

The risk factors related to operative duration and its relationship with clinical outcome in pediatric patients undergone Roux-en-Y hepaticojejunostomy

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Abstract

Background: The operative duration might be important for perioperative morbidity and the involvement has not been fully characterized in pediatric patients. We here determined the perioperative variables in association with operative duration and its influence on the clinical outcome in the pediatric patients.

Methods: We retrospectively reviewed 701 patients who underwent elective choledochal cysts followed by Roux-en-Y hepaticojejunostomy between August 2010 and Aug 2019. Based on the median operating time (165 min), patients were separated into two groups, including a long-time group (>165 min) and a short-time group (<165 min). The independent risk factors for the operative time were determined using the multivariable logistic regression analyses. To adjust for any potential selection bias, propensity score matching was performed for the long-time and short-time groups. In the 192 matched patients, perioperative outcomes, including postoperative recovery, complications measurement, and length of hospital stay were analyzed.

Results: The operating time was often increased by excision difficulty caused by the larger choledochal cyst size (OR=1.56; 95% CI, 1.09-2.23; $p < 0.001$), the greater BMI (OR=1.02; 95% CI, 1.00-1.15; $p = 0.018$), older age (OR=1.17; 95% CI, 1.02-1.39; $p = 0.012$) under multivariate analysis. The long-time surgical duration was associated with delay for gastrointestinal functional recovery, measured with the first defecation ($p = 0.027$) and first bowel movement ($p = 0.019$). Moreover, a significant decrease in serum albumin were presented in the long-time group compared with the short time group ($p = 0.0035$). The total length of postoperative hospital stay was longer in patients with long-time group (7.51 ± 2.03 days) than patients with short-time group (6.72 ± 1.54 days, $p = 0.006$).

Conclusions: Our data demonstrated that short operating time was associated with favorable postoperative results. The influencing factors for operating time could be ameliorated in the perioperative period to gain a better outcome after major abdominal operations.

Introduction

During surgical procedures, longer operative time might lead to delayed recovery and be associated with more postoperative complications [1, 2]. In the general surgery literature, particularly in gastroenterological surgery, longer operative time might result in delayed gastrointestinal function recovery, postoperative intestinal obstruction, and prolonged hospitalization [3, 4]. It is therefore recommended to optimize the speed of the surgery, especially for the major classical operation, to maintain an appropriate postoperative recovery and improve postoperative outcomes. In order to assess the impact of operative time on postoperative outcomes, it must be analyzed the risk factors that contribute to longer operative duration and determined its contribution to surgical outcome.

Operative times have been used as a measure of competence for surgeon. The specific surgeon properties, involved in operative time are well documented in the literature, which have been used to determine operative learning curves [5, 6]. A long operating time may involve insufficient experience of

surgeons. Individual surgeon characteristics should account for a fairly large part of the variability in operative time[7, 8]. In addition, a long operating time was associated with a surgeon who is more tired and may lose focus. On the other hand, operation with rush might be associated with increase the occurrence of errors during surgery. There are many other factors that may potentially impact upon operative duration including the surgeon's operative experience, the actual pathology undertaken[9]. A clear evaluation the factors, accounting for the operative duration is currently lacking. Furthermore, although operative time had been previously evaluated in adult patients, it remains poorly determined for practice among pediatric cohorts.

Here in the current research, we aimed to identify the risk factors of longer operative time in the pediatric population, which was not directly associated with the surgical morbidity. We further compared postoperative recovery and outcomes between longer or shorter operation duration. To our knowledge, no large study to date has specifically addressed the factors account for the operative time and its correlation to clinical outcomes in pediatric surgical practice.

Materials And Methods

Patients selection

We performed retrospective analysis of 810 patients who underwent elective choledochal cysts followed by Roux-en-Y hepaticojejunostomy at the department of general surgery of the affiliated chongqing children's Hospital, Chongqing medical university between August 2010 and Aug 2019. The surgical procedures were performed by five qualified and professional attending surgeons. The inclusion criteria were as follows: patients receiving resection of choledochal cysts and hepaticojejunostomy; open procedure; age>1 year and <10 years. Exclusion criteria: previous surgical history; coagulopathy or platelet dysfunction; laparoscopic surgery. The institutional review board of the Chongqing Medical University gave expedited approval of this protocol.

Data acquisition

Data extraction from the electronic medical records included the following aspects: (1) Preoperative variables, including demographic characteristics, clinical parameters and pre-existing comorbidities; (2) Intraoperative data, including American Society of Anesthesiology (ASA) classification, estimated blood loss (EBL), intraoperative hemoglobin levels, intraoperative blood transfusion, operating start time, duration of operation(time from skin incision to complete skin closure); (3) The postoperative outcomes, included the prompt gastrointestinal recovery features, postoperative laboratory profiles, and postoperative complications. Gastrointestinal features were recorded for the first 5 postoperative days, including nausea or vomiting, time to normal diet, abdominal bloating and/or cramps, the first postoperative flatus or defecation, gastric retention. The postoperative complications were ranked according to the Clavien-Dindo classification system. Only grade II complications or higher were recorded in this research, such as postoperative hemorrhage, wound infection, intra-abdominal abscesses,etc.

According to the median operating time (cutoff value, 165 min), patients were dichotomized into short time group (<165 min) and long time group (>165 min) (Table 1) for the purpose of analysis.

Propensity model

The propensity score matching was performed to minimize the biases in baseline characteristics by a multivariable logistic regression model using SPSS 20.0 (IBM, Armonk, NY) or R 3.1.2 (The R Foundation for Statistical Computing). A caliper distance of 0.2 was specified for a 1:1 Propensity scores matching using nearest-neighbor analysis. The linear assumption in PS model was checked using generalized additive model, thus matching 108 HS patients to 108 controls. The characteristics of long time group and a short time group were compared after propensity score matching.

Statistical analysis

The categorical variables, presented as frequencies with percentages, were compared using the chi-squared test or Fisher's exact test as appropriate. For normally distributed continuous data, it were expressed as the means \pm (standard deviations) and tested with the Student's t-test or Mann-Whitney U test. For non-normally distributed data, they were expressed as medians (interquartile ranges) and analyzed with the Wilcoxon rank-sum test. The multivariate analysis was performed to determine predictors of operation duration entered the variables with a significance level of $P < 0.30$ in univariate analysis. The statistical analyses were performed using the SPSS 20.0 (IBM, Armonk, NY, USA) software package.

Results

A total of 789 patients who underwent elective Roux-en-Y hepaticojejunostomy between 2009 and 2019 met the inclusion criteria. There were 701 patients entered into the final analysis for eighty-eight patients exclusion due to unobtainable notes (Table 1).

The factors associated with operating time

In the current study, the average operative time among the entire 701 patients was 165 min, with a coefficient of variation (COV) of 46.9%. The Table 1 summarizes demographic, clinical, and operation features based on the short time and long time operative duration. As indicated, there were no significant differences regarding some preoperative parameters such as gender distribution, ASA classification, prevalence of the hypertransaminasemia and hyperbilirubinemia ($P > 0.05$) (Table 1). Furthermore, some of the preoperative laboratory tests (WBC, CRP) was similar to that of the short-time group ($P > 0.05$). However, patient's deeper fat (greater Weight and BMI) were associated with the duration of operation ($P < 0.01$). Interestingly, operations performed in the morning took a longer duration than that in the afternoon. A larger choledochal cyst size, and worse symptoms (Charcot's triad), often resulted in a longer operating time ($P < 0.05$). Moreover, when analyzing individual surgeons, we discovered that the duration

of operation was associated with surgeon individual performance ($P < 0.01$) with longer duration for attending surgeon number 5.

Multivariate Analysis

Three risk factors for the development of longer operating time were identified (Table 4) under multivariable logistic regression analysis. As shown in Table 4, the larger choledochal cyst size, the more likely longer operating time **spent** (OR=1.56; 95% CI, 1.09-2.23; $p < 0.001$). Similar results were discovered in the percentage of greater BMI (OR=1.02; 95% CI, 1.00-1.15; $p = 0.018$). The patient's age (OR=1.17; 95% CI, 1.02-1.39; $p = 0.012$) was also significantly associated with longer operating time (Table 2).

Postoperative outcomes

We performed PS-matching to eliminate systematic differences in baseline characteristics between the patients with short-time group and long-time group. Under PS-matching, 268 patients with short-time group were matched to 268 patients with long-time group. After the PS-matching, the values of standardized mean differences for the included continuous and categorical variables reduced and comparable between the two groups (Table 3).

Overall, there were no differences in the number of hypokalemic episodes, intraoperative hypotensive events, metabolic acidosis (defined by low bicarbonate) or other laboratory and hemodynamic parameters between the short-time group and long-time group (Table 4). A trend for accelerated gastrointestinal function recovery was noted in patients with short-time group compared with long-time group, as indicated by the first defecation ($p = 0.027$) and first bowel movement ($p = 0.019$). Furthermore, the ALB values on POD 2-5 were lower in patients who underwent a longer procedure ($P = 0.0035$). Patients with a longer operating time suffered almost equally from vomiting and diarrhea events as patients with a shorter operating time in 5 PODs (Table 4). The incidences of abdominal distention within 5 PODs was marginally higher in the patients with longer operating time compared with the shorter operating time group ($P = 0.068$).

Finally, there were more postoperative complications in patients of long-time group than those with the short-time group, including infectious complications, anastomotic leakage, incision dehiscence, and sepsis, etc. Sixty-two patients (62/268, 23.1%) in the short-time group experienced at least 1 complication compared with 83 (83/268, 31.0%) in the long-time group, with an odds ratio (OR) of 0.67 (95% confidence interval [95%CI, 0.46-0.99]; $P = 0.026$) (Table 4). The mean length of postoperative stay was 7.51 ± 2.03 days in patients with a long-time group, which was significantly longer than that (6.72 ± 1.54 days) in patients with a short-time group ($p = 0.006$).

Discussion

We conducted the present analysis for a pediatric surgical cohort following the same surgical procedure to explore optimized operative duration undergoing abdominal surgery. Current data from three tertiary care hospital suggested that several factors were associated with the operation time, like the patient age, commodity, the mean CBD, etc. As with surgeon's peculiarity, experience and special property contributed to progressively increased operative duration variability. Furthermore, shorter operative duration was associated with significant improvements in recovery measures and postoperative complication. Only disease commodities contribute to both longer operative time and surgical outcome.

The factors led to a long duration of abdominal operations were often complicated and involved in case type, surgeon's proficiency and characteristics, emergency operation, and so on [10, 11]. The operation duration may be prolonged by unexpected intraoperative findings and operative complexity. The understanding of the risk that delay progression might be in favor to reduce operative duration. The current surgical outcomes, including complication rates, are comparable with those calculated in the previous report[12, 13]. The pediatric cohort following same surgical procedures originate from the university medical centers was therefore deemed satisfactory to assess the factors influencing operative duration. In this study, we measured the amount of variability in operative duration and identified several factors related to the longer operative duration. After multivariable analysis, the results showed that a larger choledochal cyst size, severe comorbidities, like Charcot's triad independently resulted in a longer operating time. Another factor was patients age, which has not been shown in previous studies to be associated with longer operative time after Roux-en-Y hepaticojejunostomy. the reasons for this association are unclear, but may pertain to alterations in deeper operative surface related to operative visual field exposure that are beyond the scope of this data set. Furthermore, the older patients implies the thicker anastomose, which need the longer operation time to construction. Higher adhesions were also associated with longer operative time, likely reflecting increased complexity of longer cases. We found an relationship between severe commodity and operative time, which likely relates to the chronic inflammation and the resulting impact on the pericyst tissue.

Several studies have shown that the experience and distinctive character of the individual surgeon or the surgical team influences the duration of the operative duration[14, 15, 16]. The current studies illustrate that Operative duration is longer in the presence of junior surgical trainees, which may reflect both the procedural learning curve as well as potential confounding due to referral of complex surgical cases to senior attending supervision. The senior surgeons with increased experience are likely to decrease the duration of procedures. Increased attending supervision could decrease operative duration, however, research is needed in this area. The improvements in operating process efficiency, including an operation team and an anesthesia team can reduce operative duration[17, 18]. Interestingly, we demonstrated the similar finding that operations in the morning group usually took more time than the afternoon group, which could be the main reason for this finding. The potential impact of surgeons' fatigue and human circadian variations reduced workload requirements on operative experience however, an effect has not been demonstrated so far.

Longer operation time was a surrogate marker of surgical difficulty, which might be associated with perioperative morbidity and delayed discharge. Although a goal-directed fluid therapy was adopted to control fluid administration, prolonged operative duration may account for excessive intravenous fluid administration and blood loss[19. 20]. In this study, an increased total volume of intraoperative crystalloid and blood loss were presented following operation duration increases. the blood transfusion administration, is an independent predictor of increased morbidity for surgical patients, including gastroenterology patients[21]. Furthermore, fluid accumulation might decline the tissue oxygenation, which was also unfavorable for postoperative gastroenterological recovery and wound healing, the most important reason of the postoperative length of stay[22]. Although an uneventful recovery was ending in most choledochal cyst resection patients. This study identified the remarkable beneficial effects of shorter operative duration for postoperative gastrointestinal recovery of defecation and oral solid diet. In our institute, the clinically intestinal complaints should be adequately monitored as much as possible. In our study, we indeed detected an increased total number of complications and unfavorable postoperative outcomes following an increase in operative duration, which was consistent with previous studies[23]. The longer operative time may relate to prolonged general anesthesia and potential for prolonged catheterization, which should explain some unfavorable postoperative outcomes, like increased urinary tract infection(UTI) risk with urinary retention and respiratory infections. The long operation duration might accelerate the body metabolism and increase the consumption of nutrition, as suggested by previous research[24]. Here in the current research, the postoperative ALB values, which have been widely adopted to evaluate the preoperative immunologic and nutritional status of patients undergoing gastrointestinal and cardiac surgery, significantly increased in the longer operation time group[25, 26]. In the present study for patients with an longer operative time, the average length of stay was longer than the average length of stay in shorter operative time cases in our institution at between 4 and 5 days. The present data highlighted the benefits of low operative duration, which might be associated with postoperative complications in pediatric patients undergoing major surgery. However, while our study supports several factors were associated with prolonged operation time, this was not necessarily associated with postoperative complications. evidence-based best practices should be implemented to promote a safer, higher quality of patient care.

There were several potential limitations, so when interpreting the current data, care should be taken. The retrospective study design with relatively small size of homogeneous patients may limit the generalizability of our conclusions. Moreover, the selection bias could not be fully eliminated although the PS meatching was performed. We were also unable to identify complications or returns to the OR occurring greater than 30 days after the index operations. In addition, it is unlikely that a strict separation the individual contribution of surgeons, that would have prevented us to determine the difference between individual surgeons. It is important for future studies to investigate the effect of each surgeon individually. Finally, it might be interesting to evaluate the effect of surgical nurses, because they are part of the surgical team as well and may affect the operative duration.

Conclusions

In the current study, we have characterized risk factors, such as patient comorbidities, surgeon's peculiarity, and cyst size, that may predispose to longer operative time. Long operative duration impacts negatively on the postoperative outcomes for pediatric patients with major abdominal operation. Further research is needed to delineate clinical scenarios to optimize preoperative planning and maximize surgical efficiency.

Abbreviations

ALB: albumin; ASA: American Society of Anesthesiology; BMI: Body Mass Index; CBD: common bile duct; CI: confidence interval; COV: coefficient of variation; CVP: central venous pressure; EBL: estimated blood loss; OR: odds ratio; PODs: postoperative day; RBC: red blood cells; UTI: urinary tract infection

Declarations

Ethics approval and consent to participate

This study was approved by the ethics committee of Chongqing Medical University, and was performed in accordance with the Helsinki Declaration of 1975, as revised in 1983. All the patients enrolled were comprehensively informed, and all study participants provided written informed consent prior to enrollment.

Consent to publish

Not applicable.

Availability of data and materials

The datasets during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Author Contributions

AL, KG designed and analyzed the data and evaluated the manuscript. QL performed the statistical measurements and analyzed the data. CG, AL analyzed the data and wrote the paper.

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Tables

Table 1. The factors associated with operating time

	Total Population		
	<165 minutes(348)	>165 minutes(353)	p Values
Age (yrs)	2.29±1.32	2.95±1.87	0.058
Female: Male	93(26.7)	89(25.2)	0.41
Weight (kg)	11.88±4.86	12.97±5.28	0.035
BMI, median (range)	24(20-29)	26 (22-32)	0.023
Laboratory findings			
hypertransaminasemia, n (%)	225(64.7)	236(66.9)	0.30
hyperbilirubinemia, n (%)	138(39.7)	143(40.5)	0.44
WBC(109/L), mean ± SD	9.15±3.54	9.06±3.96	0.17
CRP (mg/L, normal value: 0-8), mean ± SD	12.68±4.31	12.78±4.67	0.29
Ultrasound presentation			
Mean CBD, cm, mean ± SD	1.95±0.76	2.64±1.69	0.0012
Charcot's triad, n (%)	56(16.1)	89(25.2)	0.02
Operating start time			
Morning	95(27.3)	126(35.7)	0.010
Afternoon	253(72.7)	227(64.3)	
ASA classification			
ASA1-2	237(68.1)	252(71.4)	0.19
ASA3-4	111(31.9)	101(28.6)	
Individual surgeons, n (%)			
Attending1	72(20.7)	76(21.5)	0.43
Attending2	65(18.7)	61(17.3)	0.35
Attending3	108(31.0)	79(22.4)	0.006
Attending4	46(13.2)	49(13.9)	0.44
Attending5	57(16.4)	88(24.9)	0.003

Table 2. Multivariate analysis of related factors for longer operating time.

	OR	95%CI	p
Age (yrs)	1.17	(1.02-1.39)	0.012
choledochal cyst size	1.56	(1.09-2.23)	<0.001
BMI	1.02	(1.00-1.15)	0.018

Table 3. The inclusion variables in the PS-matching analysis

	Total Population		
	<165 minutes(268)	>165 minutes(268)	p Values
Age (yrs)	2.42±1.26	2.51±1.39	0.26
Female: Male	87(37.5)	85(39.9)	0.41
Weight (kg)	12.13±4.42	12.24±4.75	0.19
BMI, median (range)	25(22-27)	25 (22-28)	0.32
Laboratory findings			
hypertransaminasemia, n (%)	175(65.3)	176(65.7)	0.38
hyperbilirubinemia, n (%)	108(40.3)	111(41.4)	0.46
WBC(109/L), mean ± SD	9.11±3.36	9.09±3.54	0.32
CRP (mg/L, normal value: 0-8), mean ± SD	12.68±3.67	12.72±3.88	0.37
Ultrasound presentation			
Mean CBD, cm, mean ± SD	2.12±0.68	2.26±1.14	0.24
Charcot's triad, n (%)	43(16.0)	44(16.4)	0.49
Operating start time, n (%)			
Morning	81(30.2)	85(31.7)	0.45
Afternoon	187(69.8)	183(68.3)	
ASA classification, n (%)			
ASA1-2	186(69.4)	183(68.3)	0.37
ASA3-4	82(30.6)	85(31.7)	

Table 4. Outcome characteristics in the matched population with operative times above and below 165 minutes

	<165 minutes(268)	>165minutes(268)	p Values	Odds ratio (95% CI)
Hypotensive events, n(%)	26(9.7)	31(11.6)	0.29	
Norepinephrine usage, n(%)	38(14.2)	41(15.3)	0.40	
Furosemidum, n(%)	24(9.0)	27(10.1)	0.38	
Metabolic acidosis, n(%)	8(3.0)	11(4.1)	0.32	
Nadir of hemoglobin(g/L)	27(10.1)	38(14.2)	0.093	
Operative blood loss (mL)				
Intraoperative transfusion, n (%)	31(11.6)	44(16.4)	0.067	
Albumin on POD 2-5, mean \pm SD, (g/L, normal range, 35-50)	31.25 \pm 5.95	28.64 \pm 6.83	0.008	1.12 (1.01-1.56)
First bowel movement, days, Mean \pm SD	2.28 \pm 0.91	2.81 \pm 0.76	0.019	0.56(0.38-0.98)
Abdominal distension, N (%)	26(9.7)	38(14.2)	0.068	0.65(0.38-1.11)
Diarrhea, N (%)	13 (4.9)	21(7.8)	0.11	
Vomiting, N (%)	24(9.0)	32(11.9)	0.16	
Removal nasogastric tube (days)	3.17 \pm 0.39	3.35 \pm 0.47	0.51	
First defecation (days)	2.54 \pm 1.36	3.36 \pm 1.48	0.027	0.69(0.31-1.07)
No. of patients with complications, n(%)	62(23.1)	83(31.0)	0.026	0.67(0.46-0.99)
Total number of complications, n(%)	73(27.2)	94(35.1)	0.031	0.69(0.48-1.00)
postoperative stay (d)	6.72 \pm 1.54	7.51 \pm 2.03	0.006	0.72(0.42-0.96)