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Research Article

Anatomical Factors Associated With Conversion from Laparoscopic To Open Cholecystectomy Surgery in Peadiatric and Adult Populations

Hazrat Amin[1], Akhtar Ghani[2], Nauman Khan[3], Dost Mohammad[4], Fatima Abbasi[5], Khalid Shehzad[6]

[1]Institutional Medical Officer, MTI - Khyber Teaching Hospital (KTH), Peshawar, Pakistan
[2]Assistant Professor, Department of General Surgery, Bannu Medical College - MTI, Bannu, Pakistan
[3]Senior Lecturer, Department of Anatomy, Rawal Institute of Health Sciences, Islamabad, Pakistan
[4]Professor and Head of Department of Anatomy, Bannu Medical College - MTI, Bannu, Pakistan
[5]Assistant Professor, Department of Surgery, Margalla Institute of Health Sciences, Rawalpindi, Pakistan
[6]Lecturer, Department of Anatomy and Histology, College of Medicine, Qassim University, Kingdom of Saudi Arabia

Corresponding Author: Akhtar Ghani
Assistant Professor, Department of General Surgery, Bannu Medical College - MTI, Bannu, Pakistan.
Email: drakhtarghani@gmaul.com
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ABSTRACT

Background: Laparoscopic cholecystectomy is the usual surgical treatment for the symptomatic gallbladder disease for both children and adults. It has some advantages over laparotomy, but in some cases, laparotomy may be necessary due to anatomical difficulty or inflammatory distortion, which makes it unsafe for laparoscopic dissection. Dense adhesions, frozen Calot's triangle, impacted Hartmann's pouch stone, gangrenous gallbladder and unclear biliary anatomy may be risk factors for conversion.

Objective: To determine the anatomical factors associated with conversion from laparoscopic to open cholecystectomy surgery in pediatric and adult populations.

Methods: This is a descriptive, cross sectional study, which was conducted in Bannu Medical college, Bannu from January 2025 to June 2025. There were 75 patients undergoing attempted laparoscopic cholecystectomy. The patients were split into two groups: pediatrics and adults. The following information was collected: demographic data, clinical history, ultrasound findings, intra-operative anatomical findings, conversion status, reasons for conversion, operating time, and postoperative outcome. Conversions, which were considered when the laparoscopic procedure had to be abandoned and performed through an open incision. The SPSS software was used for data analysis. Categorical variables were presented as frequencies and percentages and continuous variables were presented as mean and standard deviation. Where applicable, Chi-Square test or Fisher's exact test was used, and a p value<0.05 was defined as significant.

Results: Out of 75 patients, 25 (33.3%) were pediatric and 50 (66.7%) were adults. The overall conversion rate from laparoscopic to open cholecystectomy was 12.0% (9/75). Conversion was more frequent in adults 14.0% (7/50) compared with pediatric patients 8.0% (2/25), although this difference was not statistically significant. The major anatomical factors significantly associated with conversion were dense adhesions around the gallbladder, frozen Calot's triangle, difficult cystic duct identification, impacted stone at Hartmann's pouch, gangrenous gallbladder, uncontrolled bleeding, and unclear biliary anatomy. Patients who required conversion had longer operative time and hospital stay compared with those completed laparoscopically.

Conclusion: Anatomical distortion and inflammatory changes around Calot's triangle were the main factors associated with conversion from laparoscopic to open cholecystectomy. Conversion was more common among adults than pediatric patients. Early recognition of difficult anatomy, careful dissection, and timely conversion are important for preventing bile duct injury and improving patient safety.

Keywords: Laparoscopic cholecystectomy, open conversion, Calot's triangle, gallbladder anatomy, pediatric surgery, adult cholecystectomy, Hartmann's pouch stone.

INTRODUCTION

Gall bladder disease is a fairly common surgical problem in both adults and children.

Laparoscopic cholecystectomy has emerged as the preferred technique for treating symptomatic gallstones and benign gall bladder diseases due to less pain, shorter hospital stay, a faster recovery, and a better cosmetic result than open cholecystectomy. Advances in surgical technique and laparoscopy have led to a rise in the number of children undergoing cholecystectomy for symptomatic gallbladder disease, and adults are now more likely to undergo surgery [1-3].

Although many benefits exist, some patients may develop anatomical variations, inflammation, fibrosis, adhesion and/or unclear biliary anatomy that may make laparoscopy challenging. Under these circumstances, laparotomy or laparoscopy may be necessary to make the conversion to open cholecystectomy, to ensure the safety of the patient. The conversion should not be considered a complication or surgical failure, but rather a thoughtful choice by the surgeon when continuation of laparoscopy may present the risk of injury to the bile duct, vascular injury, uncontrollable bleeding or other significant complications [4-6].

During laparoscopic cholecystectomy, the anatomy of Calot's triangle is the most important. Prior to clipping and division it is essential to identify the cystic duct and the cystic artery safely. This area can be distorted however, with repeated attacks of cholecystitis, impacted stones, gangrenous changes, edema, or dense fibrosis. Anatomic factors that may make the procedure more difficult: Frozen Calot's triangle, thickened adhesions, short or narrow cystic duct, aberrant cystic artery, and biliary anatomy that is not clear. If this anatomical difficulty is not recognized, it can cause significant damage to the bile duct [7-9].

Difficult laparoscopic cholecystectomy is frequently associated with chronic inflammation, multiple episodes of cholecystitis, obesity, diabetes mellitus, contracted gallbladder, thickened gallbladder wall and impacted stones in adults. These factors can lead to thick bands of adhesion and the normal tissue planes may be lost. It is also possible for adults to present later in the disease process, causing more advanced inflammatory changes. Thus, there is a potential for an increased risk of conversion in adults than in children [10, 11].

Pediatric gall bladder disease occurs less frequently than in adults, and with the improvement in ultrasound access and the evolving clinical presentation of disease, it is more commonly diagnosed in children. The laparoscopy cholecystectomy in children is different due to its smaller size, anatomical structures and operative space. But children may experience less chronic inflammation than adults and this may decrease the incidence of dense fibrosis and adhesions. Comparing the pediatric and adult populations is important so as to get an idea of any anatomical differences between the groups.

Preoperative ultrasonography is a valuable tool in assessing characteristics which may be associated with a prediction of the difficulty in laparoscopic cholecystectomy. Thickened gallbladder wall, contracted gallbladder, distended gallbladder, pericholecystic fluid, impacted Hartmann's pouch stone and dilated common bile duct may indicate increased operative difficulty. But there are many important anatomical issues that are only discovered at the time of surgery. Factors like dense adhesions, frozen Calot's triangle, cystic duct or artery not visible, gangrenous gallbladder and uncontrolled bleeding are good indicators for possible conversion [11, 12].

Anatomical causes of conversion are important to understand both clinically to enhance surgical planning and also in counselling patients. The identification of high-risk patients prior to surgery enables better preparation, involvement of experienced surgeons and early decision-making during the surgery. This is especially significant where delayed presentation and complicated gallbladder disease is prevalent [13].

The present study was conducted to determine the anatomical factors associated with conversion from laparoscopic to open cholecystectomy surgery in pediatric and adult populations at Bannu Medical College, Bannu. The study also aimed to compare conversion rates between pediatric and adult patients and to identify the main intraoperative reasons responsible for open conversion.

METHODOLOGY

This study was conducted at Bannu Medical College, Bannu**,** to evaluate the anatomical factors associated with conversion from laparoscopic to open cholecystectomy in pediatric and adult populations. The study was designed as a descriptive cross-sectional study. A total of 75 patients who were planned for laparoscopic cholecystectomy were included. Both pediatric and adult patients were enrolled so that anatomical and operative differences between the two age groups could be assessed.

All patients diagnosed with symptomatic gallstone disease, chronic cholecystitis, recurrent biliary colic, or other benign gallbladder conditions requiring cholecystectomy were considered eligible for inclusion. Patients of both genders were included. Pediatric patients were defined as those below 18 years of age, while patients aged 18 years and above were placed in the adult group. Patients who were primarily planned for open cholecystectomy, those with confirmed gallbladder malignancy, severe uncorrected coagulopathy, generalized peritonitis, or incomplete clinical records were excluded from the study.

Before surgery, detailed clinical history and physical examination were performed for each patient. Demographic information including age, gender, and body mass index was recorded. Clinical variables such as duration of symptoms, previous attacks of cholecystitis, history of jaundice, pancreatitis, fever, vomiting, and associated comorbidities were also documented. Relevant laboratory investigations including complete blood count, liver function tests, serum bilirubin, alkaline phosphatase, and coagulation profile were performed according to routine hospital protocol.

All patients underwent preoperative abdominal ultrasonography. Ultrasound findings were recorded with special focus on gallbladder wall thickness, contracted or distended gallbladder, number of gallstones, impacted stone at Hartmann's pouch, pericholecystic fluid, and common bile duct diameter. These preoperative findings were used to identify anatomical and inflammatory features that could increase the difficulty of laparoscopic dissection.

Laparoscopic cholecystectomy was performed using the standard four-port technique under general anesthesia. The operative findings were recorded carefully during surgery. Particular attention was given to anatomical factors such as dense adhesions around the gallbladder, frozen Calot's triangle, difficult identification of the cystic duct or cystic artery, short or wide cystic duct, aberrant cystic artery, intrahepatic gallbladder, gangrenous gallbladder, impacted Hartmann's pouch stone, and unclear biliary anatomy. The decision to convert from laparoscopic to open cholecystectomy was made by the operating surgeon when safe continuation of the laparoscopic procedure was not possible.

Conversion was defined as the need to abandon the laparoscopic approach and complete the procedure through an open right subcostal or upper abdominal incision. The reasons for conversion were recorded in detail, including dense adhesions, uncontrolled bleeding, unclear anatomy, frozen Calot's triangle, suspected bile duct injury, impacted stone at Hartmann's pouch, and gangrenous gallbladder. Operative time, intraoperative complications, bile spillage, gallbladder perforation, use of drain, and surgeon-related factors were also noted.

Postoperatively, patients were followed during their hospital stay for early complications. Postoperative variables included wound infection, bile leak, postoperative pain, length of hospital stay, need for reoperation, and mortality. The outcomes were compared between patients who completed laparoscopic cholecystectomy and those who required conversion to open surgery. Pediatric and adult groups were also compared to identify differences in anatomical difficulty and conversion rate.

Data were entered and analyzed using SPSS software. Quantitative variables such as age, operative time, and hospital stay were presented as mean and standard deviation. Qualitative variables such as gender, anatomical findings, conversion status, and postoperative complications were presented as frequencies and percentages. The chi-square test or Fisher's exact test was applied to determine the association between anatomical factors and conversion from laparoscopic to open cholecystectomy. Independent sample t-test or Mann–Whitney U test was used for comparison of continuous variables where appropriate. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The total number of patients included in the study were 75 who were subjected to attempted laparoscopic cholecystectomy. Out of these, 25 (33.3%) were pediatric patients and 50 (66.7%) were adults. The average age of the researchers was 31.6 ± 15.8 years. In females 51 (68.0%) cases were reported compared to 24 (32.0%) cases in males. The overall conversion rate from laparoscopic to open cholecystectomy was 12.0%, and required 9 out of 75 patients.

Table 1. Demographic and Clinical Characteristics of Pediatric and Adult Patients

Variable	Pediatric Group N=25	Adult Group N=50	Total N=75	P-Value
Mean Age, Years	13.8 ± 3.1	40.5 ± 11.6	31.6 ± 15.8	<0.001
Male	10 (40.0%)	14 (28.0%)	24 (32.0%)	0.292
Female	15 (60.0%)	36 (72.0%)	51 (68.0%)	0.292
Previous Attack Of Cholecystitis	7 (28.0%)	24 (48.0%)	31 (41.3%)	0.096
History Of Jaundice	3 (12.0%)	12 (24.0%)	15 (20.0%)	0.221
History Of Pancreatitis	2 (8.0%)	9 (18.0%)	11 (14.7%)	0.249
Diabetes Mellitus	0 (0.0%)	11 (22.0%)	11 (14.7%)	0.012
Obesity/Raised BMI	4 (16.0%)	18 (36.0%)	22 (29.3%)	0.074

The mean age for the adult patients was significantly higher than for the pediatric patients. Diabetes mellitus was only observed in the adult group and was shown to be statistically significantly associated with age group. Both groups were female predominant, however this was not statistically significant.

Table 2. Ultrasound and Anatomical Findings among Study Patients

Anatomical Factor	Pediatric Group N=25	Adult Group N=50	Total N=75	P-Value
Thickened Gallbladder Wall	6 (24.0%)	22 (44.0%)	28 (37.3%)	0.094
Contracted Gallbladder	3 (12.0%)	14 (28.0%)	17 (22.7%)	0.120
Distended Gallbladder	5 (20.0%)	8 (16.0%)	13 (17.3%)	0.664
Multiple Gallstones	14 (56.0%)	34 (68.0%)	48 (64.0%)	0.307
Impacted Stone At Hartmann's Pouch	2 (8.0%)	11 (22.0%)	13 (17.3%)	0.132
Dilated Common Bile Duct	2 (8.0%)	8 (16.0%)	10 (13.3%)	0.342
Suspected Mirizzi Syndrome	0 (0.0%)	3 (6.0%)	3 (4.0%)	0.211

Thickened gallbladder wall, contracted gallbladder, impacted Hartmann's pouch stone and dilated common bile duct were more common than other stones among adults as compared to pediatric patients. Most differences between the two groups, however, were not statistically significant, though.

Table 3. Intraoperative Anatomical Factors Associated With Conversion

Intraoperative Factor	Completed Laparoscopically N=66	Converted To Open N=9	P-Value
Dense Adhesions Around Gallbladder	15 (22.7%)	8 (88.9%)	<0.001
Frozen Calot's Triangle	5 (7.6%)	6 (66.7%)	<0.001
Difficult Identification Of Cystic Duct	7 (10.6%)	6 (66.7%)	<0.001
Aberrant Cystic Artery	3 (4.5%)	2 (22.2%)	0.047
Short Or Wide Cystic Duct	6 (9.1%)	3 (33.3%)	0.041
Impacted Hartmann's Pouch Stone	7 (10.6%)	6 (66.7%)	<0.001
Gangrenous Gallbladder	3 (4.5%)	3 (33.3%)	0.004
Uncontrolled Bleeding	2 (3.0%)	3 (33.3%)	0.002
Unclear Biliary Anatomy	6 (9.1%)	7 (77.8%)	<0.001

Dense adhesions, frozen Calot's triangle, difficult identification of the cystic duct, impacted Hartmann pouch stone, gangrenous gall bladder, uncontrolled bleeding and uncertain biliary anatomy were highly correlated with the conversion. These results indicate that the most important factors were the inflammatory changes around Calot's triangle and the distorted biliary anatomy that led to the open conversion.

Table 4. Conversion Rate in Pediatric and Adult Patients

Age Group	Completed Laparoscopically	Converted To Open	Total	Conversion Rate	P-Value
Pediatric	23 (92.0%)	2 (8.0%)	25	8.0%	0.418
Adult	43 (86.0%)	7 (14.0%)	50	14.0%	
Total	66 (88.0%)	9 (12.0%)	75	12.0%	

It was more likely to be converted in adults than in children/pediatric patients, but the difference was not significant. The higher conversion rate among adults could be related to a higher rate of inflammatory and anatomical difficulty.

Table 5. Reasons for Conversion from Laparoscopic To Open Cholecystectomy

Reason For Conversion	Frequency N=9	Percentage
Dense Adhesions With Unclear Anatomy	3	33.3%
Frozen Calot's Triangle	2	22.2%
Impacted Stone At Hartmann's Pouch	2	22.2%
Uncontrolled Bleeding	1	11.1%
Gangrenous Gallbladder	1	11.1%

Frozen Calot's triangle and impacted stone at Hartmann's pouch were the next most common causes of conversion, with dense adhesions with unclear anatomy being the most common cause.

Table 6. Operative and Postoperative Outcomes

Outcome	Completed Laparoscopically N=66	Converted To Open N=9	P-Value
Mean Operative Time, Minutes	58.4 ± 14.7	96.8 ± 21.5	<0.001
Mean Hospital Stay, Days	2.1 ± 0.8	4.6 ± 1.3	<0.001
Bile Spillage	9 (13.6%)	4 (44.4%)	0.021
Wound Infection	2 (3.0%)	2 (22.2%)	0.017
Bile Leak	1 (1.5%)	1 (11.1%)	0.074
Reoperation	0 (0.0%)	0 (0.0%)	—
Mortality	0 (0.0%)	0 (0.0%)	—

Patients who required conversion had significantly longer operative time and hospital stay. Bile spillage and wound infection were also more frequent in the converted group. No mortality was reported in the study population.

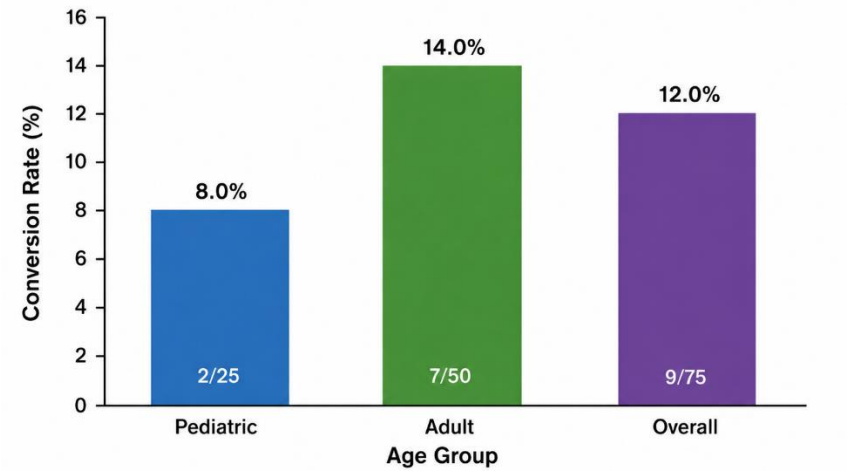

Figure 1. Conversion Rate from Laparoscopic To Open Cholecystectomy in Pediatric and Adult Patients.

Bar chart showing the conversion rate from laparoscopic to open cholecystectomy among pediatric and adult patients. The conversion rate was 8.0% (2/25) in pediatric patients and

14.0% (7/50) in adult patients, with an overall conversion rate of 12.0% (9/75). The figure demonstrates a higher rate of conversion in adults compared with pediatric patients.

DISCUSSION

Laparoscopic cholecystectomy is considered the preferred surgical approach for benign gallbladder disease because it is associated with less postoperative pain, shorter hospital stay, early mobilization, and better cosmetic results compared with open surgery. However, conversion to open cholecystectomy may still be required when anatomical distortion or operative difficulty makes safe laparoscopic dissection impossible. In the present study, involving 75 pediatric and adult patients, the overall conversion rate was 12.0%. Conversion was more frequent among adults 14.0% compared with pediatric patients 8.0%, although the difference was not statistically significant. This finding suggests that adult patients may have more advanced inflammatory changes and complex gallbladder anatomy, while pediatric cases may present with comparatively less chronic fibrosis and adhesions [14, 15].

The dense gall bladder adhesions, frozen Calot's triangle, unclear biliary anatomy, difficulty in recognising the cystic duct, impaction of stone at Hartmann's pouch, gangrenous gall bladder and uncontrolled bleeding were the most important anatomic determinants of conversion in this study. The results underscore that the inability to convert does not imply failure of laparoscopic surgery but rather a safety decision made to avoid major complications like injury to the bile duct, vascular injuries, and uncontrolled hemorrhage. Distorted Calot's triangle and dense adhesion makes the safe identification of the cystic duct and cystic artery difficult. In cases where it is not possible to reach the critical view of safety, conversion to open surgery is a protective surgical decision [16, 17].

Dense adhesions were found in 88.9% of converted cases versus 22.7% of the laparoscopically completed cases, which was highly significant as associated with conversion. Frozen Calot's triangle and lack of discernible biliary anatomy, in turn, were also highly correlated with open conversion. Clinically, these findings are significant since Calot's triangle is the crucial area of surgery during laparoscopy for cholecystectomy. Any inflammatory change, fibrosis, edema, or scarring in this area can disguise some of the important structures, and lead to confusion. Therefore adequate preoperative evaluation and prompt intraoperative identification of challenging anatomy is critical to decision making in a safe manner [18].

Another important factor associated with conversion was impacted stone at Hartmann's pouch. It was found in 66.7% of the cases converted with respect to 10.6% of the laparoscopically completed cases in this study. Local inflammation, compression of the cystic duct, problems in grasping the gall bladder, and distortion of Calot's triangle are possible due to an impacted stone. These changes make the surgery more difficult, and could even emulate or exacerbate the condition of Mirizzi. Likewise, converted cases were more likely to have gangrenous gallbladder. The gallbladder is friable and difficult to manipulate due to gangrenous changes, leading to the risk of perforation, bile spillage, bleeding and tissue planes being hard to determine [19].

The comparison of the frequency in the pediatric and adult patients revealed that in adults the frequency of thickened gall bladder wall, contracted gall bladder, impacted Hartmann's pouch stone and dilated CBD was higher. While most of these differences weren't significant, they might account for the higher conversion rate among the adults. Adult patients are more likely to have recurrent attacks of cholecystitis, delayed presentation, obesity, diabetes, and chronic inflammatory changes. Pediatric patients, however, may lack more chronic inflammatory changes, but may experience technical difficulty due to smaller anatomic structures and a smaller operative space [20].

Conversion also had a negative impact on operative and postoperative results. Patients needing conversion were significantly older, and had a longer hospital stay and operative time. In converted cases, the mean time to complete the operation was 96.8 ± 21.5 minutes, compared with 58.4 ± 14.7 minutes for those who were completed laparoscopically. Likewise, the converted group had a longer hospital stay. In addition, converted patients had a higher frequency of bile spillage and wound infection. The results suggest that conversion is linked to greater surgical burden and post-op morbidity, primarily due to the more severe inflammation and challenging anatomy of the converted cases [21].

The results of this study highlight the need for the correct patient selection, detailed preoperative ultrasonography, and careful

intraoperative evaluation. Thickened gallbladder wall, contracted gallbladder, impacted Hartmann pouch stone, dilated common bile duct and previous attacks of cholecystitis should call the surgeon's attention to possible difficulties. In these instances, it is advisable to have it done by a surgeon who has extensive experience in the procedure or supervised by him. Safe use of surgical principles, such as adequate exposure, gentle dissection, identification of the critical view of safety, and timely decision for conversion, will minimize the risk of complications.

This study has a few limitations. It was performed in one centre and had a relatively small number of patients (75), which could restrict the generalizability of the results. The number of children was fewer than adults and long-term outcomes after surgery were not evaluated. Some anatomical findings were based on how the surgery was conducted and may vary from surgeon to surgeon. The limitations of this study notwithstanding, it can offer some local evidence on the anatomical reasons that laparoscopic to open cholecystectomy conversion occurs in both pediatric and adult patients.

CONCLUSION

This study concluded that conversion from laparoscopic to open cholecystectomy was required in 12.0% of patients. The conversion rate was higher in adults than in pediatric patients, although the difference was not statistically significant. The main anatomical factors associated with conversion were dense adhesions, frozen Calot's triangle, unclear biliary anatomy, difficult cystic duct identification, impacted stone at Hartmann's pouch, gangrenous gallbladder, and uncontrolled bleeding. These findings show that anatomical distortion and inflammatory changes around Calot's triangle are the major causes of conversion.

Conversion should not be considered a surgical failure; rather, it is a safe and appropriate decision when laparoscopic continuation may increase the risk of bile duct injury or vascular complications. Careful preoperative evaluation, recognition of high-risk anatomical findings, surgeon experience, and timely conversion can improve patient safety and surgical outcomes. Further multicenter studies with larger pediatric and adult samples are recommended to better define predictors of conversion and develop risk assessment tools for difficult laparoscopic cholecystectomy.

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