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Optimal Timing of Cholecystectomy in Pediatric Acute Biliary Pancreatitis: A Prospective Comparative Analysis of Early Versus Deferred Surgical Intervention

Hassan Khalil Melek *
Department of Surgery, College of Medicine, Wasit University, Wasit, Iraq

التوقيت الأمثل لاستئصال المرارة في التهاب البنكرياس الصفراوي الحاد لدى الأطفال: تحليل مقارن مستقبلي للتدخل الجراحي المبكر مقابل المؤجل

حسن خليل ملك
قسم الجراحة، كلية الطب، جامعة واسط، واسط، العراق

*Corresponding author: hassan.melek@uowasit.edu.iq

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Abstract:

Background: Acute biliary pancreatitis (ABP) is a clinically important and rising disease in the pediatric and adolescent age group, especially in low- and middle-income countries experiencing epidemiological changes in biliary disease. The most common etiological mechanism is cholelithiasis-mediated pancreatic ductal obstruction. Although the use of international guidelines in promoting early definitive surgical intervention has been a constant agenda, in resource constrained systems like the public health infrastructure in Iraq, application has remained patchy because of multifactorial structural and logistical impediments.

Purpose: To determine the difference in the 90-day pancreatitis recurrence and cumulative healthcare resource use between pediatric patients (aged 6–18 years) with mild-to-moderate ABP who underwent early cholecystectomy (≤72 hours of diagnosis) and those with deferred surgery (>6 weeks post-discharge).

Methods: It was a prospective observational cohort study carried out at Al-Zahra Teaching Hospital, Wasit, Iraq (January 2021 September 2024). Patients meeting the Revised Atlanta Classification criteria of mild-to-moderate ABP were divided into an early cohort (Group E: n = 58) or a deferred cohort (Group D: n = 54). The most important endpoint was 90-day recurrent pancreatitis; others were cumulative inpatient days, 30-day readmission, postoperative complication per Clavien-Dindo grading, and systematic characterization of delay determinants.

Results Recurrent pancreatitis was found in 3.4% of Group E and 24.1% of Group D ($p < 0.001$), with an absolute risk reduction of 20.7 percentage points and a number-needed-to-treat of five. Although the initial picture showed a slightly prolonged stay in Group E (4.2 vs. 3.1 days; $p = 0.012$), the total inpatient burden at 90 days was significantly less (5.3 vs. 8.9 days; $p < 0.001$). The profiles of perioperative complications were similar (1.7% vs. 3.7%; $p = 0.59$). Multivariable analysis established that early cholecystectomy is an independent protective

factor (aOR = 0.11; 95% CI: 0.02-0.54; p =0.007). Health system-level factors accounted for 74% of all procedural delays.
Conclusion: The early cholecystectomy within 72 hours of ABP diagnosis offers significant clinical and economic advantages in children in the Iraqi tertiary public hospital without increasing perioperative complication risk. To scale this approach, it is necessary to have targeted structural reforms in the health system, which is in keeping with Sustainable Development Goal 3.

Keywords: Acute Biliary Pancreatitis; Cholecystectomy Timing; Pediatric Surgery; Recurrent Pancreatitis; Healthcare Utilization; Surgical Access; Iraq; Health System Barriers; Laparoscopic Cholecystectomy; SDG 3.

الملخص

الخلفية :يُعد التهاب البنكرياس الصفراوي الحاد (ABP) مرضاً مهماً سريرياً وفي تزايد مستمر بين فئتي الأطفال والمراهقين، لا سيما في البلدان ذات الدخل المنخفض والمتوسط التي تشهد تغيرات وبائية في أمراض القنوات الصفراوية. وتتمثل الآلية المسببة الأكثر شيوعاً في انسداد القناة البنكرياسية الناتج عن حصى المرارة. ورغم أن استخدام الخطوط التوجيهية الدولية لتعزيز التدخل الجراحي الحاسم والمبكر يمثل أجندة ثابتة، إلا أن التطبيق في الأنظمة محدودة الموارد (مثل بنية الصحة العامة التحتية في العراق) لا يزال مجزأً بسبب معوقات هيكلية ولوجستية متعددة العوامل. **الغرض من الدراسة :**تحديد الفرق في معدل تكرار التهاب البنكرياس خلال 90 يوماً، والاستخدام التراكمي لموارد الرعاية الصحية بين المرضى الأطفال (تتراوح أعمارهم بين 6-18 عاماً) المصابين بالتهاب البنكرياس الصفراوي الحاد البسيط إلى المتوسط، والذين خضعوا لعملية استئصال المرارة المبكر (≥72 ساعة من التشخيص) مقابل أولئك الذين خضعوا لجراحة مؤجلة (>6أسابيع بعد الخروج من المستشفى). **المنهجية :**دراسة أتراب (Cohort) رصدية استباقية أُجريت في مستشفى الزهراء التعليمي بمحافظة واسط، العراق (من يناير 2021 إلى سبتمبر 2024). تم تقسيم المرضى المستوفين لمعايير "تصنيف أتلانتا المعدل" لالتهاب البنكرياس الحاد البسيط إلى المتوسط إلى مجموعتين: مجموعة التدخل المبكر (المجموعة :E عدد = 58) ومجموعة التدخل المؤجل (المجموعة :D عدد = 54). كانت النقطة النهائية الأهم هي تكرار التهاب البنكرياس في غضون 90 يوماً؛ وشملت النقاط الأخرى إجمالي أيام التنويم في المستشفى، وإعادة الإدخال خلال 30 يوماً، والمضاعفات الجراحية وفقاً لـ "تصنيف كلافين-ديندو"، والتوصيف المنهجي لمحددات التأخير. **النتائج: تكرار الإصابة :**وُجد تكرار لالتهاب البنكرياس بنسبة 3.4%في المجموعة المبكرة مقابل 24.1%في المجموعة المؤجلة($p < 0.001$) ، مع انخفاض في المخاطر المطلقة قدره 20.7 نقطة مئوية، وبلغ "العدد المطلوب علاجه (NNT) "خمسة مرضى فقط. **مدة الإقامة :**رغم أن النتائج الأولية أظهرت إقامة أطول قليلاً في المجموعة المبكرة 4.2) مقابل 3.1 يوم؛($p = 0.012$ ، إلا أن العبء الإجمالي للتنويم عند 90 يوماً كان أقل بكثير 5.3) مقابل 8.9 يوم؛.($p < 0.001$ **المضاعفات :**كانت ملفات المضاعفات الجراحية متشابهة بين المجموعتين (1.7%مقابل 3.7%؛$p = 0.59$) **التحليل المتعدد :**أثبت التحليل متعدد المتغيرات أن استئصال المرارة المبكر عامل حماية مستقل.(aOR = 0.11) **أسباب التأخير :**شكلت العوامل المتعلقة بالنظام الصحي 74%من جميع حالات تأخير العمليات الجراحية.
الاستنتاج :يوفر استئصال المرارة المبكر خلال 72 ساعة من تشخيص التهاب البنكرياس الصفراوي الحاد مزايا سريرية واقتصادية كبيرة للأطفال في المستشفيات الحكومية العراقية، دون زيادة خطر حدوث مضاعفات جراحية. ولتعميم هذا النهج، من الضروري إجراء إصلاحات هيكلية مستهدفة في النظام الصحي، بما يتماشى مع الهدف الثالث من أهداف التنمية المستدامة.

الكلمات المفتاحية: التهاب البنكرياس الصفراوي الحاد؛ توقيت استئصال المرارة؛ جراحة الأطفال؛ التهاب البنكرياس المرتجع؛ استغلال موارد الرعاية الصحية؛ الوصول إلى الخدمات الجراحية؛ العراق؛ عوائق النظام الصحي؛ استئصال المرارة بالمنظار؛ الهدف الثالث من أهداف التنمية المستدامة (SDG 3).

Introduction

ABP is a clinically significant and increasingly studied inflammatory disease of the pancreas in the pediatric and adolescent population. Traditionally theorized as an adult-dominated condition, ABP has experienced an interesting epidemiological transition during the last 20 years, with the accumulating data of multinational registries indicating a significant increase in incidence in all age groups of the pediatric age category, especially in low- and middle-income nations undergoing changes in nutritional habits and biliary diseases rates [1, 2]. The INSPPIRE (International Study Group of Pediatric Pancreatitis: In search of a cure) consortium has presented historic population-based information validating that the etiologies of gallstones contribute disproportionately to the overall burden of pediatric acute pancreatitis in resource-strained settings, and biliary causes have been found in an estimated 15–25 percent of all cases of disease presenting to tertiary referral centers.

In contrast to non-biliary etiologies of pediatric acute pancreatitis that have rather mild recurrence risks after cessation of the acute episode, ABP is defined by a significantly higher risk of relapse in the absence of complete control of biliary source. Recurrence rates among patients who do not receive timely cholecystectomy are consistently reported in population-based and registry data, exceeding 30% within 90 days of the index episode, and some cohorts have reported up to 50 percent recurrence rates at one year [2, 4]. Every recurrent episode has cumulative risk of complications, including development of chronic pancreatitis, exocrine insufficiency, endocrine dysfunction, and increased rate of progression of the biliary disease, which increases the morbidity of individuals and overall burden to the healthcare system [5].

Following this evidence, international clinical practice guidelines such as those developed by the International Association of Pancreatology and the American Pancreatic Association (IAP/APA), those issued by the European Society of Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the European Pancreatic Club [6] all recommend cholecystectomy during the first hospital admission of patients with mild-to-moderate ABP [5, 6]. Level I evidence from randomized controlled trials demonstrates substantial reductions in recurrent biliary events, secondary complications including cholangitis and gallstone ileus, and cumulative direct healthcare costs — supporting an operative window within 72 hours of diagnosis following biochemical stabilization and confirmation of common bile duct patency [5, 7]. Meta-analyses of early versus interval cholecystectomy further support the superiority of same-admission surgery for recurrence prevention and total hospitalization burden, without increasing perioperative risk [12, 13].

Although this international evidence base is strong, compliance with the timely surgical intervention in the Iraqi and other similar resource-constrained hospitals is still not optimal. A combination of structural and functional obstacles such as chronically overutilized operating theatres with limited weekend accessibility, fragmented primary-to-secondary care referral systems, inadequate availability of dedicated pediatric surgical groups, limited institutional financial resources, and suboptimal caregiver health literacy all contribute to procedural deferral, often taking more than six weeks after the index episode [3]. These obstacles have been put in a systematic form of documentation in regional reports of surgical care accessibility in central Iraq wherein delays in final biliary intervention are frequent and can mainly be ascribed to systemic breakdowns instead of patient or family issues [3, 10]. More importantly, the clinical and economic downstream outcomes of such delays re-hospitalization, increased resource use, and needless family psychosocial cost are only poorly measured in the present regional setting because there is a severe lack of locally generated prospective data.

The current study aimed to fill this evidence gap via a prospective cohort study at Al-Zahra teaching hospital in Wasit, Iraq comparing clinical, economic, and health system level outcomes in pediatric patients with ABP who underwent laparoscopic cholecystectomy at early

timepoints (≤72 hours) and deferred timepoints (>6 weeks). We theorized that early surgery would result in a significant and clinically meaningful decrease in 90-day pancreatitis recurrence and cumulative inpatient resource burden, without an unreasonable increase in perioperative risk, and that the structural shortcomings of the system most likely to result in surgical delay would be amenable to institutional change. In addition to its main clinical aims, this research aims to produce practical regional evidence to inform policy changes and align pediatric biliary surgical care provision with Sustainable Development Goal 3 (SDG 3: Good Health and Well-being).

2. Materials and Methods

2.1 Study Design and Setting

This study was carried out as a prospective observational cohort study at the Al-Zahra Teaching Hospital a 300-bed, state-funded tertiary referral hospital in Wasit Governorate, central Iraq, acting as the main surgical referral hospital to the wider western region. The timeframe of the study was between January 2021 and September 2024. The methodological transparency was maintained by the use of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting framework [15]. The Institutional Review Board of Wasit University, College of Medicine gave institutional ethical approval (Reference No.: WU/CM/2021/07). Informed consent was taken in written form by the parent or legal guardian of all the participants before the enrolment process and verbal consent was also obtained by patients above the age of 12 years as per national research ethics laws.

2.2 Eligibility Criteria

Potential participants were determined by means of systematic prospective screening of all inpatient pediatric surgical admissions daily. The diagnostic criteria of ABP were determined with the Revised Atlanta Classification (2012) [4], which states that to be diagnosed with it, a person must satisfy at least two out of the following three conditions: (i) acute epigastric or periumbilical pain typical of pancreatitis; (ii) a serum amylase or lipase level over three times the upper range of normal; (iii) compatible cross-sectional imaging findings consistent with acute pancreatitis on computed tomography or magnetic resonance imaging [4]. Inclusion criteria also required that enrolled patients: were aged between 6 and 18 years; had ultrasonographic evidence of cholelithiasis and/or biliary sludge on transabdominal examination within 24 hours of admission; and met predefined surgical stability criteria at the time of operative assessment, defined as absence of systemic organ dysfunction, hemodynamic stability, and tolerance of oral intake.

The patients were not included in the study when they presented with severe pancreatitis complicated with persistent organ failure lasting more than 48 hours; had radiological or biochemical evidence of choledocholithiasis that required endoscopic retrograde cholangiopancreatography (ERCP) before surgical planning; had a history of a prior cholecystectomy or biliary tract surgery; or had a co-occurring medical condition contraindicating general anaesthesia or laparoscopic surgery (e.g., uncorrected coagulopathy or severe cardiorespiratory comorbidity).

2.3 Intervention Allocation and Surgical Protocol

This study had a pragmatic and observational design; therefore, participants were not randomly allocated to intervention groups. The cohort assignment was a product of the institutional scheduling capacity and as a result of consensus between the pediatric surgery and pediatric gastroenterology teams during daily multidisciplinary ward rounds. Group E (early intervention) included patients who had laparoscopic cholecystectomy within 72 hours of the onset of symptoms or the diagnosis of ABP, and met the surgical stability requirements. Group D (deferred intervention) was a group of patients that were conservatively treated at the index admission, who had an elective cholecystectomy scheduled over six weeks after discharge of

the hospital, reflecting current local practice constraints related to operating room scheduling and referral pathway inefficiencies. All procedures were performed using a standardized four-port laparoscopic technique under the direct observation of board-certified pediatric surgeons, and selective intraoperative cholangiography was used when common bile duct anatomy was uncertain. In both groups, no conversions to open cholecystectomy were required.

2.4 Outcome Measures

The main outcome of the study was 90-day recurrent acute pancreatitis, which consists of a new clinically distinct episode meeting the Revised Atlanta Classification criteria [4], which was verified by laboratory and/or imaging results of the time. Secondary outcomes included: total 90-day inpatient days; 30-day all-cause readmission rate; incidence of postoperative complication(s) by the Clavien-Dindo classification (Grades I-V) [14]; time-to-surgery; structured prospective categorization of procedural delay determinants into health-system factors (operating room unavailability, absence of on-call pediatric surgical coverage, and delayed primary care referral) and patient/caregiver factors (refusal of recommended surgery, financial or transportation barriers, and missed follow-up appointments). Institutional tariff schedules were applied to estimate direct 90-day healthcare costs per patient. Follow-up was conducted via clinic assessments at two- and six-weeks post-discharge and telephone interviews at 30 and 90 days.

2.5 Statistical Analysis

The data were all inputted into a secure REDCap electronic database and analyzed in IBM SPSS Statistics (version 28.0). Categorical variables are presented in frequencies and percentage and compared with the help of the Pearson chi-square test or Fisher exact test. Continuous variables were evaluated in terms of normality using the Shapiro-Wilk test; normally distributed data are presented as mean ± standard deviation (SD) and compared with independent samples t-tests, whereas non-normally distributed data are presented as median and interquartile range (IQR) and are compared using the Mann-Whitney U test. Multivariate binary logistic regression was done to determine independent predictors of 90-day recurrence and the covariates of age, sex, ultrasound morphology, and admission CRP were included. The Hosmer-Lemeshow goodness-of-fit statistic was used to determine model calibration. Statistical significance was defined as a two-tailed p-value < 0.05. Post-hoc power analysis confirmed power >90% ($\alpha = 0.05$) to reject a relative reduction in recurrence of 20%.

3. Results

3.1 Participant Characteristics and Baseline Comparability

Over the study period, 112 pediatric patients fulfilling all eligibility criteria for mild-to-moderate ABP were prospectively enrolled: 58 in Group E and 54 in Group D. Baseline demographic and clinical characteristics, presented in Table 1, demonstrated satisfactory comparability across both cohorts. Mean age was 13.6 ± 2.7 years in Group E versus 13.2 ± 3.0 years in Group D ($p = 0.43$). The proportion of female participants was 62.1% and 59.3%, respectively ($p = 0.75$). No statistically significant intergroup differences were identified in body mass index, ultrasound morphology, or admission serum CRP and amylase concentrations confirming the internal validity of the subsequent outcome comparisons.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (N = 112)

Variable	Group E (n = 58)	Group D (n = 54)	p-value
Age (years, mean ± SD)	13.6 ± 2.7	13.2 ± 3.0	0.43
Female sex, n (%)	36 (62.1%)	32 (59.3%)	0.75
BMI (kg/m², mean ± SD)	21.4 ± 3.1	20.9 ± 3.3	0.39
Gallstones on ultrasound, n (%)	49 (84.5%)	45 (83.3%)	0.87
Biliary sludge only, n (%)	9 (15.5%)	9 (16.7%)	0.87

CRP on admission (mg/L, mean ± SD)	98 ± 24	102 ± 28	0.38
Serum amylase (U/L, mean ± SD)	420 ± 95	435 ± 102	0.36

Note. BMI = Body Mass Index; CRP = C-reactive protein; SD = standard deviation. Group E: cholecystectomy ≤72 hours from symptom onset; Group D: elective cholecystectomy >6 weeks post-discharge.

3.2 Primary Outcome: Incidence of 90-Day Recurrent Pancreatitis

The principal study endpoint - 90-day recurrent acute pancreatitis - was substantially less frequent in the early intervention cohort. As detailed in Table 2, recurrence occurred in only 2 patients (3.4%) in Group E, compared with 13 patients (24.1%) in Group D ($p < 0.001$). This corresponds to an absolute risk reduction of 20.7 percentage points and a number-needed-to-treat (NNT) of five to prevent one recurrent episode through early rather than deferred surgical management. The magnitude of this benefit is consistent with findings from analogous investigations in higher-income settings [5, 11, 13] and underscores the biological rationale for timely biliary source control in preventing relapsing disease [2, 4].

3.3 Secondary Outcomes: Healthcare Resource Utilization and Perioperative Safety

Table 2 gives a comprehensive overview of the predominant clinical outcomes, both primary and secondary. Although the primary hospitalization length was also somewhat increased in Group E (4.2 ± 1.1 days compared with 3.1 ± 0.9 days; $p = 0.012$) due to the extra operative preparation and procedure integrated with the primary index admission this initial difference was offset by significantly lower subsequent healthcare utilization. The aggregate 90-day inpatient burden was significantly lower in Group E (5.3 ± 1.4 versus 8.9 ± 3.6 days; $p < 0.001$). Group E had a 30-day all-cause readmission rate of 5.2% compared with 27.8% in Group D ($p = 0.001$) and unplanned 90-day emergency department attendances were also lower (3.4% compared with 20.4%; $p = 0.003$). Direct 90-day healthcare costs were estimated to be USD 420 in Group E, versus USD 585 in Group D, which is a 28% per-patient cost difference whose implications have significant consequences on resource allocation in hospital settings in the public sector, where inpatient capacity is regularly overstretched.

Table 2: Primary and Secondary Clinical Outcomes Stratified by Cholecystectomy Timing

Outcome Measure	Group E (n = 58)	Group D (n = 54)	p-value
Recurrent pancreatitis at 90 days, n (%)	2 (3.4%)	13 (24.1%)	<0.001
Initial length of stay (days, mean ± SD)	4.2 ± 1.1	3.1 ± 0.9	0.012
Total hospital days, 90-day (mean ± SD)	5.3 ± 1.4	8.9 ± 3.6	<0.001
30-day all-cause readmission, n (%)	3 (5.2%)	15 (27.8%)	<0.001
Postoperative complication (Clavien-Dindo ≥II), n (%)	1 (1.7%)	2 (3.7%)	0.59
Unplanned ER visits, 90-day, n (%)	2 (3.4%)	11 (20.4%)	0.003
Estimated direct healthcare cost, 90-day (USD)	$420	$585	

Note. SD = standard deviation; ER = emergency room. p-values derived from chi-square test (categorical) or independent t-test (continuous). "—" denotes descriptive comparison only.

Regarding perioperative safety, complication profiles were comparable between cohorts. Postoperative complications of Clavien-Dindo grade II or higher were observed in 1.7% of

Group E and 3.7% of Group D patients (p = 0.59). No patient required reoperation within 30 days, and no laparoscopic-to-open conversion was recorded in either group. The safety equivalence of early versus interval cholecystectomy demonstrated here aligns with findings from systematic reviews and meta-analyses in adult and pediatric biliary surgery literature [12, 13].

3.4 Determinants of Surgical Delay in the Deferred Cohort

All delay determinants were categorized prospectively in a structured checklist in order to describe the structural and patient-level factors underlying procedural deferrals in Group D. Table 3, which presents the results, shows that health system-related barriers are far more prevalent than patient-based ones a finding also indicative of analyses of surgical access limitations in central Iraq on a regional basis. Precisely, 74% of system level delays were in total operating room unavailability (40.7), no on-call pediatric surgical cover (22.2), and delayed primary care referral (11.1). At the patient level and caregiver level, only 26 percent of delays that included refusal of recommended procedure (14.8 percent), financial and transportation barriers (7.4 percent), and missed follow-up appointments (3.7 percent) were explained. The key implication of this distribution is that surgical delay is not a patient compliance failure but a system failure, and policy reform design cannot be done independently of this idea.

Table 3: Structured Classification of Procedural Delay Determinants in the Deferred Cohort (Group D, n = 54)

Category	Subcategory	n (%)
System-level (74%)	Operating room unavailability	22 (40.7%)
	Absence of on-call pediatric surgeon	12 (22.2%)
	Delayed referral from primary care	6 (11.1%)
Patient-level (26%)	Caregiver declined surgery	8 (14.8%)
	Financial or transportation barriers	4 (7.4%)
	Missed scheduled follow-up	2 (3.7%)
Total		54 (100%)

Note. Classification performed prospectively using a predesigned structured checklist, distinguishing system-level from patient/caregiver-level delay determinants.

3.5 Multivariable Regression Analysis

To determine if the protective effect of early cholecystectomy against 90-day recurrence was independent of the possible confounders, a multivariate binary logistic regression analysis was developed that included the covariates of patient age, biological sex, and gallstone size [Note: Methods section 2.5 originally listed CRP among covariates; the final model used gallstone size — authors should harmonize Methods with Table 4]. The final model outcome is shown in Table 4. Early cholecystectomy was a statistically significant and clinically significant independent protective factor against recurrent pancreatitis after adjustment to all the specified confounders (aOR = 0.11; 95% CI: 0.02 -0.54; p = 0.007) confirming that the odds of recurrent pancreatitis were reduced nearly ninefold with early cholecystectomy compared with deferred management (aOR = 0.11; 95% CI: 0.02–0.54; p = 0.007). Gallstones ≥5 mm showed a non-significant trend toward increased recurrence risk (aOR = 2.3; 95% CI: 0.8–6.6; p = 0.12), suggesting a potential high-risk subgroup warranting prioritized surgical scheduling. This finding aligns with prior studies linking larger calculi to greater biliary obstruction and

recurrent ductal impaction [7]. The model demonstrated satisfactory calibration (Hosmer-Lemeshow: p = 0.67).

Table 4: Multivariable Logistic Regression Analysis for 90-Day Recurrent Pancreatitis

Variable	Adjusted OR	95% CI	p-value
Early cholecystectomy (reference: deferred)	0.11	0.02 – 0.54	0.007
Age > 12 years (reference: ≤12 years)	1.4	0.5 – 3.9	0.53
Female sex (reference: male)	0.9	0.3 – 2.7	0.82
Gallstone size ≥5 mm (reference: <5 mm)	2.3	0.8 – 6.6	0.12

Note. OR = odds ratio; CI = confidence interval. Model adjusted for age, sex, and gallstone size. Hosmer-Lemeshow goodness-of-fit: $\chi^2 = 4.21$, $p = 0.67$.

3.6 Operative Performance and Postoperative Recovery Indicators

Table 5 shows a detailed comparison of the operative and postoperative performance measures of the surgical activity. There were no statistically significant intergroup differences observed in any of the operative parameters. Group E (median) had an operative duration of 48 +/- 9 minutes compared to Group D (45 +/- 11 minutes) (p = 0.31). In Group D (1.9%), one minor intraoperative bile leak was treated with conservative intraoperative management, no reoperation. Postoperative hospital stay was virtually identical (1.8 ± 0.6 versus 1.7 ± 0.5 days; p = 0.42). Both groups used the laparoscopic procedure in 100% cases and no 30-day reoperations, no open conversions. These data confirm the technical safety and feasibility of early cholecystectomy in a resource-constrained public hospital setup in line with those of other similar laparoscopic series in lower-middle-income country settings.

Table 5: Operative and Postoperative Surgical Performance Indicators by Cohort

Variable	Group E (n = 58)	Group D (n = 54)	p-value
Operative time (minutes, mean ± SD)	48 ± 9	45 ± 11	0.31
Intraoperative complications, n (%)	0 (0.0%)	1 (1.9%) †	0.48
Postoperative LOS (days, mean ± SD)	1.8 ± 0.6	1.7 ± 0.5	0.42
Laparoscopic completion, n (%)	58 (100%)	54 (100%)	
Conversion to open surgery, n (%)	0 (0.0%)	0 (0.0%)	
30-day reoperation, n (%)	0 (0.0%)	0 (0.0%)	

Note. LOS = length of stay; SD = standard deviation. † Minor intraoperative bile leak managed conservatively without reoperation.

3.7 Caregiver Satisfaction and Psychosocial Experience

To complement the quantitative outcome data, structured qualitative interviews were conducted with a representative subset of 30 caregivers (15 per cohort). The results, summarized in Table 6, revealed marked disparities in caregiver experience. Among Group E caregivers, 93.3% considered the timing of surgery appropriate, and all 15 (100%) rated overall satisfaction as excellent or good. By contrast, only 40.0% of Group D caregivers expressed satisfaction with the surgical timing, and 86.7% reported significant anxiety about recurrence during the waiting interval nearly seven times the proportion in Group E (13.3%). These psychosocial findings complement emerging literature on family-centered pediatric surgical

quality assessment, which increasingly recognizes caregiver experience as a measurable and policy-relevant dimension of surgical care outcomes.

Table 6: Caregiver Satisfaction and Perceived Anxiety by Surgical Timing Group (Structured Interview, n = 30)

Interview Item	Group E (n = 15)	Group D (n = 15)
Timing of surgery felt appropriate	14 (93.3%)	6 (40.0%)
Experienced anxiety about recurrence while waiting	2 (13.3%)	13 (86.7%)
Understood rationale for surgical timing	15 (100%)	9 (60.0%)
Overall satisfaction: Excellent or Good	15 (100%)	11 (73.3%)

Note. Responses collected via structured interview at the 6-week post-discharge clinic visit. Results are presented as n (%).

4. Discussion

The present prospective cohort study offers real world clinical evidence of a community tertiary teaching hospital in central Iraq that early laparoscopic cholecystectomy within 72 hours of ABP diagnosis reduces pancreatitis re-occurrence and overall healthcare use in children significantly, and that perioperative safety is similar to the deferred surgery. The relative risk reduction of 85% was similar to the PONCHO randomized controlled trial, which found the rates of recurrence of 4% vs. 25% with same-admission vs. interval cholecystectomy in an overall European multicenter population [5]. The current paper builds on the evidence to a public-sector context in the Middle East where the potential regional data have been conspicuously missing thus offering context-specific evidence to inform regional policy reform.

One of the key and original contributions of this study is the systematic quantitative characterization of procedural delay determinants. The finding that about three-quarters of all surgical delays were due to health system structural failure as opposed to patient or caregiver noncompliance essentially changes the traditional story about late surgery in resource-constrained environments. Specifically, the most common impediments were the bottlenecks in the operating room schedule, irregular on-call pediatric surgical cover and disjointed primary-to-secondary care referral patterns [3, 14]. This fact puts the policy discussion a step closer to the institutional attribution where the policy fails to provide patients with timely access to surgery due to institutional gaps that can be addressed, and hence surgical access reform becomes a structural requirement, which falls within the health equity paradigm and achievement of SDG 3 objectives.

Unlike the current anxiety that cholecystectomy during the acute post-inflammatory phase of pancreatitis might pose technique difficulty and risk prior to and following the operation, our data reassures against this fear. There were also low incidences of complications between groups (1.7% vs. 3.7; $p = 0.59$) and laparoscopy to open conversions were not witnessed and average time in the operating room was the same. These findings are consistent with systematic reviews that indicate no significant increase in bile duct injury, hematoma, or conversion rates in case of cholecystectomy performed at the time of the initial hospitalization of mild biliary pancreatitis [12, 15]. In addition, the safe execution of each of the procedures through a laparoscopic procedure by senior residents under supervision can confirm that early cholecystectomy can be replicated in even low-resource facilities with only basic laparoscopic facilities and well-trained personnel that is similar to the series [16, 17].

This analogy is particularly pertinent in the Iraqi healthcare context, which has an economic dimension. Although the first hospitalization was modestly extended in Group E, there was a

90-day net decrease in inpatient burden of about 40% and this is more than overwhelmingly caused by the avoidance of recurrence-related readmissions. A USD 165 (28) per-patient direct cost saving supports the economic argument of front-loaded investment in surgery. These financial pressures are consistent with health-economic modelling of early and interval cholecystectomy approaches in low and middle-income health systems, where the decrease in readmission rates related to recurrence generate a disproportionately large savings compared to the upfront expenses of the procedures [18, 19]. This economic argument is another solid justification that institutional policy must change in a hospital where the bed occupancy rate is habitually 90% or higher and surgical waiting lists create a long-term operational burden.

The qualitative component of this study offers valuable data on the patient- and family-based value of surgery intervention in a prompt fashion. The deferred cohort caregivers were high and persistent in their anxiety about recurrence in the waiting period - a psychosocial pressure that is seldom included in conventional utilization outcomes but is becoming a major outcome area in the pediatric surgical quality literature [20]. Conversely, early surgical resolution was not only clinically reassuring, but also psychologically reassuring, and in all Group E families satisfaction was complete [NOTE: Table 6 indicates 100% satisfaction, not just nearly all - precise to accuracy). These findings support the concept of caregiver-reported experience scales being part of typical pediatric surgical quality measurement models [23, 24].

It has several limitations that can be noted. Firstly, as a single-center pragmatic observational study, the external generalizability needs to be viewed with caution, even though the population of the catchment of the Al-Zahra Hospital is heterogeneous. Second, the non-random cohort assignment presents the risk of residual confounding not captured by the covariates, despite there being good comparability between the baseline and multivariate adjustment. Third, the exclusion of patients with severe ABP was done in an appropriate manner with the current guidelines [6], which restricted it to more severe manifestations of the disease. Fourth, the cost estimates relied on institutional tariffs, and might be lower than aggregate family-paid spending. Despite these limitations, the future nature of the research, rigor in adhering to the protocol, a systematic categorization of the delay, and a combination of the results of the multi-domain provides a solid and practical evidence base to change at the institutional and national policy.

5. Conclusion

This prospective observational cohort study offers a solid argument that early laparoscopic cholecystectomy within 72 hours of the diagnosis of ABP is clinically and economically better than delayed surgical management in the pediatric population in the Iraqi public tertiary hospital sector with no increment in the perioperative risk. A cumulative inpatient burden of approximately 40% reduction, a reduction in 30-day readmission of 22.6 percentage points, and a 90-day readmission rate of less than 4 in the early intervention arm all represent a strong evidence base to support the use of early cholecystectomy as the institutional standard of care of mild-to-moderate ABP in the resource-constrained public hospital

These findings that three-quarters of surgical delays in the deferral cohort could be ascribed to system-level structural failures reveal clear institutional reform targets: specialized pediatric laparoscopic operating room scheduling; institutionalized weekend and on-call pediatric surgery coverage; formal primary-to-secondary care referrals of ABP; and additional pediatric laparoscopic training of general surgical residents. These actions are consistent with SDG 3, and with national commitments of Iraq to decrease preventable morbidity and ensure equal access to the required surgical services [23,24].

We endorse the formal adoption of the early procedures of cholecystectomy in the national guidelines of biliary surgery of the ministry of health of Iraq with pilot site Al-Zahra Teaching hospital. These results should be narrowed down and confirmed by further future multicenter

prospective studies using longer follow-ups with large samples and health-economic modelling that includes indirect costs to the family to better confirm the results to the multitude of working environments of the Iraq public health system.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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