

# Clinical practice on intra-operative fluid therapy in Poland

## A point prevalence study

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### Abstract

Intra-operative fluid therapy (IFT) is the cornerstone of peri-operative management as it may significantly influence the treatment outcome. Therefore, we sought to evaluate nationwide clinical practice regarding IFT in Poland.

A cross-sectional, multicenter, point-prevalence study was performed on April 5, 2018, in 31 hospitals in Poland. Five hundred eighty-seven adult patients undergoing non-cardiac surgery were investigated. The volume and type of fluids transfused with respect to the patient and procedure risk were assessed.

The study group consisted of 587 subjects, aged 58 (interquartile range [IQR] 40–67) years, including 142 (24%) American Society of Anesthesiology Physical Status (ASA-PS) class III+ patients. The median total fluid dose was 8.6 mL kg<sup>-1</sup> h<sup>-1</sup> (IQR 6–12.5), predominantly including balanced crystalloids (7.0 mL kg<sup>-1</sup> h<sup>-1</sup>, IQR 4.9–10.6). The dose of 0.9% saline was low (1.6 mL kg<sup>-1</sup> h<sup>-1</sup>, IQR 0.8–3.7). Synthetic colloids were used in 66 (11%) subjects. The IFT was dependent on the risk involved, while the transfused volumes were lower in ASA-PS III+ patients, as well as in high-risk procedures ( $P < .05$ ).

The practice of IFT is liberal but is adjusted to the preoperative risk. The consumption of synthetic colloids and 0.9% saline is low.

**Abbreviations:** 0,9%S = 0.9% NaCl solution, ASA-PS = American Society of Anesthesiologists Physical Status, BC = balanced crystalloid, G5/G10 = glucose 5/10% solution, GDT = goal-directed therapy, HES = hydroxyethyl starch, IQR = interquartile range, IFT = intra-operative fluid therapy, IQR = interquartile range, NS = normal saline, 0.9% NaCl solution.

**Keywords:** fluid therapy, point prevalence study, pre-operative medicine, risk

## 1. Introduction

Prudent fluid-therapy is a cornerstone of modern perioperative treatment, particularly in high-risk patients undergoing high-risk procedures.<sup>[1]</sup> It needs to be adjusted to local procedures and availabilities.<sup>[2]</sup> Improper intra-operative fluid therapy (IFT) may increase morbidity and mortality.<sup>[3]</sup>

The definition of the optimal fluid dose is still unclear. Although IFT is usually described in terms of restrictive (i.e., “low” dose) or liberal (i.e., “high” dose) models, hemodynamic stability requires the continuous adjustment of IFT to the individual patient’s needs. This so-called “goal-directed therapy”

(GDT) or “personalized approach” plays a fundamental role in the perioperative medicine.<sup>[4–6]</sup>

The composition of the transfused fluids is also of great importance. Balanced crystalloids (BCs) are recommended over 0.9% NaCl (0,9%S, NS). The non-physiological value of the strong ion difference in NS promotes the development of hyperchloaemic acidosis and may increase the risk of postoperative complications.<sup>[5,7,8]</sup> The safety of synthetic colloid preparations, mainly hydroxyethyl starch (HES), is also debatable.<sup>[6,9]</sup> Recent study from Denmark demonstrated that from 2012 to 2015 there was a marked decrease in transfusions of synthetic colloid solutions (of 82%) and a significant increase in the use of BCs (of 686% in general surgery departments).<sup>[10]</sup> Similar pattern was observed across intensive care units in an international, multicenter cross-sectional study, in which from 2007 to 2014 the use of crystalloids increased nearly twice, primarily due to a significant increase in the use of BCs, and the use of colloids decreased nearly twice, primarily due to a decrease in the use of HES.<sup>[11]</sup>

Therefore, we sought to investigate the strategy of IFT in adult patients undergoing surgery in Poland, with regard to the preoperative risk.

## 2. Methods

The study was performed in accordance with the declaration of the Helsinki. Our project was approved and registered by a scientific board of the School of Medicine in Katowice (registration number 3/7/1/2018/2019), under the auspices of the Intensive Care Section of the Polish Society of Anesthesiology and Intensive Therapy, according to the STROBE Statement

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(Strengthening the Reporting of observational Studies in Epidemiology).<sup>[12]</sup> As survey study, ethics committee approval was not required (decision of the bioethics commission number KNW/0022/KB/2012/19). Due to the anonymous and non-interventional nature of the project, there was no requirement for the patients' written consent. This study was registered in the Research Registry (UIN researchregistry5176).

A cross-sectional, multicenter, point-prevalence study was set up. A total of 70 hospitals were randomly selected from 119 secondary and tertiary hospitals in Poland. Pediatric and cardiac surgery centers were excluded from selection. The invitations for participation were sent twice. Thirty-three hospitals agreed to participate (a response rate of 47%), including 21 university centers (a response rate of 84%). Patients undergoing general and/or regional anesthesia for all elective and non-elective (emergency) surgical procedures performed during the day shift were subjected to analysis. Subjects receiving monitored anesthetic supervision or analgo-sedation were not included.

The study protocol covered basic demographic (i.e., gender; age; body mass and height) and clinical parameters (i.e., American Society of Anesthesiologists Physical Status (ASA-PS) class; duration and type of anesthesia; duration and type of surgical procedure; type and dose of fluids transfused in the intra-operative period; type and dose of vasoactive and inotropic drugs administered in the intra-operative period; type of hemodynamic monitoring and recorded static hemodynamic indices, including systolic, diastolic and mean arterial pressure, heart rate – before and after induction of anesthesia and in 30-minute intervals, up to the patient's discharge from the operating room).

An assessment was performed on April 5, 2018. A total of 685 filled-in questionnaires were received from all 33 centers within 2 weeks of the study's termination. After verification of data completeness, the final analysis covered 587 protocols from 31 hospitals, including 20 university centers. A flow chart explaining the selection of the study group is presented in Figure 1.

The patients' individual pre-operative risk was assessed using ASA-PS classification,<sup>[13]</sup> according to the guidelines of the Cardiac and Thoracic Anesthesia Section of the Polish Society of Anesthesiology and Intensive Therapy.<sup>[14,15]</sup> ASA-PS III+ subjects covered the high risk group. Surgical procedures were classified as low, intermediate, and high risk, according to the guidelines of the European Society of Cardiology and the European Society of Anesthesiology.<sup>[16]</sup> Emergency procedures, according to the ASA-PS system, were classified as those of high risk. Global risk categories were calculated based on a patient's individual risk and the risk of the procedure involved (Fig. 2).

The modified Aldrete scoring system was applied for assessing recovery from anesthesia.<sup>[17]</sup>

### 2.1. Statistical analysis

Statistical analysis was performed using licensed MedCalc software v.18.2.1 (MedCalc Software for Windows, Ostend, Belgium). Quantitative variables were presented as median and interquartile ranges (IQR, i.e., 25%–75%), whereas qualitative variables were depicted as crude and percentage values. All continuous variables were tested for normal distribution using the Shapiro–Wilk test. Between-group differences for continuous variables were assessed using Student *t* test or the Kruskal–Wallis test, while for categorical variables the Chi-squared or the exact Fisher test were applied. Correlation was assessed using

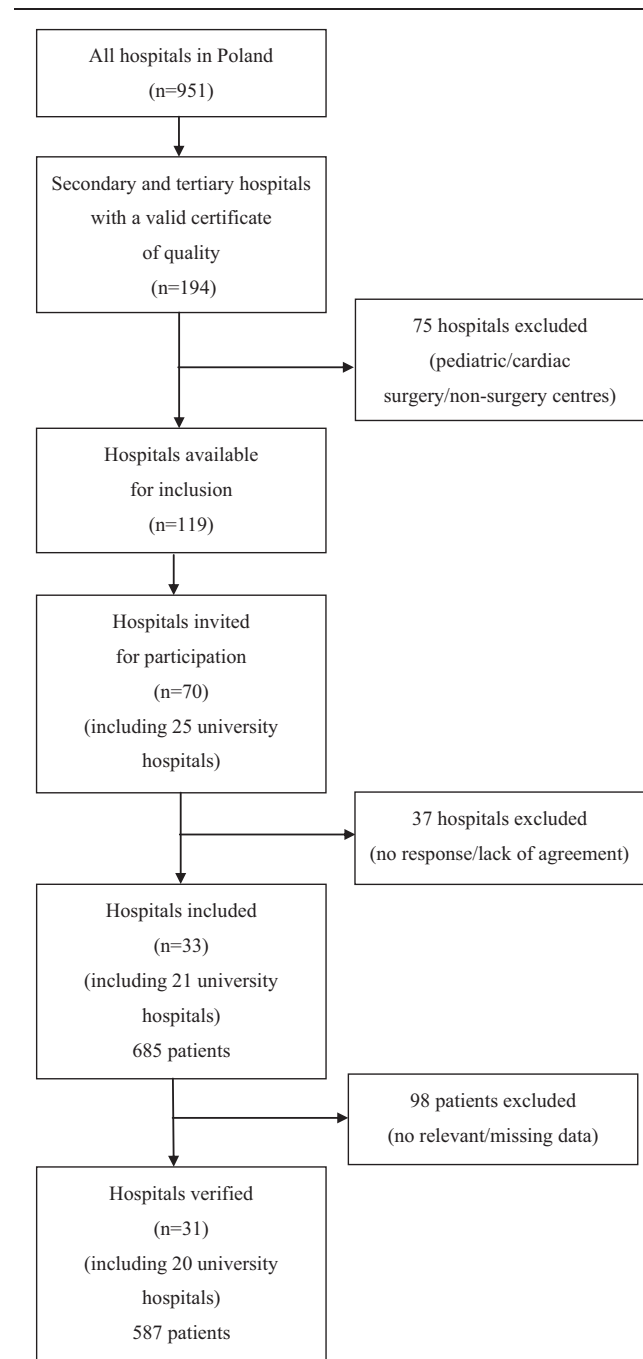


Figure 1. Study flow chart.

Spearman rank correlation coefficient. A *P*-value of  $<.05$  was considered statistically significant.

### 3. Results

The study group consisted of 587 patients, including 315 women and 272 men, aged 58 years (IQR 40–67). There were 142 (24%) high-risk patients. The detailed characteristics of the participants are shown in Table 1.

The median total intra-operative fluid dose was  $8.6 \text{ mL kg}^{-1} \text{ h}^{-1}$  (IQR 6–12.5) (adjusted for actual body mass and duration of anesthesia). BCs were predominantly used ( $n = 566, 96\%$ ).

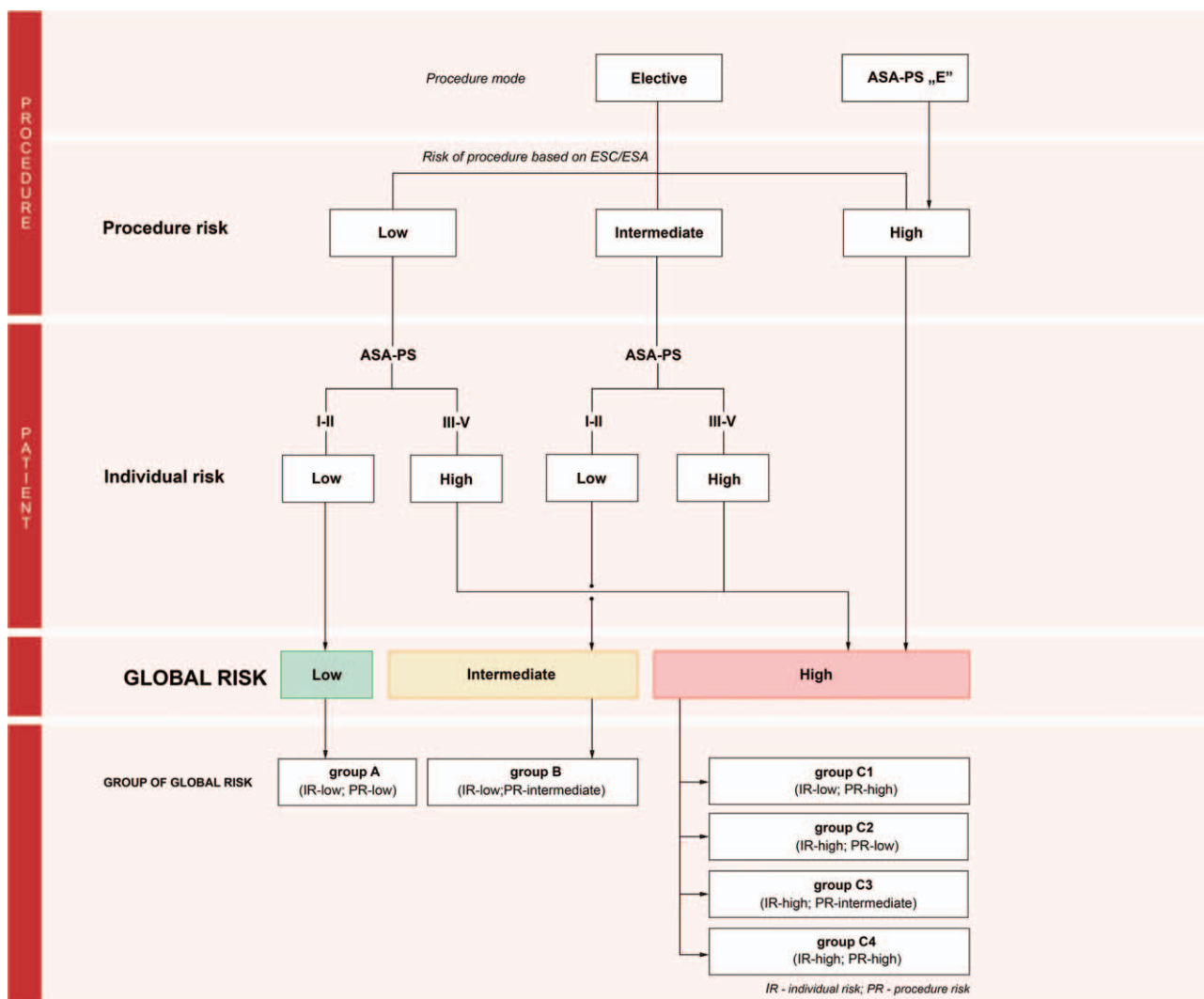


Figure 2. Risk stratification.

NS, 5/10% glucose solutions (G5/G10, *glucose 5/10%*), and synthetic colloids were used less frequently in lower volumes (Table 2). Patients who underwent longer procedures received significantly less fluid ( $P < .001$ ), while BCs also dominated in this group. Subjects receiving anesthesia for over 120 minutes were transfused significantly less fluid with a median dose of  $6.3 \text{ mL kg}^{-1} \text{ h}^{-1}$  (IQR 4.6–8) (Table 3).

The fluid regimen differed statistically significantly between categories of individual, procedural, and global risk ( $P < .05$  for all); the higher the risk, the lower the fluid dose. Moreover, within the group of high risk patients, if the risk was the result of an emergency procedure, the total fluid dose, and the dose of colloid preparations, was higher comparing with other groups ( $P < .05$ ) (Table 4).

#### 4. Discussion

This 1-day point prevalence study aimed to assess IFT in Polish hospitals. We showed that although IFT was liberal, it was adjusted to patient- and procedure-related preoperative risk. Of importance is the fact that subjects undergoing long-term elective procedures received less fluid compared with shorter surgeries. In

addition, the consumption of 0.9% NaCl and synthetic colloids was low.

Unfortunately, there is a paucity of data on real-life anesthetic practice regarding IFT, especially at a national level. Comparison of our findings is therefore limited. Most available projects are single-center<sup>[18]</sup> or limited to investigations within one particular specialty (i.e., abdominal surgery or orthopedics).<sup>[18–20]</sup> Moreover, previously published analyses have focused on the IFT-related complications in the context of hemodynamic monitoring.<sup>[21]</sup> However, the daily practice of anesthesiologists differs day-by-day and is rarely limited to one type of patient, surgical procedure or anesthesia. This is why our findings are innovative and have important clinical implications. On the one hand, our data are similar to the findings of a multi-center audit conducted in British hospitals, in which the volumes of fluids were as follows:  $\sim 30 \text{ mL kg}^{-1}$  during abdominal surgeries and  $\sim 15\text{--}20 \text{ mL kg}^{-1}$  for orthopedic procedures, with a predominant use of BCs ( $\sim 90\%$ ).<sup>[20]</sup> In this project, however, a pre-operative risk assessment was not performed, which is a clear limitation. On the other hand, our results are different from those of Australian researchers who evaluated the intra-operative fluid supply during major gastrointestinal surgery. In their study, the mean dose

**Table 1****Demographic and clinical data.**

Variable	Value
Females/males	315 (54%) / 272 (46%)
Age (yr)	58 [40–67]
Weight (kg)	77 [66–88]
Height (cm)	169 [163–175]
BMI (kg m <sup>-2</sup> )	26.6 [23.8–29.8]
Duration of anesthesia (min)	90 [50–140]
Duration of surgery (min)	60 [35–99]
Type of procedure	
Abdominal surgery	116 (20%)
Orthopedics	113 (19%)
Gynecology and obstetrics	75 (13%)
Urology	73 (12%)
ENT	51 (9%)
Breast and thyroid surgery	37 (6%)
Vascular surgery	36 (6%)
Neurosurgery	33 (6%)
Thoracic surgery	18 (3%)
Eye surgery	10 (2%)
Interventional radiology	8 (1%)
Other	17 (3%)
Type of anesthesia	
General	396 (67%)
Combined	348 (59%)
TIVA	41 (7%)
VIMA	7 (1%)
Regional	173 (29%)
SA	143 (24%)
SA+EA	5 (1%)
SA+regional block	9 (1%)
Regional block	16 (3%)
General+regional	18 (3%)
General+SA	1 (<1%)
General+EA	7 (1%)
General+PVB	6 (1%)
General+regional block	4 (<1%)
Modified Aldrete score (points)	10 [9–10]
Individual risk	
ASA-PS class	
I	121 (21%)
II	325 (55%)
III	126 (21%)
IV	15 (3%)
Low risk (ASA-PS I-II)	446 (76%)
High risk (ASA-PS III-V)	141 (24%)
Procedure risk	
Type of surgery	
Low	273 (46%)
Intermediate	297 (51%)
High	17 (3%)
Mode of surgery	
Low risk, i.e., elective surgery	525 (89%)
High risk, i.e., ASA-PS „Emergency”	62 (11%)
Global risk	
Low (A)	218 (37%)
Intermediate (B)	183 (31%)
High (C <sub>1</sub> -C <sub>4</sub> )	186 (32%)
Group of global risk*	
A	218 (37%)
B	183 (31%)
C <sub>1</sub>	45 (8%)
C <sub>2</sub>	43 (7%)
C <sub>3</sub>	69 (12%)
C <sub>4</sub>	29 (5%)

Quantitative values are presented as medians and interquartile ranges and qualitative variables are presented as absolute values and percentages.

ASA-PS=American Society of Anesthesiologists Physical Status, BMI=body mass index, EA=epidural anesthesia, ENT=ear, nose, and throat surgery, PVB=paravertebral block, SA=spinal anesthesia, TIVA=total intravenous anesthesia, VIMA=volatile induction and maintenance anesthesia.

\* see Figure 2 for details.

**Table 2****Fluids used intra-operatively, with regard to their type and dose.**

Type of fluid	n (%)	Unadjusted dose (mL)	Adjusted dose* (mL kg <sup>-1</sup> h <sup>-1</sup> )
Crystalloids			
Total dose	580 (99%)	1000 [500–1200]	8.0 [5.6–11.4]
BC	566 (96%)	1000 [500–1000]	7.0 [4.9–10.6]
0.9%S	225 (38%)	250 [100–500]	1.6 [0.8–3.7]
G5/G10	8 (1%)	250 [212.5–500]	1.2 [0.7–4.1]
Colloids			
Total dose	68 (12%)	500 [500–500]	3.4 [2–5.5]
Synthetic	66 (11%)	500 [500–500]	3.4 [1.8–5.5]
Gelatin	42 (7%)	500 [500–500]	3.0 [1.7–5.4]
Starch	26 (4%)	500 [500–500]	3.2 [1.6–5.5]
Natural	10 (2%)	560 [280–779]	1.1 [0.6–2.6]
All fluids – total dose	581 (99%)	1000 [600–1500]	8.6 [6–12.5]

Quantitative values are presented as medians and interquartile ranges and qualitative variables are presented as absolute values and percentages.

0.9%S=0.9% saline, BC=balanced crystalloid, G5/G10=5/10% glucose.

\* Based on duration of anesthesia.

(±SD) of fluids was: 4229 ± 1840 mL (in total), 3762 ± 1687 mL (for crystalloids), 467 ± 601 mL (for colloids); while the percentage of patients who received blood products was 11%, which was much higher compared with our observations.<sup>[18]</sup> However, one ought to remember that all the above-mentioned volumes were unadjusted to body mass, duration of anesthesia, as well as risk.

Optimal IFT strategy has been investigated for many years, while the association between “liberal” IFT and compromised outcomes has been known for 20 years.<sup>[4]</sup> The introduction of the “restrictive” model as a part of the Enhanced Recovery After Surgery protocol has been revealed to reduce the number of perioperative complications and to improve outcomes.<sup>[7]</sup> The results of the RELIEF study from 2018 challenged this hypothesis: restriction of fluids, defined as an equal or negative fluid balance (i.e., up to –10% of baseline) among patients undergoing abdominal surgery had no impact on mortality. In contrast, “liberal” fluid therapy, for which the supply of crystalloid was accepted in the amount of 10 mL kg<sup>-1</sup> of the actual body weight at the beginning of the procedure (as a bolus), followed by infusion at a dose of 8 mL kg<sup>-1</sup> h<sup>-1</sup> throughout the duration of anesthesia, was associated with a lower incidence of acute kidney injury.<sup>[4]</sup> These interesting findings shed light on the results of the meta-analysis of Jia et al who showed that patients who had a “restrictive” IFT model had a shorter hospital stay and a faster recovery, although no improvement in survival was proved.<sup>[22]</sup> The results of the ongoing OPTIMISE II study should provide new evidence in terms of IFT.<sup>[23]</sup> The fundamental goal of IFT is to maintain physiological fluid and electrolyte balance, in order to avoid excessive loading of water, sodium, and chloride.<sup>[8,9]</sup> Maintenance fluid therapy resulting from current water and electrolyte losses should be conducted based on BC solutions.<sup>[3]</sup> Therefore, the Polish experience is in agreement with current recommendations, which is in line with previous some reports.<sup>[24]</sup> Although they were often used in Polish hospitals, unbalanced NS solution doses were relatively small and resulted from its use as a drug solvent. Previous studies have clearly demonstrated that IFT based on 0.9%S is associated with metabolic disturbances (i.e., hyperchloremic acidosis) and has direct negative effects on the bowel, kidney and circulatory system functions.<sup>[5,8,9]</sup> In a study by Pfortmueller et al, the use of 0.9%S in high-risk patients undergoing major abdominal surgery was associated with the

**Table 3**  
The dose of fluids and duration of anesthesia.

Type of fluid	Adjusted dose* (mL kg <sup>-1</sup> h <sup>-1</sup> )					P
	Duration of anesthesia (min)					
	<30	31-60	61-90	91-120	>120	
Crystalloids						
Total	17.6 [14.2-28]	11.4 [8.1-15.8]	8.7 [5.7-11.3]	7.0 [5.5-9.2]	5.9 [4.5-7.8]	<.001
BC	16.4 [13.6-27.3]	9.3 [7.1- 14.2]	7.5 [5.5-10.8]	6.1 [4.2-7.8]	5.1 [3.9-7.0]	<.001
0.9%S	3.4 [2.6-12.8]	4.4 [1.9-8.6]	1.9 [1-4.6]	1.2 [0.7-3.3]	1.0 [0.5-1.8]	<.001
G5/G10	-	7.4 [6.3-8.6]	1.7 [1.5-1.9]	-	0.7 [0.4-1]	.04
[0,1-7]Colloids						
Total	18.5 [18.5-18.5]	10.5 [7.2-11.4]	4.7 [3.9-5.5]	3.0 [2.6-4.3]	2.0 [1.7-3.1]	<.001
synthetic	18.5 [18.5-18.5]	8.9 [7.2-10.8]	4.7 [3.9-5.5]	3.2 [2.8 - 4.4]	1.8 [1.4-3.0]	<.001
Gelatin	18.5 [18.5-18.5]	7.8 [6.6-10.6]	4.9 [4.4-6.2]	3.6 [3-4.9]	1.8 [1.5-2]	<.001
Starch	-	9.7 [8-10.7]	3.8 [1.9-5.1]	3.2 [2.3-4]	2.0 [1.4-3.3]	<.001
natural	-	30.4 [30.4-30.4]	-	1.2 [0.7-1.7]	0.8 [0.7-2]	.3
All fluids-total dose	17.6 [14.9-28.2]	12.7 [9.3-18]	8.7 [6-11.5]	7.5 [5.6-10.2]	6.3 [4.6-8]	<.001

Quantitative values are presented as medians and interquartile ranges.  
 0.9%S=0.9% saline, BC=balanced crystalloid, BMI=body mass index, G5/G10=5/10% glucose.  
 \*Based on duration of anesthesia.

**Table 4**  
Intra-operative fluid therapy and pre-operative risk.

	Adjusted dose* (mL kg <sup>-1</sup> h <sup>-1</sup> )		
	Crystalloids	Colloids	Total dose
Individual risk			
ASA-PS class			
I	8.9 [6.4-14]	3.9 [3-9.7]	9.2 [6.5-13.9]
II	8.6 [5.8-12]	3.0 [1.8-4.8]	8.9 [6.3-13]
III	6.3 [4.7-9.4]	3.3 [1.9-5.2]	7.1 [5-11]
IV	7.5 [5.1-8.5]	6.3 [3.8-10.2]	8.3 [7.2-11.1]
(P)	(<.001)	(.2)	(<.001)
Low risk (ASA-PS I-II)	8.7 [6-12.3]	3.3 [1.9-5.2]	8.9 [6.4-13.3]
High risk (ASA-PS III-V)	6.6 [4.7-9.3]	3.6 [2.1-5.5]	7.3 [5.1-11]
(P)	(<0.001)	(0.8)	(<0.001)
Procedure risk			
ESC/ESA			
Low	8.9 [6-13]	4.9 [2.9-7.5]	9.5 [6.6-13.6]
Moderate	7.5 [5.5-10.9]	3.0 [1.9-5.2]	7.8 [5.6-11.4]
High	5.4 [4.4-8.4]	1.8 [1.7-3.6]	7.3 [4.5-9.5]
(P)	(.001)	(.06)	(.001)
Mode of procedure			
Elective	7.9 [5.5-11.4]	3.0 [1.8-4.9]	8.3 [5.9-11.7]
ASA-PS „E”	8.6 [6.5-14.4]	5.7 [3.5-7.5]	10 [6.9-17.1]
(P)	(.1)	(.008)	(.03)
Global risk†			
Low (A)	9.3 [6.7-13.6]	4.7 [2.1-7.5]	9.8 [6.9-13.6]
Moderate (B)	7.5 [5.6-10.7]	2.8 [1.7-4.3]	7.9 [5.6-11.1]
High (C <sub>1</sub> -C <sub>4</sub> )	7.1 [4.8-11.1]	3.5 [2.1-5.6]	7.6 [5.3-11.7]
(P)	(<.001)	(.09)	(<.001)
Group of global risk†			
A	9.3 [6.7-13.6]	4.7 [2.1-7.5]	9.8 [6.9-13.6]
B	7.5 [5.6-10.7]	2.8 [1.7-4.3]	7.9 [5.6-11.1]
C <sub>1</sub>	9.1 [5.7-16.3]	3.4 [2.1-10.2]	10.4 [6.9-19.5]
C <sub>2</sub>	6.4 [4.7-11.5]	5.1 [3.8-8.5]	7.3 [4.9-11.7]
C <sub>3</sub>	6.2 [4.7-8.5]	2.5 [1.7-4.6]	7.1 [5.2-8.6]
C <sub>4</sub>	7.3 [4.7-10.2]	3.6 [3.2-6]	8.3 [4.7-11.8]
(P)	(<.001)	(.1)	(<.001)

Quantitative values are presented as medians and interquartile ranges.  
 \*Based on duration of anesthesia.  
 † see Figure 2 for details.



need to use catecholamines more frequently, while replacing 0.9% S with BCs reduced the need for these drugs by 50%.<sup>[25]</sup>

Synthetic colloids were infrequently used in our study. According to the recommendations, these solutions may be transfused only to restore the intravascular volume resulting from current blood loss.<sup>[2]</sup> The use of starches may increase the risk of organ-related complications, primarily due to acute kidney injury and blood coagulation disorders.<sup>[26,27]</sup> Reliable data on the safety of hydroxyethyl starch in the peri-operative period are to be provided by the results of the PHOENICS study.<sup>[28]</sup>

#### 4.1. Study limitations

Our study has some limitations. First of all, the method of hospital selection may result in systematic errors as district low-volume centers were not included in the sampling frame. Secondly, the 1-day assessment could also be biased in terms of the number of recruited patients and their aligned risk, as well as the risk of procedures performed. However, there is no clear solution to this issue. One-day point prevalence studies (PPSs) reflect the real-life scenario and have not been found to be of lower quality compared with longer observations. Thirdly, in our study, the number of patients with high global risk was different from the literature reports.<sup>[29]</sup> This discrepancy may result from the type of study (PPS vs cohort) or the fact that peri-operative risk assessment is performed in some hospitals with different methods. We decided to use tools which were the simplest possible but reliable, which is in line with national recommendations<sup>[14]</sup> and makes our findings comparable worldwide. Moreover, our analysis did not include an intra-operative assessment of fluid loss, particularly blood loss, which could affect the total fluid dose transfused. However, our method of assessment of IFT is consistent with previously published reports as no universal method estimating the losses during surgery and subsequent hypovolemia<sup>[30,31]</sup> has been recommended so far.

#### 5. Conclusions

The practice of IFT in Polish hospitals is liberal but is adjusted to the preoperative risk. The consumption of synthetic colloids and 0.9% saline is low. Further research is needed to investigate relationship between perioperative risk and fluid regimen in consecutive risk categories.

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#### Author contributions

Anna J. Szczepańska: study design, study performance, data collection, data interpretation, literature search, manuscript preparation, manuscript approval.

Michał Pluta: data interpretation, statistical analysis, manuscript preparation, literature search, manuscript approval.

Łukasz J. Krzych: study design, study performance, manuscript preparation, manuscript approval.

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