

Unplanned surgical reoperations as a quality indicator in pediatric tertiary general surgical specialties

Associated risk factors and hospitalization, a retrospective case–control analysis

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Abstract

Unplanned reoperations have not been studied extensively in pediatric patients, especially concerning risk factors. We aim to estimate the rate of unplanned reoperations and to determine the associated factors in pediatric general surgical specialties.

This analysis included a retrospective case–control study of unplanned reoperations from July 1, 2010 to June 30, 2017 in the general surgical specialties. For each case, we identified approximately 2 randomly selected controls who underwent the same type of operation. The factors involved in the unplanned reoperations were investigated using univariate and multivariate analysis.

Of the 3263 patients who underwent surgery, unplanned reoperations were performed in 139 patients (4.3%). The main indications for unplanned reoperations were wound complications ($n=52$, 42.6%), followed by postoperative ileus ($n=12$, 9.8%), postoperative bleeding ($n=8$, 6.6%), and intraabdominal infection ($n=13$, 10.7%). Following multivariate analysis, 2 factors remained significantly associated with unplanned reoperation: higher initial surgery-related risk level ($P=.007$, risk ratio (RR)=0.48; 95% confidence interval (CI)=0.27–0.82) and operation performed outside working hours ($P=.031$, RR=0.52; 95% CI=0.30–0.89).

Various patient- and procedure-related factors were associated with unplanned reoperations. This information might be helpful for the optimization of treatment planning and resource allocation.

Abbreviations: ASA = American Society of Anesthesiologists, CI = confidence interval, IQR = interquartile range, NNIS = National Nosocomial Infections Surveillance, RR = risk ratio, SPSS = Statistical Product and Service Solutions.

Keywords: general surgical specialties, pediatric, unplanned surgical reoperations

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1. Introduction

Unplanned reoperation rate could be a useful index for surgical quality improvement, possibly resulting from postoperative complications, including anastomotic leaks and wound infections.^[1–4] Due to the complexity and heterogeneity of surgical procedures, surgical complications are not necessarily the result of an error. An unplanned reoperation may occur after almost any procedure, and thus, is broadly applicable and is gathering increasing attention.^[5,6] Currently, rates of unplanned reoperation have been reported as highly variable in the literature, ranging from 0.8% to 7%.^[7–9] Evaluating and tracking unplanned surgical results on surgical wards can raise awareness of complications and surgical errors. This practice has been implemented as an indicator of quality of care in order to increase transparency in surgical care. Nevertheless, administrative data have been shown to improperly identify many postsurgical events, and isolating the factors underlying specific types of errors has proven to be a formidable task. Furthermore, complications are often too procedure-specific to be useful across the heterogeneous range of general surgical procedures.

To improve the outcomes of surgery, it is important to predict complications that contribute to prolonged hospitalizations and increased costs. Identification of high-risk patients or procedures may allow heightened vigilance and corresponding interventions, which could possibly improve clinical outcomes.^[2] In addition,

whether events such as massive blood loss and higher grade surgery are potentially related to some pediatric conditions needs to be elucidated. Detailed information regarding the incidence and risk factors for pediatric general surgery of patients under the age of 14 has not yet been researched.

In this study, we investigated the accuracy and the risk factors of 30-day unplanned reoperation variables at a single institution to provide direction for ameliorative efforts that could serve as indicators of the quality of patient care, contributing to quality improvement.

2. Methods

We retrospectively performed case–control analysis on the documents regarding unplanned surgical reoperation in the Dept. of Pediatric General Surgery and Liver Transplantation, Children’s Hospital of Chongqing Medical University from July 1, 2010 to June 30, 2017. These documents included patients in the general surgical specialties. The electronic medical records of all included patients were complete and independently reviewed for any unexpected surgical procedure by a clinician within 30 days of the initial procedure, planned vs unplanned status, and any documented reasons for the reoperation. Controls were identified for patients who had undergone the same type of procedure without an unplanned surgical reoperation during the same period at the same institution. To sufficiently detect the risk factor in 122 patients available for review, we randomly selected approximately 2 control patients who had undergone the same principal procedure during the 6-month period preceding the date of surgery in the corresponding case to review their records. Because this was an observational study with no interventions other than routine care, specific informed consent was not considered necessary. Unplanned surgical reoperation was defined as any secondary procedure performed within 30 days of the initial surgery as a result of a complication resulting directly or indirectly from the initial operation. Surgical procedures that were planned for 2 stages were excluded. The patients who died during initial surgery were also excluded. The Ethics Committee of Chongqing Medical University gave expedited approval of this protocol (Approval No. 166/2018).

2.1. Data collection

To assess the primary suspected reason for unplanned reoperations, 2 clinicians independently evaluated abstracted data. We recorded 11 preoperative and intraoperative variables, including demographic data (age, gender, and weight), the American Society of Anesthesiologists (ASA) physical status classification, operative time, starting time, duration of the operation, anesthesia, intraoperative events, volume of blood lost, whether the operation was performed on the weekend or on an emergency basis, and the National Nosocomial Infections Surveillance (NNIS) index classified on a previously published method,^[10] as well as whether the operation was performed by a particular level of surgeons, including senior surgeons, surgical residents, and interns. Furthermore, the causes of the reoperation were judged based on objective criterion and assigned to the following classifications: an error in management; an error in surgical technique; a patient’s illness; or a complication outside surgical department. Our research team members participated in the meeting and reached a consensus on the classifications for the reasons of unplanned reoperation. The complications here only

included grade II complications or higher, defined by the Clavien–Dindo classification system, such as septic shock, gastrointestinal bleeding, abdominal abscess, late ileus, etc.

2.2. Statistical analysis

We generated descriptive statistics to determine the overall frequency of the 30-day postoperative procedures for treatment of complications. We examined patient demographic variables and clinical variables among patients with and without unplanned reoperations. Continuous data were presented as the mean \pm standard deviation or median (minimum, maximum or 25th and 75th interquartile range [IQR]) unless otherwise indicated. Categorical data were reported as percentages. For univariate comparisons, Student’s *t* tests, Shapiro–Wilk tests, or Wilcoxon rank sum (Mann–Whitney *U*) tests were used to compare continuous variables, whereas χ^2 tests or Fisher exact tests were used to compare categorical variables. A 2-sided *P* value $\leq .05$ was considered significant. Variables found to be associated with unplanned reoperations in the univariate analysis at a statistical significance level of $P < .10$ and those proven significant in previous studies or considered clinical importance were then included in a multivariate conditional logistic-regression model. All analyses were performed using Statistical Product and Service Solutions (SPSS) 20.0 (IBM, Armonk, NY) software.

3. Results

From July 1, 2010 to June 30, 2017, a total of 3263 surgical procedures were performed at the Dept. of Pediatric General Surgery and Liver Transplantation, Children’s Hospital of Chongqing Medical University. We identified 159 patients eligible for analysis, and 37 patients were excluded due to incomplete information ($n=29$). At last, the remaining 122 patients who underwent one or more postoperative unplanned reoperations within 30 days of their initial operation, giving an unplanned reoperation rate of 4.3%. Table 1 summarizes the features of reoperations performed. Unplanned reoperations occurred following 8 different types of initial operations. However, 3 procedures accounted for almost half of the unplanned reoperations. The single procedure accounting for the largest proportion of reoperations was appendectomy, of which most were done on an emergency basis.

The indications for unplanned reoperations are listed in Table 2. The most common postoperative procedures were

Table 1

The initial procedures performed in patients which required reoperations.

Type of surgery	First reoperations	Two or more reoperations
Total number	122	17
Appendectomy	31	3
Small bowel and colon anastomosis	22	3
Diagnostic laparotomy	24	2
Hernia corrective surgery	16	2
Hepatobiliary surgery	13	5
Liver transplantation	8	2
Reposition of intussusception	6	0
Small bowel and colon fistulation	2	0

Table 2
Indications for first reoperations.

Indications, n (%)	Unplanned reoperation, n (%)	Median (range) post-op day of first reoperation
Postoperative ileus	12 (9.8%)	13 (3, 21)
Postoperative bleeding	8 (6.6%)	10 (1, 13)
Wound infection	35 (4.1%)	9 (1, 25)
Wound dehiscence	17 (13.9%)	6 (3, 29)
Intraabdominal infection	13 (10.7%)	11 (4, 16)
Anastomotic leakage	11 (9.0%)	5 (2, 7)
Hernia recurrence	17 (13.9%)	18 (2, 30)
Omentum hernia	4 (3.3%)	8 (2, 8)
Other	5 (28.7%)	4 (1, 30)
Total	122	8 (1, 30)

related to the treatment of wound complications (n=52, 42.6%), postoperative ileus (n=12, 9.8%), postoperative bleeding (n=8, 6.6%), intraabdominal infection (n=13, 10.7%), anastomotic leakage (n=11, 9.0%), and hernia recurrence (n=13, 13.9%). Postsurgical bleeding included active hemorrhage and hematomas. The median date of reoperations was the 8th day after surgery (range, 1–30 days). In only 16 patients (13.1%) did reoperation occur on the first day after surgery. In 24 patients (19.7%), the unplanned reoperation was performed 20 days or more after the initial surgery. Some patients required more than 1 reoperation after their initial operation: 13 patients had 2 reoperations (10.7% of all reoperations), 3 patients needed 3 reoperations (2.5%), and 1 patient needed 4 reoperations (0.8%).

Of all reoperations, 73 (59.8%) were classified as being the result of an error in surgical technique and 23 (18.9%) were the

Table 3
Cause of first reoperation.

Cause of first reoperation	n (%)
Error in surgical technique	73 (59.8)
Error in management	23 (18.9)
Patient's illness	11 (9.0)
Cause outside surgical department	15 (12.3)
Total	122

result of an error in the management of the patient. In 15 patients (12.3%), the cause of the reoperation was determined to originate outside the surgical department (Table 3). Anastomotic leakage, hemorrhage, and wound dehiscence were all classified as errors in surgical technique, even when there was no reason to believe they were caused by the surgeon.

3.1. Case–control analysis

Patient characteristics, comorbidities, operative variables, and outcomes were compared between patients undergoing unplanned reoperation and patients without reoperation (Table 4). According to univariate analyses, there were significant differences in terms of whether the surgery was performed on working hours or not (P=.004). The procedures performed on working hours were less likely to result in reoperations. The procedures involving higher initial surgery-related risk level (NNIS) posed a higher risk for unplanned reoperation (P=.008). Patients undergoing unplanned reoperations had longer operative times during the original operation (118.7±37.9 vs 146.0±47.6

Table 4
Univariate analysis of factors present at initial operation associated with need for reoperation.

Variables	Control (n=214)	Unplanned reoperation (n=122)	P values
Age (yrs)	2.9±3.3	3.0±3.7	.79
Male:female	133:81	73:49	.77
Operative time (min)	118.7±37.9	146.0±47.6	.058
Operative blood loss (mL)	77.6±30.2	83.9±34.0	.32
Transfused patients, n (%)	53 (24.8)	31 (25.4)	.51
Scheduling conditions, n (%)			.36
Selected surgery	92 (43.0)	55 (45.1)	
Emergency	122 (57.0)	67 (54.9)	
Initial surgery-related risk level (NNIS), n (%)			.008
NNIS0	128 (59.8)	49 (40.2)	
NNIS1	60 (28.0)	52 (42.5)	
NNIS2	25 (11.7)	18 (14.8)	
NNIS3	1 (0.5)	3 (2.5)	
ASA classification, n (%)			.17
ASA1	28 (13.1)	12 (9.8)	
ASA2	96 (44.9)	40 (32.8)	
ASA3	74 (34.6)	54 (44.3)	
ASA4	14 (6.5)	11 (9.0)	
ASA5	2 (0.9)	5 (4.1)	
Surgeons level, n (%)			.62
Resident	34 (15.9)	25 (20.5)	
Senior resident	87 (40.7)	54 (44.3)	
Fellow	37 (17.3)	18 (14.8)	
Attending	56 (26.2)	25 (20.5)	
Operation performed on working hours, n (%)	64 (29.9)	22 (18.0)	.016
Operation on weekend, n (%)	76 (35.5)	47 (38.5)	0.33

ASA=American Society of Anesthesiologists, NNIS=National Nosocomial Infections Surveillance.

Table 5
Multivariable analyses of the factors with unplanned surgical reoperation.

Variables	P values	RR	95% CI
<NNIS2	.007	0.48	0.27–0.82
Operation finished on working hours	.031	0.52	0.30–0.89

The multivariate logistic-regression analysis included the following variables: operative time (min), scheduling conditions, operative blood loss, transfused patients, initial surgery-related risk level (NNIS), ASA classification, operation finished on working hours. CI=confidence interval, NNIS=National Nosocomial Infections Surveillance, RR=risk ratio.

minutes, $P=.058$), although there was no significant difference (Table 4). There were no statistically significant differences in terms of age, gender, or operative blood loss. After adjusting for other characteristics, 2 factors remained significantly associated with unplanned reoperation: higher initial surgery-related risk level ($P=.007$, risk ratio (RR)=0.48; 95% confidence interval (CI)=0.27–0.82) and operation performed outside working hours ($P=.031$, RR=0.52; 95% CI=0.30–0.89). The total length of hospital stay was longer in patients who underwent unplanned reoperation (20.98 ± 10.60 days) than in the controls (12.12 ± 7.71) (Tables 5 and 6).

4. Discussion

In this retrospective cohort study, we examined all postoperative reoperations as an indicator of surgical quality in a level 3 pediatric general surgical unit. We found that an unplanned return to the operation room occurred in 4.3% of all patients. Compared to patients without reoperation, the patients with unplanned reoperations had higher NNIS score and more operations on weekends.

Because unplanned reoperations are often caused by problems resulting from the original procedure, reoperation rate is commonly accepted as indicator to monitor quality improvement for surgery, serving as an important method of safety audit and review within hospitals or departments of surgery. The information can also be used to compare different clinics, as well as to provide selection criteria for patients seeking an appropriate health care facility.^[11,12] Although it provides a readily measurable outcome to more accurately identify influential processes of care, the wide range of unplanned reoperation rates suggests that caution should be taken in terms of indication of the quality of care.^[13] Here, in this study, the unplanned reoperation rate for our pediatric general surgical specialties cohort was 4.3%. Similar to previous findings, our results showed that intraabdominal infection, anastomotic leakage, wound infection, postoperative

Table 6
Outcomes of patients undergoing unplanned surgical reoperation compared to control.

Variables	Control (214)	Unplanned reoperation (122)	P values
Total hospital length of stay, d, mean \pm SD	12.1 \pm 7.7	21.0 \pm 10.6	<.001
The initial hospital length of stay, d, mean \pm SD	12.1 \pm 7.7	12.9 \pm 8.0	.28
Total number of grade II or higher complications, n (%)	36 (16.8)	22 (18.0)	.48

hemorrhage, and postoperative ileus were the major indications for reoperation. Wound infection or dehiscence contributed to about a third of the postoperative procedural interventions. The second most common reason for a postoperative procedure, intraabdominal infection, accounted for approximately 20% of reoperations. Simpler procedures, such as appendectomy and hernia surgery, had low reoperation rates. The incidence of unplanned reoperations can be used to initiate future studies and continuous improvement to identify the key processes of care that reduce the number of major surgical complications to analyze and evaluate the surgical quality and performance.^[14,15]

Effective unplanned reoperation prevention requires recognition of risk. Previous studies evaluated risk factors and found that comorbidities, operating time, and vital sign criteria were most predictive.^[16–18] Emergency surgery was also reported as a risk factor in some studies.^[1,18] In the current study, most risk factors, including poor physical condition and massive surgery were either nonmodifiable comorbidities or were markers for severe underlying illness, which are not surprising. Nevertheless, in this study, less-intuitive factors were also associated with substantial risk, including operation performed outside working hours. We found that reoperation was 2 times more likely when an operation was extended to the off duty time (6 PM), though some authors have not found this association; this is a potentially causative modifiable risk factor, in which disorganization is increased. There could be several ways to interpret this finding. For the procedure extending to the off duty time (6 PM), they should be longer complicated with more operation time, which could be supported by the differences of operative time and initial surgery-related risk level (NNIS) between the 2 groups. So the current finding reflects the fact that patients requiring unplanned reoperation had undergone a more complicated surgery, which might cause more complications during the index surgery and are thus more likely to be managed with unplanned reoperation. We of course should take the notion that the severity of the complications, not the actual number, is driving the rate of unplanned reoperation. Future prospective analysis will be needed to clarify this result. The patient characteristics were less predictive of unplanned reoperation than acuity of illness was, supporting the notion that postoperative complications requiring reoperation tend to be associated with surgical comorbidities, rather than with baseline patient characteristics.^[17] This was supported by the interesting fact that the rate of unplanned reoperation was higher in large tertiary hospitals compared with small local hospitals, reflecting the case-mix of patients in the various hospitals.^[19,20] When preoperative patient characteristics correlate with the severity of the initial operation performed, this should be a useful indicator of the quality of care. In addition, tracking unplanned reoperations may help to support or refute the efficacy of a protocol applied across the initial operations. The insight obtained from the reoperation rate can be used to alter perioperative action, even to develop new surgical methods in the context of regular complication control; finally, the lessons learned can be of great value in teaching young clinicians.^[21,22]

There are some limitations of this study. First, the sample size was relatively small from a single institutional review. Future studies on this topic in multiple participating hospitals would result in a larger number of patients. Additionally, because reoperation covers a broad range of surgeries, it is difficult to draw concrete conclusions regarding reoperation rates of specific surgical types, an important factor for identifying the key processes of care that reduce the number of major surgical

complications. Further quality improvement efforts will be aimed at decreasing wound infection complications, with the ultimate goal of improving patient care. Third, medical or nonoperative complications are not captured by postoperative procedures, including potentially life-threatening events, such as pneumonia, that can also be affected by the quality of care provided. If repeated events are identified, a method of prospectively tracking future events could prove to be a source of improving quality at a different level.

5. Conclusion

We found that the percentage of unplanned reoperations can be a useful indicator to assess the frequency and pattern of a subset of some of the most clinically significant surgical complications in a surgical department. The most common reasons for reoperations at our institution were infection and hemorrhage. A prospective, standardized, well-defined registry of all unplanned reoperations classified by type of index operation is important to focus on the delivery of surgical care across large population groups.

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Author contributions

CG, QL designed, analyzed, and measured the data. AL, HZ, HZ, JL, YD helped design the experiments, performed the statistical analysis, and evaluated the manuscript; CG analyzed and interpreted the data, and wrote the paper.

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