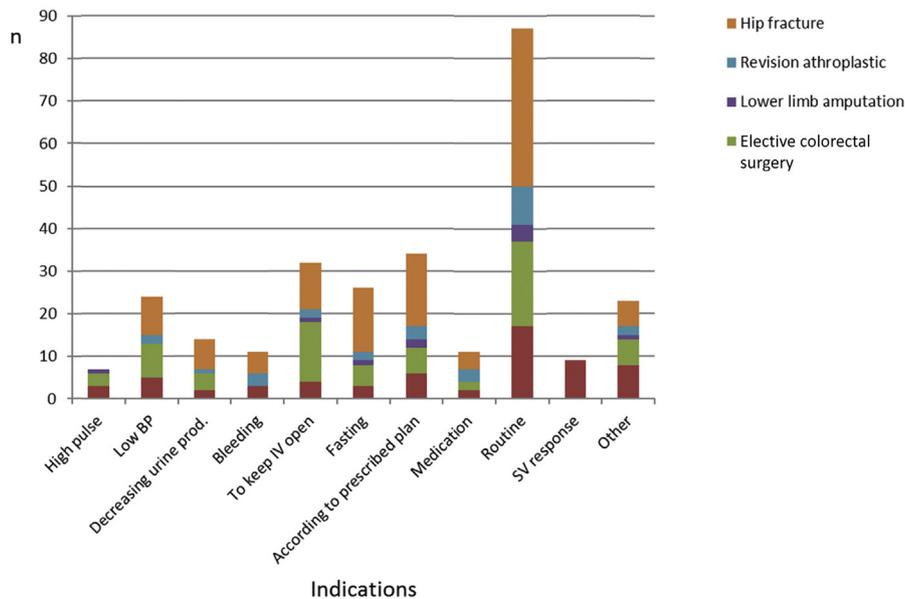


Figure 1. Indications for administering crystalloid during surgery. Other including large output from stoma, sepsis, weaning from vasopressor, increasing serum lactate, patient cold and pale, central venous saturation, and other. BP, blood pressure; IV, intravenous; SV, stroke volume. This figure is available in color online at www.jopan.org.

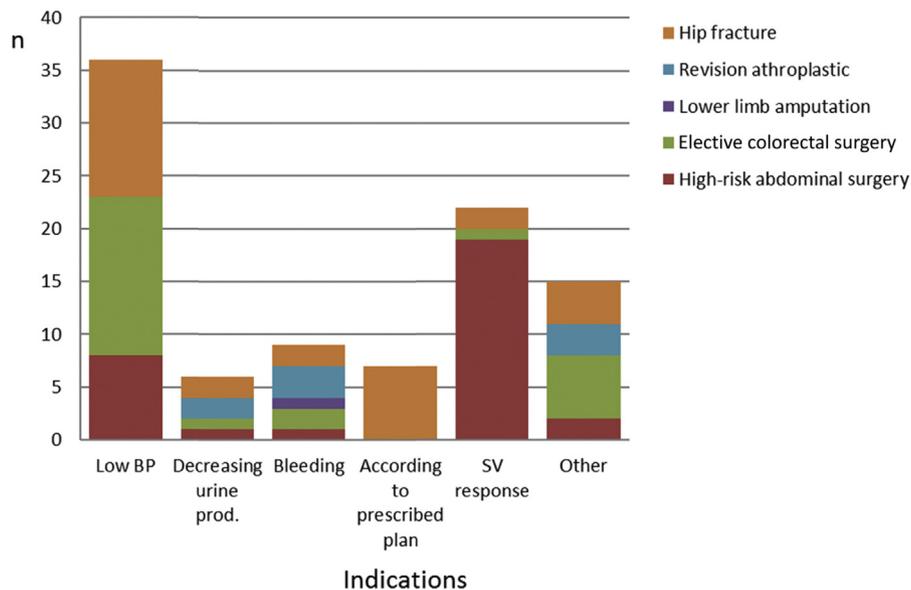


Figure 2. Indications for administering colloid solution during surgery. Other including high pulse, large output from stoma, to keep IV open, fasting, sepsis, weaning vasopressor, increasing serum lactate, patient cold and pale, fluid with medication, routine, central venous saturation, and other. BP, blood pressure; IV, intravenous. This figure is available in color online at www.jopan.org.

Indications Given by Nurse Anesthetists for Administering IV Fluid

The most frequent indications given by nurse anesthetists for administering isotonic crystalloid to patients scheduled for elective colorectal surgery, lower limb amputations, revision arthroplasty, or patients undergoing hip fracture surgery intraoperatively were “routine” ($n = 70$) and “low blood pressure” ($n = 19$), respectively (Figure 1). The most frequent indication for administering a colloid solution to these patient groups was low blood pressure ($n = 28$) (Figure 2).

The most frequent indication given by nurse anesthetists for administering isotonic crystalloids intraoperatively for patients undergoing high-risk abdominal surgery was routine ($n = 17$) (Figure 1), whereas “SV response” ($n = 19$) was the indication given most frequently for administering a colloid solution (Figure 2).

The indications “to keep IV open” ($n = 32$), “fasting” ($n = 26$), and “according to prescribed plan” ($n = 34$) were also frequent indications for administering crystalloid to all included patient groups

during surgery (Figure 1), whereas the less frequent mentioned indications during surgery were “patient cold and pale” ($n = 1$) and “increasing serum lactate” ($n = 1$).

Indications Given by Nurses in the PACU for Administering IV Fluid

The most frequent indications given by nurses in the PACU for administering isotonic crystalloid were low blood pressure ($n = 25$), routine ($n = 13$), SV response ($n = 12$), and “decreasing urine production” ($n = 13$). This applies to all the included groups of patients (Figure 3). The most frequent indications for administering colloid solutions were SV response ($n = 19$) and low blood pressure ($n = 8$). In PACU, colloid solutions were used most often for patients undergoing high-risk abdominal surgery (Figure 4).

In PACU, the indications to keep IV open ($n = 11$) and according to prescribed plan ($n = 9$) were also frequent mentioned indications for administration of crystalloid. The less frequent mentioned indication in the PACU was increasing serum lactate ($n = 4$).

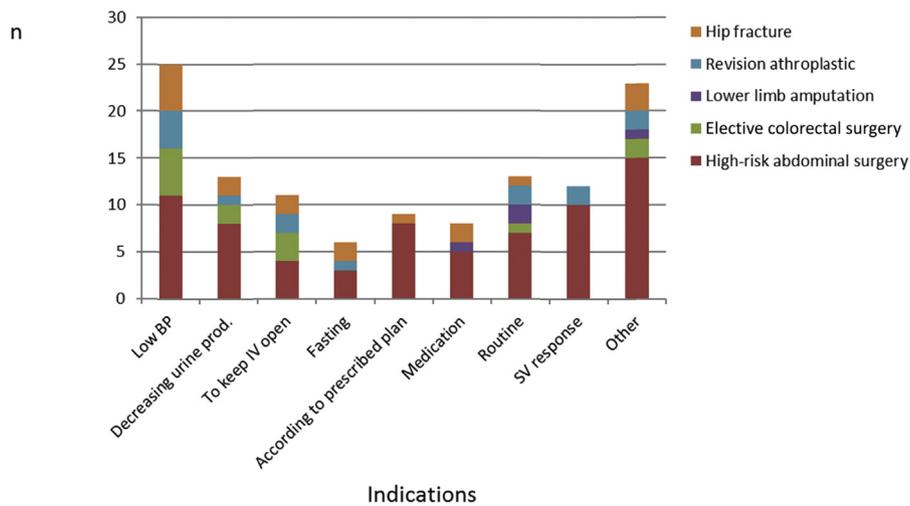


Figure 3. Indications for administration of crystalloids in the PACU. Other including high pulse, large output from stoma, to keep IV open, fasting, sepsis, weaning vasopressor, increasing serum lactate, patient cold and pale, medication, routine, central venous saturation, and other. IV, intravenous; PACU, postanesthesia care unit; SV, stroke volume. This figure is available in color online at www.jopan.org.

Amount of Fluid Administered Intraoperatively

The median amount of isotonic crystalloids administered intraoperatively to patients scheduled for elective colorectal surgery, lower limb amputations, revision arthroplasty, or patients undergoing

high-risk abdominal surgery was not statistically significantly different between cohorts (Table 3). The median amount of isotonic crystalloids administered intraoperatively for patients undergoing hip fracture surgery was higher in cohort 2 (1,200 mL) than in cohort 1 (950 mL), which was statistically significant $P = .01$ (Table 3).

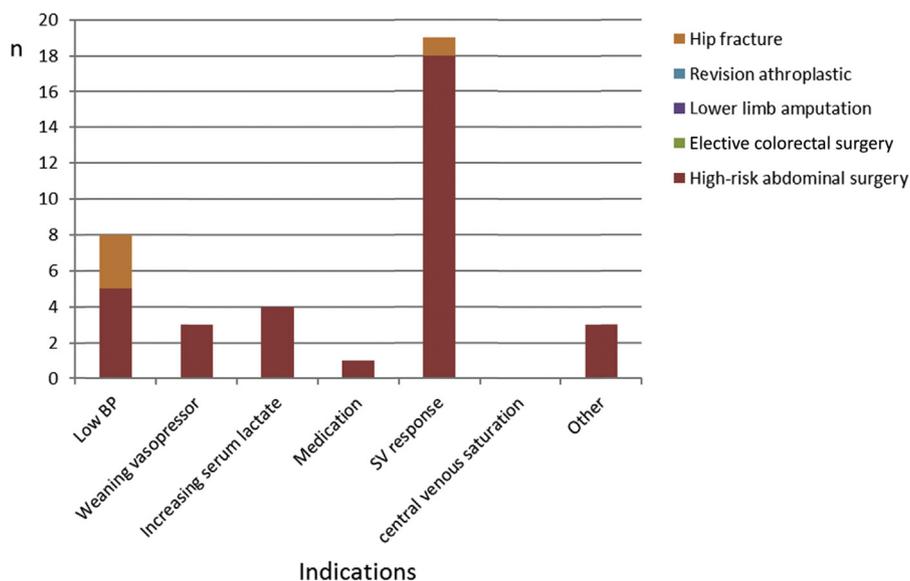


Figure 4. Indication for administration of colloid solution in the PACU. Other including high pulse, decreasing urine production, bleeding, large output from stoma, to keep IV open, fasting, sepsis, weaning vasopressor, increasing serum lactate, patient cold and pale, according to prescribed plan, routine, and other. BP, blood pressure; IV, intravenous; PACU, postanesthesia care unit. This figure is available in color online at www.jopan.org.

Table 3. Fluid Administration Intraoperatively

Patient Groups	Cohort 1 (n = 126)*	Cohort 2 (n = 187)*	P
High-risk abdominal surgery (n = 32/44)			
Crystalloid, median (IQR) (mL)	2,100 (1,500-2,900)	2,100 (1,100-2,745)	.46
Colloid, median (IQR) (mL)	500 (250-650)	675 (325-1,000)	.12
Elective colorectal surgery (n = 30/41)			
Crystalloid, median (IQR) (mL)	1,750 (1,475-2,025)	1,900 (1,900-2,300)	.44
Colloid, median (IQR) (mL)	300 (0-500)	400 (0-500)	1
Lower limb amputation (n = 5/11)			
Crystalloid, median (IQR) (mL)	1,200 (950-2,000)	1,000 (1,000-1,550)	.51
Colloid, median (IQR) (mL)	0 (0-400)	0 (0-500)	.91
Revision arthroplasty (n = 12/17)			
Crystalloid, median (IQR) (mL)	1,150 (700-1,975)	1,100 (850-1,850)	.74
Colloid, median (IQR) (mL)	500 (0-1,000)	400 (0-750)	.37
Hip fracture (n = 46/71)			
Crystalloid, median (IQR) (mL)	950 (675-1,325)	1,200 (900-1,500)	.01
Colloid, median (IQR) (mL)	0 (0-500)	0 (0-400)	.1

Note. Bold treatment indicates statistical significance at $P < .05$.

IQR, interquartile range.

*Number of patients with missing values because of missing fluid charts: high-risk abdominal surgery n = 0/2 and elective colorectal surgery n = 1/1. Analyzed using Mann-Whitney test.

The median amount of colloid solutions administered intraoperatively to patients scheduled for elective colorectal surgery, lower limb amputations, revision arthroplasty, patients undergoing hip fracture surgery, or high-risk abdominal surgery was not statistically significantly different between cohorts (Table 3). However, when investigating colloid solutions administered to patients undergoing high-risk abdominal surgery, we saw a tendency toward the administration of more colloid solutions in cohort 2 (median amount in cohort 1 = 500 mL, median amount in cohort 2 = 675 mL, $P = .12$) (Table 3). We found a statistically significant association between the amount of colloid administered in the cohorts with 74% (95% CI 55 to 88) of patients receiving more than 500 mL in cohort 2 versus 26% (95% CI 12 to 45) in cohort 1, or 1.6 (95% CI 1.1 to 2.3) with $\phi = 0.3$ indicating a moderate association ($P = .02$) between receiving more than 500 mL colloid solution in cohort 2.

Amount of Fluid Administered in the PACU

In PACU, there was no statistical significant difference between cohorts in the amount of crystalloid or colloid solutions administered to patients scheduled for elective colorectal surgery, lower limb amputations, revision arthroplasty, or patients undergoing hip fracture surgery (Table 4).

The median amount of isotonic crystalloids and colloid solutions administered to patients undergoing high-risk abdominal surgery was higher in cohort 2 (1,925 and 800 mL) than in cohort 1 (350 and 0 mL), the difference was statistically significant $P = .02$ and $P = .01$, respectively (Table 4). There was a nonsignificant tendency toward longer LOS for this group of patients in cohort 2 (median LOS in cohort 2 = 1,100 minutes, median LOS cohort 1 = 367 minutes, $P = .12$).

Discussion

In this study, we wanted to examine IV fluid practice among nurse anesthetists and nurses in the PACU to investigate whether their IV fluid practice is based on evidence and clinical guidelines. Secondary aims were to investigate how much and what kind of fluid was administered and if providing indications for IV fluid administration affected practice in the form of changes in the amount of fluid administered.

Discussion of Findings

Indications given by nurse anesthetists for using crystalloid intraoperatively were mainly routine, but also fasting, to keep IV open, and according to prescribed plan were commonly mentioned. Nurses in the PACU used the same indications

Table 4. Fluid Administration in the PACU

Patient Groups	Cohort 1 (n = 126)*	Cohort 2 (n = 187)*	P
High-risk abdominal surgery (n = 28/44)			
Crystalloid, median (IQR) (mL)	800 (500-1,775)	1,925 (1,000-3,687)	.02
Colloid, median (IQR) (mL)	0 (0-3,000)	350 (0-1,000)	.01
Elective colorectal surgery (n = 30/41)			
Crystalloid, median (IQR) (mL)	400 (100-725)	500 (100-800)	0.63
Colloid, median (IQR) (mL)	0 (0)	0 (0)	0.13
Lower limb amputation (n = 4/10)			
Crystalloid, median (IQR) (mL)	100 (25-400)	250 (0-600)	0.45
Colloid, median (IQR) (mL)	0 (0)	0 (0)	1
Revision arthroplasty (n = 12/17)			
Crystalloid, median (IQR) (mL)	200 (0-750)	200 (50-700)	0.85
Colloid, median (IQR) (mL)	0 (0)	0 (0)	0.47
Hip fracture (n = 46/71)			
Crystalloid, median (IQR) (mL)	300 (200-500)	250 (100-600)	0.82
Colloid, median (IQR) (mL)	0 (0)	0 (0)	1

Note. Bold treatment indicates statistical significance at $P < .05$.

IQR, interquartile range; PACU, postanesthesia care unit.

*Number of patients with missing values because of missing fluid charts: High-risk abdominal surgery n = 4/2, elective colorectal surgery n = 1/1, and lower limb amputation n = 1/1. Analyzed using Mann-Whitney test.

but they also gave crystalloids according to low blood pressure, decreasing urine production, and SV response. It is interesting that several static parameters are used because they have shown to be insufficient to predict microcirculatory impairment.¹⁷⁻¹⁹ Crystalloid was not supposed to be used for SV response unless colloid solutions are contraindicated.

Indications given by nurse anesthetists and nurses in the PACU for administering colloid solutions were primarily low blood pressure and SV response. Colloid solutions given to correct low blood pressure is primarily used to patients undergoing hip fracture surgery or elective colorectal surgery. However, low blood pressure was also used as an indication for administering a colloid solution to patients undergoing high-risk abdominal surgery. This indicates that principles for GDT are not always followed, although it is mandatory in this group of patients.

The indicator low blood pressure is mainly used to patients undergoing high-risk abdominal surgery or hip fracture surgery and patients scheduled for elective colorectal surgery. This could be because of an expectation from the nurses that these patients need fluid.

Markers of inadequate tissue perfusion such as increasing serum lactate or patient cold and pale

were only sparsely used as an indication for administering crystalloid (patient cold and pale 1, increasing serum lactate 5). Markers of inadequate tissue perfusion were not used as an indication for administering colloid solutions intraoperatively. Increasing serum lactate was used as an indication for administering colloid solutions three times in the PACU. Arterial line is only standard equipment for patients undergoing high-risk abdominal surgery. This could be the reason why increasing serum lactate is not often mentioned. Direct observation of the patient, such as assessing if the patient is cold and pale, is an easy accessible parameter. Accordingly, it seems paradoxical that it has been used rarely in the assessment of the patient's hemodynamic condition and fluid status, because fluids are mostly indicated to increase cardiac output.¹

According to our results, nurse anesthetists and nurses in the PACU are not always following the GDT guideline for patients undergoing high-risk abdominal surgery. Adoption and compliance of GDT based on flow-related variables have tended to be low, even during studies.²⁰ Challenges in implementing GDT could be lack of immediate results, requirement of substantial training, and vigilance in application.^{20,21}

In patients undergoing high-risk abdominal surgery, GDT is used as standard care in contrast

to the rest of the included patients. Nurse anesthetists and nurses in the PACU are responsible for administering colloid solution based on measured SV according to the principals based on GDT. This guideline has had more focus compared with other guidelines, in the form of extra education. Therefore, nurses and doctors could be more aware of this guideline. In implementation science, the concept diffusion, dissemination, and implementation are used. Diffusion is a passive concept and those who receive the diffused messages are likely already open to seeking the information.²² Dissemination is a more active concept and can be an effective form of communication. Writing up guidelines and providing education to health professionals is as an attempt to spread knowledge of a guideline by dissemination. This can generate changes in health professionals' awareness, attitude, and knowledge. The education offered to nurses and doctors in the GDT guideline might have increased their awareness of this particular guideline, which can be predisposing for altering their behavior.²² Our intervention in the form of asking nurse anesthetists and nurses in the PACU to provide indications for their IV fluid administration might have been pushing to this awareness and thereby increased the amount of IV fluid administered to these patients in the PACU.

Together our results indicate that clinical decisions made by nurse anesthetists and nurses in the PACU regarding IV fluid therapy are not always based on evidence and clinical guidelines. Static parameters and indications not grounded in the patients' clinical need for IV fluid are often used as indication for IV fluid administration. Moreover, the guideline regarding GDT is not always followed. This is in line with results from previous studies examining how health professionals administer fluid. The Fluid Challenges in Intensive Care (FENICE) study by Cecconi et al¹ found that simple inadequate signs for fluid administration like hypotension and oliguria lead to a fluid challenge in more than 80% of the patients. Markers of inadequate tissue perfusion like increasing serum lactate and skin mottling were only used in 8% of the cases. In a study aimed to describe current practices at volume expansion in French intensive care units the authors found that low blood pressure and low urine output were the most used triggers for IV fluid administration.²³ A study from Australia and New Zealand

conducted to describe critical care nurses' self-reported practices on fluid bolus therapy found that the most common physiological triggers for administering a fluid bolus was hypotension and oliguria.²⁴ A review by the National Confidential Enquiry into Patient Outcome and Death in the United Kingdom found that inappropriate IV fluid therapy may occur in one in five patients.²⁵ In 2016 Calebrant et al²⁶ interviewed 16 anesthetic nurses to explore how they assess patients' intraoperative fluid requirements. This study revealed differences regarding fluid management among nurses and they rarely seemed to use evidence-based practice.

Our results could indicate that nurse anesthetists and nurses in the PACU need extra education in IV fluid administration. Educational activities are commonly used interventions to implement new knowledge in clinical practice.²⁷ However, a Cochrane review from 2009 concludes that education alone is not likely to be effective for changing complex behavior.²⁸ Education is a way to disseminate knowledge and may generate increased awareness, attitude, and knowledge that predispose health professionals to consider changing behavior.²⁹ In this study, nurse anesthetists and nurses in the PACU have been presented new knowledge on IV fluid therapy in connection with education in GDT for patients undergoing high-risk abdominal surgery. However, even when education has increased knowledge, Nilssen et al²⁹ found that people, including nurses and doctors, are prone to develop automatically activated habits. Habits are automatic responses to contextual cues, acquired through repetition of behavior in the presence of these cues. Individuals who have developed habitual behavior are becoming less likely to act on new information.¹¹ This could explain why nurse anesthetists and nurses in the PACU use routine and well-known indications like low blood pressure and decreasing urine production as indicators for IV fluid administration. According to Nilssen et al,¹¹ implementation of evidence-based practice presents two interlinked challenges: acquisition of evidence-based skills and abandonment of ingrained non-evidence-based practices. This requires two modes of learning: adaptive and developmental learning. Adaptive learning involves a gradual shift from slower deliberate behaviors to faster, smoother, and more efficient

behaviors. A conversion of explicit to implicit knowledge. Developmental learning involves a progress in the opposite direction whereby more or less automatically behavior becomes more deliberate and conscious. It occurs when an individual critically reflects on previously implicit assumptions and action patterns and involves making implicit knowledge explicit. Yet, it still looks as if they hold on to well-known indications. To implement evidence-based practice doctors and nurses must not only acquire “good habits,” they also need to abandon the old “bad habits.” Abandonment of ingrained habits represents a profound challenge because there are barriers at many levels.¹¹

Strengths and Limitations

Our study has some obvious strength. First, we have obtained data from a historical cohort, which provide us with knowledge on how nurse anesthetist and nurses in the PACU administer IV fluid therapy routinely. Second, our study contributes with knowledge in an area that is only sparsely investigated. However, there are several limitations to be considered. No formal sample size estimation was made for this descriptive study because data distribution for the obtained variables was unknown. Because of this, there is a risk that the study contains type I or type II error. The study is a single-center study and the indications given by the nurses might have been different, if we had made a multicenter study or if we had allowed them to write any indication instead of making a list with predefined indications. During the data collection in cohort 2 the nurses often forgot to write the indication numbers in the patients’ fluid

charts, and therefore this part of the data collection was longer than in cohort 1. Because of these missing data in cohort 2 we might underestimate the differences between the cohorts. The low number of registrations in PACU could be because of a shift in the responsible nurse when the patient arrives in the PACU. It could also be that the patient already has IV fluid administered and registered during surgery.

Conclusions

We conclude that administration of IV fluid therapy provided by nurse anesthetists and nurses in the PACU does not seem to be based on evidence and clinical guidelines. Education in use of GDT has been offered to all nurses in this study and the results indicate that this education needs reinforcement. Knowledge alone does not result in behavior change. Perhaps the intervention to reflect and record why IV fluid was administered did encourage behavior changes seen by changes in the amount of IV fluid administered in some patient groups. This is seen by an increase in administration of crystalloid and colloid solutions to patients undergoing high-risk abdominal surgery and an increased use of crystalloid administered to patients undergoing hip fracture surgery. There is an urgent need for studies exploring barriers and facilitators for administering IV fluid therapy in accordance with evidence-based guidelines. There is also a need for education to abandon habitual behavior, so nurses administer fluid based on relevant observations and knowledge about how to assess hemodynamic impairment.

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