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Multicenter and Multivariate Analysis of Complications Associated with Biliary and Vascular Anomalies in Patients Who Underwent Laparoscopic Cholecystectomy

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Abstract

BACKGROUND/AIMS: In this retrospective study, the aim was to analyze complications associated with biliary and vascular anomalies in patients who underwent cholecystectomy.

MATERIALS AND METHODS: A total of 925 patients who underwent cholecystectomy between 1993 and 2018 were included in the study. The patients' gender, age, diagnosis, comorbidities, antibiotic use, drainage use and duration, operation, hospital stay, and complications were analyzed.

RESULTS: Mean age was significantly higher in the no-anomaly group ($p<0.05$). Drainage and duration of hospitalization were significantly higher in the biliary anomaly group ($p<0.05$). Differences in gender, diagnosis, endoscopic retrograde cholangiopancreatography, hypertension, diabetes mellitus, chronic artery disease, chronic obstructive pulmonary disease, antibiotic usage, drainage, and operation duration between anomaly groups were not significant ($p>0.05$). Having an anomaly was significantly correlated with hospitalization duration ($r=0.088$; $p<0.01$). Biliary anomaly was also significantly correlated with hospitalization duration ($r=0.105$; $p<0.05$). Vascular anomaly was not significantly correlated with the research parameters ($p>0.05$). Complications were significantly correlated with gender ($r=0.097$; $p<0.01$), diagnosis ($r=-0.072$; $p<0.05$), operation duration ($r=0.129$; $p<0.01$), hospitalization duration ($r=0.257$; $p<0.01$), biliary anomaly ($r=0.127$; $p<0.01$), and no anomaly ($r=-0.122$, $p<0.01$). The effect of operation duration on complications was significant at the multivariate level ($B=0.033$; $p<0.01$). Receiver operating characteristic analysis showed that the area under the curve for operation time was 0.701, indicating that operation time has significant predictive value at the 70.1% level for complications in cholecystectomy patients. When operation time exceeded 29 minutes, sensitivity for complications was 82.8% and specificity was 37.7%. When operation time exceeded 31 minutes, sensitivity was 72.4% and specificity was 59.2% for complications.

CONCLUSION: Prolonged operation times in cholecystectomy patients with biliary anomalies significantly increase the risk of complications compared with the non-anomaly and vascular anomaly groups. Depending on the duration of the operation, complications may be predicted and precautions taken.

Keywords: Cholecystectomy, anomaly, biliary, vascular anomaly, complication

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INTRODUCTION

Cholecystectomy, performed when the gallbladder is non-functional and requires removal, is considered the gold standard for most gallbladder pathologies, including acute cholecystitis.[1] With the development of laparoscopic methods, interest in laparoscopic cholecystectomy (LC) has increased, and it has become a minimally invasive alternative to open cholecystectomy.[2] After LC, patients can be discharged after a stay of less than two days, and return to work within two weeks, and have a mortality rate of less than 0.2%.[3] Patients can usually resume their daily diet within one to two days after the operation and report very low levels of pain.[4] On the other hand, complications can still develop even when the minimally invasive approach is used.

Biliary atresia (BA) is an anomaly affecting the pancreas and biliary system.[5] BA is a pathological condition that occurs after bile duct obstruction, which begins before or shortly after birth.[6] Anomalies that are more common in patients with congenital aberrations of the gallbladder are rare but important in surgical operations.[7] BA occurs in 0.5-0.8 per 10,000 births in Western countries, whereas rates are higher in Eastern countries.[8] Although the incidence is low, studies have reported severe inflammation and complications in patients with BA.[9] A vascular anomaly, another biliary anomaly, has been associated with choledochal cysts.[10] Vascular anomalies in infants and children may present with ascites or abdominal pain and may also be detected on imaging.[11] BA, which is more common in girls than in boys, may cause complications during surgical procedures.[12] Because the gallbladder and biliary tree are connected to the portal venous system, venous drainage may predispose them to lesser-known vascular events, such as gallbladder bed perfusion abnormalities[13], which are associated with postoperative complications.[14]

Studies have reported bile leakage, iatrogenic injuries, and other complications following cholecystectomy in patients with biliary and vascular anomalies.[15-17] However, there were insufficient studies examining the complications of these anomalies. Therefore, this study aimed to analyze complications in patients with biliary and vascular anomalies who underwent LC.

MATERIALS AND METHODS

Research Model

The study used a retrospective, mixed-model design that included descriptive and relational screening models. In the study, patients who underwent LC over a 25-year period were analyzed, and the relationships between complications and patients' clinical and demographic parameters were examined.

Patients

The study included 925 patients who applied for and underwent surgery for LC at different health centers between 1993 and 2018. Patient selection was based on patients individuals who had been treated by the researchers' teams throughout their careers at the centers where they had worked. Although there were differences between institutions differed, the research team was the same across institutions, and a similar procedure was performed on all patients. Using the time-based sampling method, all patients with 25 years' experience who met the inclusion criteria were included in the study.

The inclusion criteria were as follows:

- Being 18 years of age or older,
- Having had LC,
- Not having any comorbidities that would prevent the study,
- Patient data must be complete in the file,

The exclusion criteria for the study were as follows:

- Being under 18 years of age,
- Having missing data in the file,
- Having a health condition that would affect follow-up and research,

USG results may be subject to deviations in the identification of identifying biliary and vascular anomalies. Therefore, during the operation, the surgeon performed an intraoperative examination and made a decision. In cases where observational exploration was inconclusive, the decision was supported by postoperative radiological examination.

Data Set

Data on gender, age, diagnosis, endoscopic retrograde cholangiopancreatography (ERCP), comorbid diseases, antibiotic use, drainage, length of stay, and complications were obtained from patient files. Patients were also divided into anomaly groups.

Ethical Approval

Ethical approval was obtained from the Üsküdar University Non-Interventional Research Ethics Committee (approval number: 04, date: 26.05.2025). Because the research involved a retrospective review of medical records, patient consent forms were not obtained. The study was conducted in accordance with the Declaration of Helsinki. Due to the retrospective nature of the study, Üsküdar University Non-Interventional Research Ethics Committee waived the need to obtain informed consent.

Statistical Analysis

Frequency analysis was used to describe nominal and ordinal data, and Fisher's exact and chi-square tests were used to assess differences in these data. Measurement data were summarized using the mean, standard deviation, median, and range. The Kolmogorov-Smirnov test was used to assess the normality of the measurement data. The Kruskal-Wallis test was used to analyze differences in the measurement data. Binary logistic regression analysis was performed because Spearman's rho correlation and linearization deviations[18,19] were observed during relational screening analysis. Receiver operating characteristic (ROC) analysis was performed to evaluate the diagnostic value of operation time for predicting complications. All analyses were performed using SPSS 25.0 for Windows at the 95% confidence level.

RESULTS

Age mean was significantly higher in no-anomaly group ($p<0.05$). Drainage and hospitalization duration were significantly higher in Biliary anomaly group ($p<0.05$). Differences between anomaly groups in gender, diagnosis, ERCP, hypertension, diabetes mellitus, chronic

artery disease, chronic obstructive pulmonary disease, antibiotic usage, drainage, and operation duration were not significant (p>0.05) (Table 1).

Having an anomaly was significantly correlated with duration of hospitalization (r=-0.088, p<0.01). Biliary anomaly was also significantly correlated with hospitalization duration (r=0.105; p<0.05). Vascular anomaly was not significantly correlated with research parameters (p>0.05) (Table 2).

Spearman's rho correlation analysis showed that complication was significantly correlated with gender (r=0.097, p<0.01), diagnosis (r=-0.072, p<0.05), operation duration (r=0.129, p<0.01), hospitalization duration (r=0.257, p<0.01), biliary anomaly (r=0.127, p<0.01), and noanomaly (r=-0.122, p<0.01) (Table 3).

Binary logistic regression analysis showed that only the effect of operation duration on complications was significant at the multivariate level (B=0.033; p<0.01). The effects of gender, diagnosis, hospitalization duration, biliary anomaly (presence versus absence) were not statistically significant (p>0.05) (Table 4).

In the no-anomaly group, complications were significantly correlated with gender (r=-0.106, p<0.01), operation duration (r=-0.127, p<0.01), drainage (r=-0.084, p<0.05), and hospitalization duration (r=-0.233, p<0.01). In the biliary anomaly group, complications were significantly correlated with hospitalization duration (r=0.752; p<0.01) (Table 5).

The complication rate was highest in the biliary anomaly group (26.1%), followed by the vascular anomaly group (12.5%) and the no-anomaly group (Figure 1).

Among patients who developed complications, hospitalization duration was highest in the biliary anomaly group, followed by the no-anomaly and vascular anomaly groups. Among patients without complications, the hospitalization duration was highest in the biliary anomaly group, followed by the no-anomaly group (Figure 2).

ROC analysis showed that the area under the curve for operation time was 0.701, indicating that operation time has a significant predictive value of 70.1% for complications in cholecystectomy patients (Figure 3). For operation time over 29 minutes, sensitivity was 82.8% and specificity was 37.7% for complication. For operation time over 31 minutes, sensitivity was 72.4% and specificity was 59.2% for complication.

Table 1. Baseline characteristics and difference analysis results between patient groups

	Anomaly			p-value
	No-anomaly (n=894; 96.6%)	Biliary (n=23; 2.5%)	Vascular (n=8; 0.9%)	
Gender, n (%)				
Female	614 (68.7)	16 (69.6)	6 (75.0)	0.923[a]
Male	280 (31.3)	7 (30.4)	2 (25.0)	
Age	52.18±14.71 52.00 (18.00-97.00)	40.35±15.86 36.00 (18.00-68.00)	41.50±11.63 40.50 (26.00-59.00)	0.001[b]
Diagnosis, n (%)				
Acute cholecystit	133 (14.9)	5 (21.7)	-	0.501[a]
Cholelitiasis	721 (80.6)	17 (73.9)	7 (87.5)	
Polyp	28 (3.1)	1 (4.3)	1 (12.5)	
Other	12 (1.3)	-		
ERCP, n (%)				
Pre operation	36 (83.7)	2 (100.0)	-	0.710[c]
Post operation	7 (16.3)	-	-	
HT, n (%)	152 (17.0)	2 (8.7)	1 (12.5)	0.494[a]
DM, n (%)	30 (3.4)	1 (4.3)	-	0.737[a]
CAD, n (%)	78 (8.7)	3 (13.0)	-	0.380[a]
COPD, n (%)	12 (1.3)	-	-	0.662[a]
Antibiotic usage, n (%)				
Single	529 (92.5)	14 (100.0)	4 (100.0)	0.597[a]
Dual	40 (7.0)	-	-	
Mixed	3 (0.5)	-	-	
Operation duration	36.20±19.92 30.00 (10.00-180.00)	39.21±14.07 35.00 (20.00-80.00)	32.86±26.12 30.00 (15.00-90.00)	0.118[b]
Drainage, n (%)	611 (74.2)	22 (96.7)	7 (87.5)	0.016[a]
Hospitalization duration	3.09±3.10 2.00 (0.00-36.00)	5.23±4.73 3.00 (2.00-18.00)	2.75±2.06 2.50 (1.00-5.00)	0.042[b]
Complication, n (%)	50 (6.8)	6 (26.1)	1 (12.5)	0.018[a]

[a]: Chi-square test, [b]: Kruskal-Wallis test, [c]: Fisher's exact test.
HT: Hypertension, DM: Diabetes mellitus, CAD: Chronic artery disease, COPD: Chronic obstructive pulmonary disease, ERCP: Endoscopic retrograde cholangiopancreatography.

Table 2. Spearman's rho correlation between having anomaly and research parameters according to anomaly groups

	No-anomaly		Biliary		Vascular	
	r	p	r	p	r	p
Gender	0.009	0.787	-0.003	0.933	-0.013	0.702
Diagnosis	-0.002	0.956	-0.027	0.411	0.049	0.137
Operation duration	-0.030	0.392	0.060	0.086	-0.041	0.240
ERCP	0.093	0.545	-0.093	0.545		
Hospitalization duration	**-0.088***	0.034	**0.105***	0.012	-0.007	0.865

*p<0.05.
ERCP: Endoscopic retrograde cholangiopancreatography.

Table 3. Spearman's rho correlation between complication and research parameters

Complication	r	p
Gender	**0.097****	0.003
Age	0.045	0.175
Diagnosis	**-0.072***	0.029
Operation duration	**0.129****	0.000
Hospitalization duration	**0.257****	0.000
Biliary	**0.127****	0.000
Vascular	0.023	0.488
No-anomaly	**-0.122****	0.000

*p<0.05, **p<0.01.

Table 4. Binary logistic regression analysis on effect of significant correlated parameters on complication

	B	S.E.	Wald	df	p	OR	95% CI for OR	
							Lower	Upper
Gender	-0.883	0.525	2.828	1	0.093	0.413	0.148	1.158
Diagnosis			2.863	3	0.413			
Acute cholecystit	-1.233	1.226	1.012	1	0.314	0.291	0.026	3.221
Cholelitiasis	-1.501	1.180	1.620	1	0.203	0.223	0.022	2.250
Polyp	-0.082	1.542	0.003	1	0.957	0.921	0.045	18.902
Operation duration	0.033	0.007	19.323	1	0.000	1.033	1.018	1.048
Hospitalization duration	0.108	0.061	3.099	1	0.078	1.114	0.988	1.257
Biliary	-20.784	16525.532	0.000	1	0.999	0.000	0.000	.
No-anomaly	-19.297	16525.532	0.000	1	0.999	24.194	0.000	.
Constant	-1.963	1.627	1.456	1	0.228	0.140		

CI: Confidence interval, OR: Odds ratio, S.E.: Standard error.

DISCUSSION

In this study, the factors affecting complications in BA and Variations in anatomy (VA) cases complications after cholecystectomy in BA cases were analyzed. The results showed that, in BA cases, longer operation time was significantly associated with a higher risk of complications.

LC cholecystectomy is a procedure associated with lower patient mortality and morbidity and with faster recovery compared with open cholecystectomy.[20] However, in cases of anomalies such as BA and VA, patients may experience undesirable surgical outcomes or complications.[21-25] Lee et al.[21] reported that reoperation is required in cases of major biliary injury in laparoscopic approach (LA) operations, and described the relationship between biliary injury and complications. Radunovic et al.[22] reported that major BA and VA complications after LA are clinically significant and may be more likely to result in mortality than other complications. Alexander et al.[23] reported that LC soneal complications vary and that the BA parameter is important among them. Deziel et al.[24] reported in their studies that although cholecystectomy performed with LA is associated with a low complication rate, anomalies may increase this rate. Murphy et al.[25] examined the main causes of complications after LA and reported that patient-related factors were the most important cause of major complications. Kim et al.[26] evaluated hepato-biliary-pancreatic cancercancers and reported that BA diagnosis is more common after cholecystectomy. Perry et al.[27] reported that BA may be a operation delay reason for cholecystectomy timing related decisions.a reason

to delay an operation in decisions related to cholecystectomy timing. Varshney and Kapoor.[28] reported that BA surgical repair is related withrelated to cholecystectomy operationoperative parameters. Yue and Hu.[29] reported that acute BA and complications are related withassociated with cholecystectomy parameters. The conclusion from these studies is that anomalies, such as BA and VA, and patient characteristics have an important effect on complications after LA.

Although there have been studies on LA complications in the literature[21-25], there are insufficient studies correlating them with BA and VA. In this limited study, complications after LA are associated with patient characteristics and anomalies.[25] In our study, BA was significantly correlated with hospitalization duration (r=0.105). Complications were significantly correlated with gender (r=0.097), diagnosis (r=-0.072), operation duration (r=0.129), hospitalization duration (r=0.257), biliary anomaly (r=0.127), and no-anomaly (r=-0.122). The effect of operation duration on complications was significant at the multivariate level (B=0.033). According to the multivariate analysis results, the significant effect of operation duration on complications in BA cases may inform the management of the treatment process based on this variable.

Correlations between complications and gender, operation time, hospitalization duration, and the presence or absence of biliary anomaly were highly significant, whereas only a weak correlation was observed between diagnosis and complications. A weak correlation was also observed between anomaly status and hospitalization duration in the no-anomaly and biliary-anomaly groups.

Study Limitations

The most important limitation of the study is that, owing to the rarity of BA cases, there is insufficient published literature on BA complications; therefore, there are not enough studies to compare the results obtained in the study. Although complications after LA have been analyzed relatively extensively, those occurring in BA cases have been examined less frequently. Although this is a limitation of the study, it also contributes to the study's status as a pioneer in the field.

Another limitation of the study is that it is prospective; therefore, many patients are lost to follow-up. The study examines cases over a 25-year period. Because collecting and compiling patient data was less feasible in the past than it is today, significant data gaps exist, especially in patient files before 2000. This is another important limitation of the study.

Contribution of the Research to Literature and Surgical Practice

The study's most important contribution to the literature is that it examines the complications in BA and VA patients using a relational screening model and reveals the relationship between operation time and complications. In this respect, the study is designed using a relational screening model, unlike a limited number of studies with a 25-year or longer duration. This situation may provide a basis for further studies aimed at reducing the occurrence of complications in patients with BA after LC.

The contribution of the research to surgical practices is that it numerically demonstrates the relationship between operation duration and complications, and shows that when operations are prolonged for any reason, the surgeon contributes to the management of postoperative complications and recommends that these patients receive increased attention. In this respect, the research makes a positive contribution to surgical practices by addressing them in a pragmatic manner.

Table 5. Spearman's rho correlation between complication and research parameters according to anomaly groups

	No-anomaly		Biliary		Vascular	
	r	p	r	p	r	p
Gender	**-0.106****	0.001	0.037	0.865	-0.218	0.604
Age	-0.059	0.076	0.045	0.839	0.247	0.555
Diagnosis	0.063	0.058	-0.195	0.373	-0.143	0.736
Operation duration	**-0.127****	0.000	0.096	0.696		
HT	0.025	0.449	0.168	0.443	-0.143	0.736
DM	-0.032	0.337	-0.127	0.565		
CAD	-0.023	0.490	0.064	0.772		
COPD	-0.012	0.723				
Drainage	**-0.084***	0.016	-0.359	0.093	0.143	0.736
Drainage duration	-0.108	0.193				
Antibiotic	-0.070	0.095				
Hospitalization duration	**-0.233****	0.000	**0.752****	0.003		

*p<0.05, **p<0.01.
HT: Hypertension, DM: Diabetes mellitus, CAD: Chronic artery disease, COPD: Chronic obstructive pulmonary disease.

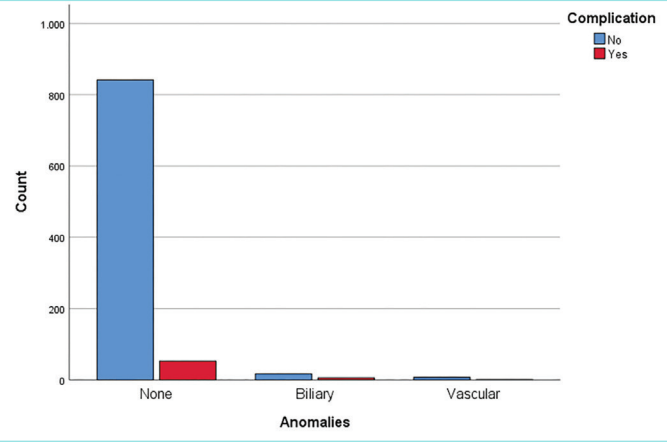

Figure 1. Complications according to anomaly groups.

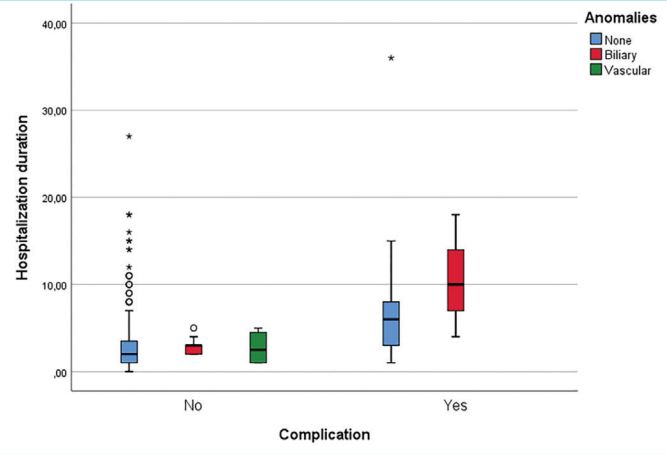

Figure 2. Hospitalization durations of anomaly groups according to complications.

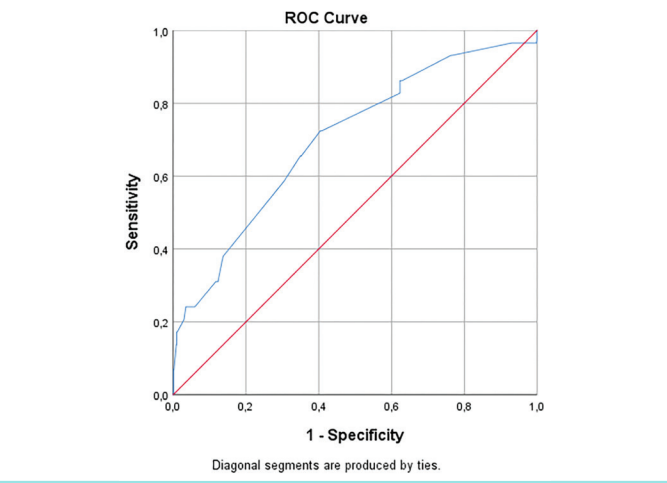

Figure 3. ROC analysis for predictive value of operation time on complication.

ROC: Receiver operating characteristic.

CONCLUSION

Prolonged operation time in cholecystectomy patients with BA is associated with a significantly higher complication rate than in the non-anomaly and VA groups. Depending on the duration of the operation, it may be possible to predict complications and take precautions. At this point, since the surgeon already tends to perform the operation as quickly and with the least-invasive procedures possible, a short operation time does not necessarily prevent complications. Complications are more commonly observed in patients undergoing prolonged operations for various reasons.

Although BA and VA are rare anomalies, they have important implications for both the health system and patients' quality of life because of postoperative complications. However, because they are rare, few studies have been conducted on them. Therefore, coordinated, multicenter studies that recruit larger patient cohorts are needed.

MAIN POINTS

- Operation time has significant predictive value for complication in cholecystectomy patients.
- Prolonged operation time in cholecystectomy patients with biliary anomalies significantly increases complications.
- Complications and take precautions in biliary anomalies may be predicted by operation time.

ETHICS

Ethics Committee Approval: Ethical approval was obtained from the Üsküdar University Non-Interventional Research Ethics Committee (approval number: 04, date: 26.05.2025).

Informed Consent: The research involved a retrospective review of medical records, patient consent forms were not obtained. Due to the retrospective nature of the study, Üsküdar University Non-Interventional Research Ethics Committee waived the need to obtain informed consent.

Footnotes

Authorship Contributions

Surgical and Medical Practices: V.M., K.E., Concept: V.M., K.E., K.Y., Design: K.E., Data Collection and/or Processing: V.M., K.E., K.Y., Analysis and/or Interpretation: K.Y., Literature Search: V.M., Writing: V.M., K.Y.

DISCLOSURES

Conflict of Interest: No conflict of interest was declared by the authors.

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