

Original Research Article

Incidence of vascular and biliary anomalies found during laparoscopic cholecystectomy and their outcomes

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ABSTRACT

Background: Laparoscopic cholecystectomy represents the preferred surgical approach for gallbladder pathology, yet remains technically challenging due to frequent anatomical variations of the hepatobiliary system. Undetected preoperatively in many cases, these anomalies substantially influence procedural difficulty and patient outcomes. This investigation systematically evaluated their incidence and clinical consequences.

Methods: This was a prospective observational study conducted at a tertiary care center from April 2023 to April 2024, enrolling 50 consecutive patients meeting inclusion criteria. Intraoperative documentation of vascular and biliary variations was performed, with subsequent analysis of operative duration, complication rates, and conversion frequencies. Statistical comparisons employed appropriate tests with significance set at $p < 0.05$.

Results: Among study participants, 26% demonstrated anatomical variations- predominantly biliary (20%) rather than vascular (6%). Specific anomalies included short cystic duct (6%), accessory bile ducts (10%), and double cystic artery (2%). Procedures involving anatomical variations required significantly extended operative times ($p = 0.047$), with 23% exceeding two hours compared to 5% in standard anatomy cases. The overall complication rate remained low (8%), including bile leaks (4%) and hemorrhage (2%), without statistically significant difference between groups ($p = 0.72$). Conversion to open procedure occurred in 6% of cases, principally due to challenging dissection (4%) or significant bleeding (2%).

Conclusions: While anatomical variations prolong operative duration during laparoscopic cholecystectomy, meticulous surgical technique maintains acceptable complication rates. These findings underscore the importance of preoperative imaging evaluation and intraoperative vigilance. Future technological advances in three-dimensional reconstruction and robotic assistance may further enhance procedural safety in complex anatomical scenarios.

Keywords: Biliary tract abnormalities, Hepatobiliary anatomy, Minimally invasive surgery, Surgical complications, Vascular variations

INTRODUCTION

Laparoscopic cholecystectomy is the current gold standard for the treatment of symptomatic gallstone disease, offering reduced postoperative pain, shorter hospital stay, and quicker recovery compared to open surgery. However, the procedure remains technically challenging due to the frequent presence of vascular and biliary anatomical variations, which may complicate

dissection and increase the risk of iatrogenic injury. The incidence of vascular and biliary anomalies has been reported in 20-30% of patients, though their prevalence varies among populations.^{1,2}

Among vascular anomalies, aberrant or multiple cystic arteries and the “caterpillar hump” of the right hepatic artery are of particular surgical relevance, with some studies reporting incidences up to 6.9%.³ Biliary

anomalies such as short cystic ducts, low insertion of the cystic duct, and accessory bile ducts also represent common challenges. Failure to recognize these variations intraoperatively may result in bile duct injury (BDI), a dreaded complication with reported rates between 0.3% and 0.8%.^{4,5}

To minimize such risks, the critical view of safety (CVS) technique and recognition of anatomical landmarks such as Rouviere's sulcus are recommended.⁶ Preoperative imaging such as MRCP may aid in identifying anomalies but is not routinely employed in all centers. Thus, intraoperative vigilance, careful dissection, and surgical training remain crucial for safe outcomes.

Aims and objectives

The aim of this study was to analyze the prevalence, types, and clinical implications of vascular and biliary anomalies encountered during laparoscopic cholecystectomy and to assess their impact on surgical outcomes.

Specifically, the objectives were: (1) to determine the frequency and spectrum of vascular and biliary anatomical variations observed during laparoscopic cholecystectomy, (2) to evaluate the impact of these anomalies on surgical outcomes such as duration of surgery, intraoperative complications, and postoperative recovery, (3) to identify the surgical challenges posed by these anomalies and describe strategies used to overcome them, and (4) to compare the present findings with existing literature in order to provide a broader perspective.

METHODS

This was a cross-sectional study conducted in the department of general surgery at Kamineni Institute of Medical Sciences, Narketpally. The study was carried out over a period of one year, from April 2023 to April 2024.

Sample Size Calculation

The sample size was calculated using the formula for a cross-sectional study estimating prevalence:

$$n = Z^2 \times p \times (1 - p) / e^2$$

where Z = 1.96 for a 95% confidence level, p = expected prevalence of anomalies (25% based on literature), and e = margin of error (5%). The calculated sample size was 288 patients. After adjustment for a finite population of 500 annual procedures, the sample size was 184. For robustness, the final sample size was rounded to 200. However, due to practical constraints, only 50 patients could be included in this study.

This reduction in sample size was due to practical constraints, including the limited number of eligible

patients presenting during the study period and strict inclusion/exclusion criteria. Consequently, the smaller sample size may affect the generalizability and statistical power of the findings. Despite this, the observed trends remain consistent with existing literature and provide a meaningful foundation for future research with larger cohorts.

Statistical tests

Data were analyzed using Chi-square or Fisher's Exact Test to compare categorical outcomes such as complication rates and conversion rates between groups with normal and anomalous anatomy. A p value of less than 0.05 was considered statistically significant. In this study, surgical duration showed a significant difference (p<0.05), whereas complication rates did not show a statistically significant difference (p=0.72).

Inclusion criteria and exclusion criteria

Patients aged between 10 and 70 years who were diagnosed with symptomatic cholelithiasis or chronic calculous cholecystitis on clinical and radiological evaluation and underwent laparoscopic cholecystectomy were included in the study. Patients with acute pancreatitis, obstructive jaundice, acute cholecystitis, empyema of the gallbladder, bleeding disorders, those who were medically unfit for surgery, or those unwilling to provide informed consent were excluded.

Procedures

All patients underwent a thorough preoperative evaluation that included medical history, physical examination, and radiological imaging to assess biliary anatomy and rule out complex conditions. Intraoperatively, vascular and biliary anomalies were identified and documented, and any surgical challenges or complications were recorded. Postoperatively, patients were monitored for complications such as bile leaks, infections, or vascular injuries, and recovery time and overall outcomes were assessed.

Parameters studied

The study focused on the types of anomalies observed, including biliary anomalies such as variations of the cystic duct and accessory bile ducts, and vascular anomalies such as double cystic arteries or Moynihan's hump. Demographic data including age and gender distribution were collected. Surgical outcomes assessed were duration of surgery, intraoperative complications, and postoperative complications.

RESULTS

Below is a table presenting data for the study on the incidence of vascular and biliary anomalies in laparoscopic cholecystectomy and their outcomes:

Table 1: Demographic distribution of patients (n=50).

Parameters	Age group (years)			Total
	10-30	31-50	51-70	
Male	5	10	5	20
Female	7	15	8	30
Total	12	25	13	50

Explanation

The study included 50 patients, with females constituting 60% of the sample. The majority of patients (50%) were aged 31-50 years, indicating that cholelithiasis is most prevalent in this age group.

Table 2: Types of anatomical variations observed.

Type of variation	N	%
No anomalies (37)		
Normal anatomy	37	74
Biliary anomalies (10)		
Short cystic duct	3	6
Low cystic duct insertion	2	4
Accessory ducts	5	10
Vascular anomalies (3)		
Double cystic artery	1	2
Moynihan's hump	1	2
Aberrant hepatic artery	1	2
Total anomalies	13	26

Explanation

Anomalies were identified in 26% of cases. Biliary anomalies were more common (20%) compared to vascular anomalies (6%).

Table 3: Surgery duration based on anatomical variations.

Surgery duration	Normal anatomy (n=37)	With anomalies (n=13)	P value
<1 hour	15	2	0.047
1-2 hours	20	8	
>2 hours	2	3	

Explanation

Cases with anomalies showed significantly longer surgery durations. The presence of anomalies required additional time for careful dissection, reflected in the increased proportion of surgeries lasting over 2 hours.

Table 4: Postoperative complications.

Complications	Normal anatomy (n=37)	With anomalies (n=13)	P value
No complications	35	11	0.72
Bile leak	1	1	
Bleeding	0	1	

Explanation

Postoperative complications were more frequent in cases with anomalies, but the overall rate of complications was low (8%). These included bile leaks and minor bleeding, manageable without significant long-term effects.

Table 5: Conversion to open surgery.

Reason for conversion	Frequency	Percentage
Difficult dissection (frozen Calot's)	2	4
Severe vascular bleeding	1	2
Total conversions	3	6

Explanation

Conversion to open surgery was necessary in 6% of cases, primarily due to challenging dissections in patients with anatomical anomalies.

Insights from data

Anatomical anomalies significantly impact surgical duration and complexity.

Despite challenges, laparoscopic cholecystectomy has a low complication rate.

Preoperative identification and intraoperative vigilance are critical for managing anomalies effectively.

DISCUSSION**Prevalence and types of anomalies**

This study identified anatomical anomalies in 26% of patients, with biliary (20%) outnumbering vascular anomalies (6%). Short cystic duct (6%) and accessory bile ducts (10%) were the most common biliary variations, while double cystic artery (2%) and Moynihan's hump (2%) dominated vascular anomalies. These findings mirror global reports, such as Sen et al, who noted a 25% anomaly rate, and Khamiso et al, who reported 24.66% biliary variations.⁷ The slightly lower vascular anomaly rate (versus 7.6% in Masroor et al) may reflect regional anatomical differences or imaging limitations.⁸

Impact on surgical outcomes**Operative duration**

Anomalies significantly prolonged surgery ($p=0.047$), with 23% of cases exceeding 2 hours (versus 5% in normal anatomy). This aligns with Wu et al, who attributed extended durations to meticulous dissection of aberrant structures.⁹

Complications

The overall complication rate was low (8%), including bile leaks (4%) and bleeding (2%). The non-significant p value (0.72) suggests that anomalies, while increasing complexity, do not inevitably raise complications when managed adeptly. This supports Strasberg's critical view of safety (CVS) protocol, which reduces bile duct injuries by 50%.

Conversion rates

Conversions to open surgery (6%) were driven by frozen Calot's triangle (4%) and vascular bleeding (2%), consistent with Majeed et al.¹⁰

Clinical implications

Preoperative imaging

Despite anomalies often being missed on ultrasound, MRCP detects 85-90% of biliary variations, as demonstrated by Sureka et al.¹¹ Routine MRCP could reduce intraoperative surprises, particularly in high-risk patients.

Intraoperative strategies

High-definition laparoscopy and near-infrared cholangiography improve anomaly identification, reducing conversion rates by 30% (Andall et al).¹² The CVS method remains paramount; its adoption correlates with a 70% decline in bile duct injuries.

Training

Simulation-based programs enhance anomaly recognition, as shown by Hasan et al, who reported a 40% reduction in dissection errors post-training.¹³

Comparison with literature

Our anomaly prevalence (26%) closely matches recent meta-analyses (e.g., 27% in Ghosh et al).¹⁴ However, vascular anomaly rates vary geographically, from 5% in Asian cohorts to 10% in European studies (Lutfi et al). The lack of significant complication differences (p=0.72) contrasts with Strickland et al, who linked anomalies to a 15% complication rate, possibly due to smaller sample size limitations here.¹⁵

Limitations of this study are:

Sample size

The study's power was limited by including only 50 patients (versus calculated 200). Larger cohorts are needed for robust subgroup analyses.

Imaging gaps

Reliance on intraoperative findings may underestimate true anomaly prevalence. Preoperative MRCP was not standardized.

Single-center design

Results may not generalize to diverse populations.

Future directions

Advanced imaging

3D reconstructions and AI-assisted MRCP could improve preoperative anomaly detection.¹⁶

Robotic assistance

Early studies show robotic cholecystectomy reduces dissection errors in anomalous anatomy by 25%.¹⁷

Multicentre registries

Collaborative databases could refine anomaly prevalence and risk stratification.¹⁸

CONCLUSION

This study reaffirmed that vascular and biliary anomalies complicate laparoscopic cholecystectomy but need not compromise safety when managed systematically. Preoperative MRCP, adherence to CVS, and enhanced training are pivotal. Despite prolonging operative time, anatomical anomalies need not increase complications if managed with preoperative imaging (e.g., MRCP) and adherence to the critical view of safety. Future integration of AI and robotics may further optimize outcomes.

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