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# Timing of Choledochal Cyst Excision in Early Infancy — Perioperative and Long-Term Outcomes in a Single-Center Cohort

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# Timing of Choledochal Cyst Excision in Early Infancy — Perioperative and Long-Term Outcomes in a Single-Center Cohort

**Running Title**: Early-infant choledochal cyst excision outcomes

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## Abstract

**Background.** Advances in minimally invasive pediatric surgery have lowered the feasible age window for choledochal cyst (CC) excision. We examined perioperative and long-term outcomes by age at surgery in a contemporary single-center cohort.

**Methods.** We retrospectively reviewed 270 children who underwent primary CC excision with Roux-en-Y hepaticojejunostomy (2011–2022), stratified by age at surgery (≤6 vs >6 months), and compared preoperative, operative, early postoperative, and long-term biliary outcomes.

**Results.** Of 270 children, 81 (30%) were infants (≤6 months) and 189 (70%) were older children (>6 months), with a median follow-up of 90.4 months. Preoperative CC-related inflammatory findings and prior biliary interventions were more frequent in the older-age group. Operative time was shorter in infants ($p<0.001$) while transfusion was more frequent (23.5% vs 10.1%, $p=0.007$). Early postoperative complications were similar in both groups, and follow-up liver biochemistry remained within the institutional reference range. Long-term fatty liver was detected only in the older-age group (0/81 vs 10/189, $p=0.036$), at ages ranging from 5.4 to 25.4 years.

**Conclusions.** CC excision at ≤6 months showed outcomes comparable to those of surgery in older children across all four aspects, apart from a higher transfusion rate. Early surgery may be considered as an option in antenatally or neonatally diagnosed, medically stable infants.



***Keywords***: Choledochal cyst, Infant, Time factors, Treatment outcome, Minimally invasive surgical procedures

## Background

Choledochal cyst (CC) is a congenital dilatation of the biliary tree for which complete cyst excision with Roux-en-Y hepaticojejunostomy (HJ) is the standard treatment. Contemporary minimally invasive surgery (MIS)-era series report surgical mortality well below 1% [1,2], and the risk of biliary tract malignancy from a retained cyst has established complete excision as the clear preventive strategy over cystic drainage [3]. The expanded use of prenatal ultrasound has increased antenatal and early-infancy detection of asymptomatic cases [4–6], and pediatric MIS has steadily extended into the neonatal period in experienced centers [7,8]. Recently, the indications for both laparoscopy and robotic-assisted surgery have expanded into infancy and the neonatal period. Rong et al [9] compared robotic CC excision in infants ≤1 year of age with older children >1 year and reported that age is not a contraindication for robotic surgery. Jin et al [10] reported the feasibility of robotic resection in infants weighing <6 kg, and Zhang et al [11] in a multicenter cohort of neonates under three months of age. Liao et al [12] directly compared Da Vinci robotic and laparoscopic approaches in neonates and reported comparable safety. Including a 318-case all-age robotic cohort [13], the lower bounds of operable age and body weight have progressively been pushed down. Nevertheless, within-institution direct comparisons of outcomes by age at surgery remain scarce. In this context, two questions remain relevant. The first is when to operate on an asymptomatic, antenatally diagnosed neonate or infant. The second is whether operation immediately after diagnosis is safe.

Prior literature on surgical timing offers considerations on both sides. Considerations favoring delay include technical difficulty in a small infant and limited intraperitoneal working space for MIS [5,14,15], weight- and age-based operative thresholds motivated by anesthetic and

neurodevelopmental considerations (van den Eijnden [14] body weight >5.6 kg, Ho [5] ≥4 months and ≥7 kg, Zhang [15] >2 months and >4 kg), and reports of more frequent complications or longer operative time in early-surgery groups [5,14]. Considerations supporting earlier operation include subclinical cholestasis during cyst preservation that can progress to fibrosis [16,17], preoperative inflammation and adhesion that increase operative difficulty, and histological evidence that portal fibrosis does not regress after bile-flow restoration [17–19]. The only randomized study by Diao et al [16] supported earlier operation but excluded 32 of 68 enrolled patients who developed symptoms within the first month of life, leaving only 36 asymptomatic randomized patients. Prior retrospective cohorts proposing selective delay to 4–6 months [5,14,15] are mostly short-term (≤5-year) reports, and within-institution comparisons across age at surgery with long-term biliary follow-up are scarce.

In light of this literature, six months of age may be considered a pragmatic threshold, around which infant weight gain approaches the anesthetic-safety range and preoperative clinical findings begin to accumulate. In a single-center cohort of 270 children operated on between 2011 and 2022, drawing on accumulated institutional experience with laparoscopic CC excision in ≤6-month infants, we examined whether CC excision at ≤6 months of age is feasible and safe, and whether long-term biliary and hepatic outcomes remain comparable to those in older children. The comparison was organized along four aspects (preoperative baseline, operative, early postoperative, and long-term biliary outcomes).

## Methods

*Study design and patients*

This study was retrospectively conducted on patients less than 18 years of age who underwent primary CC excision and Roux-en-Y hepaticojejunostomy at the Department of Pediatric Surgery, Asan Medical Center, Seoul, between January 2011 and December 2022. Patients who underwent CC excision at an outside institution and received only liver transplantation at our center were excluded. Demographic information, preoperative clinical findings, operative information, early postoperative outcomes, and long-term follow-up data were collected from the patients' medical charts. Follow-up duration was calculated based on the most recent outpatient visit. Complications were assessed according to the Clavien–Dindo classification. Outpatient follow-up was performed at the discretion of each operating surgeon, generally at 3- to 6-month intervals during the first postoperative year and at 1- to 2-year intervals thereafter. Liver function tests were done at intervals determined by each operating surgeon, and ultrasonography was performed at scheduled intervals or selectively based on blood test results. The study was conducted in accordance with the Declaration of Helsinki and was reviewed and approved by the Institutional Review Board of Asan Medical Center (IRB approval No. 2023-0837). Informed consent was waived because of the retrospective nature of the study. Reporting followed the STROBE guidelines. During the study period (2011–2022), laparoscopy was the only MIS approach used for ≤6-month infants. Robotic-assisted surgery for ≤6-month infants was selectively introduced at our institution in 2024 and is therefore not represented in this cohort.

*Exposure and outcomes*

Patients were divided into two groups by age at surgery, with 6 months as the threshold. Prior CC cohorts have proposed around 4–6 months of age as a clinical transition point for surgical-

timing decisions in antenatally or neonatally diagnosed patients [5,14,15], and the 6-month cut-off was adopted as a pragmatic age threshold aligned with the upper end of this range. In this study, the ≤6-month group is referred to as the "infant group" and the >6-month group as the "older-age group". The "older-age group" encompasses children older than 6 months of age and includes the late-infancy range (7–12 months). Comparisons were made across four aspects, covering preoperative baseline (Table 1), operative outcomes (Table 2), early postoperative outcomes (Table 3), and long-term biliary outcomes (Table 4). Pre-operative and last follow-up liver function values were compared in a paired fashion within each age group (Table 5).

*Statistical analysis*

Continuous variables were presented as median (interquartile range, IQR) and compared using the Mann–Whitney U test. Categorical variables were presented as frequency (%) and compared using Fisher's exact test. For binary outcomes, odds ratios with 95% confidence intervals are reported. Pre-operative and last follow-up liver function values were compared within each age group using the Wilcoxon signed-rank test. All statistical analyses were performed with R 4.3.3, and $p<0.05$ was considered statistically significant.

## Results

Of the 270 included patients, 81 (30.0%) were infants (≤6 months) and 189 (70.0%) were older children (>6 months). The median age at surgery was 30.2 months (IQR 2.7–62.7), 77.8% were

female, and no deaths occurred. The median follow-up was 90.4 months (IQR 60.8–120.3), with the longest follow-up reaching 172 months.

*Baseline characteristics*

The infant group had a median weight at surgery of 3.5 kg (IQR 3.1–4.3), compared with 15.8 kg (IQR 12.3–24.2) in the older-age group. Todani type I was the predominant anatomy in both groups (90.1% vs 83.1%), with type IVa accounting for 8.6% and 14.8%, respectively. A history of biliary intervention (endoscopic retrograde cholangiopancreatography [ERCP] or endoscopic nasobiliary drainage [ENBD]) and preoperative CC-related inflammatory findings were observed only in children operated on beyond infancy. No infant had undergone preoperative ERCP (0% vs 29.1%) or ENBD (0% vs 7.9%), and peritoneal signs on examination (0% vs 15.9%, $p<0.001$) and image-confirmed perforation (1.2% vs 7.9%, $p=0.045$) were likewise concentrated in the older-age group. That is, the infant group was mostly operated on without preoperative CC-related inflammatory burden or prior biliary intervention, whereas in the older-age group a substantial proportion of children had become symptomatic before surgery and had received biliary interventions or inflammation treatment prior to operation. In preoperative laboratory testing, infants had higher total bilirubin while older children had higher alanine aminotransferase (ALT), amylase, and lipase (all $p<0.001$), with different preoperative hepatobiliary profiles between the two groups.

In a three-way comparison of surgical approach (open vs MIS vs open conversion), the two groups did not differ significantly ($p=0.54$, Table 1). Within the MIS subset, however, all 69 infants received laparoscopic surgery (including single-port), without any robotic cases, whereas

older children were split approximately evenly between laparoscopic (45.2%) and robotic (44.7%) approaches. This reflects our institutional practice during the study period, in which robotic surgery was not actively performed in ≤6-month patients.

*Perioperative outcomes*

Operative time was shorter in the infant group (median 253 vs 312 min, p<0.001). Transfusion was more frequent in the infant group (23.5% vs 10.1%, OR 2.74 [95% CI 1.36–5.52], p=0.007). Open-conversion rates (7.4% vs 7.9%) and reoperation rates (4.9% vs 7.4%) were similar between the groups (Table 2).

Hospital stay was slightly but significantly longer in the infant group (median 9 vs 8 days, p=0.001). Early postoperative complications were uncommon in both groups and did not differ significantly, with ileus 1.2% vs 3.2%, fluid collection 0% vs 0.5%, and HJ anastomotic leak 2.5% vs 2.6% (Table 3).

*Long-term outcomes*

Liver function tests were done during follow-up at intervals determined by each operating surgeon. Ultrasonography was performed selectively based on each operating surgeon's clinical judgment. Liver function values in both age groups, which had been elevated preoperatively, recovered to within the institutional reference range (aspartate aminotransferase [AST]/ALT ≤40 U/L) in the immediate postoperative period and remained within that range through the final follow-up (Table 5, Figure 1). The physiologic total bilirubin elevation observed preoperatively

in the infant group (median 7.70 mg/dL) had normalized to within the reference range (median 0.30 mg/dL) by the last follow-up. The recovery course did not differ substantially between the two groups.

Fatty liver was initially screened by ultrasound during follow-up, with additional investigations performed when indicated. Fatty liver was detected only in children operated on after 6 months of age (0/81 vs 10/189, p=0.036). No patient operated on at or before 36 months of age (0/148) developed fatty liver. The proportion rose to 4.8% among those operated on between 3 and 6 years and 11.9% among those operated on after 6 years of age (Figure 2). The 10 children in whom fatty liver was detected were between 5.4 and 25.4 years of age at the time of detection. Other long-term biliary events were less frequent in infants but did not differ significantly between groups (Table 4, Figure 3), with cholangitis 2.5% vs 2.6%, pancreatitis 1.2% vs 3.7%, HJ stricture or leak 2.5% vs 4.2%, and pancreatic-duct or remnant common bile duct (CBD) stone 2.5% vs 5.3%.

## Discussion

Across the four aspects compared in our single-center cohort of 270 patients, the ≤6-month infant group and the >6-month older-age group differed at baseline. The infant group had virtually no preoperative biliary-intervention history (ERCP or ENBD), peritoneal signs, image-confirmed perforation, or other CC-related inflammatory findings (all $p \leq 0.045$), whereas a substantial proportion of the older-age group presented with such findings. In preoperative laboratory values, infants had higher total bilirubin while older children had higher ALT, amylase, and lipase (all $p < 0.001$). The elevated bilirubin in infants likely reflects physiologic

infantile characteristics rather than true biliary hyperbilirubinemia, whereas the elevated hepatic enzymes in older children commonly reflect clinical signals of CC-related inflammation, consistent with their preoperative biliary-intervention history.

Shorter operative time in the infant group (median 253 vs 312 min, $p<0.001$) may be interpreted alongside the baseline observation that preoperative inflammation and biliary-intervention history were concentrated in the older-age group. In addition, the approach mix differed between groups (the infant group was operated on only laparoscopically, whereas 44.7% of older children were operated on robotically, with robotic cases requiring additional docking and setup time). The between-group difference in operative time may therefore partly reflect this approach-mix effect. Transfusion was more frequent in the infant group (23.5% vs 10.1%, OR 2.74). Open-conversion (7.4% vs 7.9%) and reoperation (4.9% vs 7.4%) rates were similar between the groups. These operative findings, particularly operative time and overall intraoperative safety, align with several recent reports of early-infancy MIS CC surgery. Rong et al [9] reported similar total operative time between infants ≤1 year and children >1 year, Jin et al [10] described robotic CC excision in infants <6 kg completed in 150–248 minutes, and Liao et al [12] observed acceptable intraoperative safety for both laparoscopic and robotic approaches in neonatal CC surgery. Together, these studies place our early-infancy laparoscopic experience within the currently reported range of early-infancy MIS CC surgery.

Early-infancy MIS has traditionally been approached with caution [5,14,15]. In our cohort, early postoperative complications (ileus, fluid collection, HJ anastomotic leak) were uncommon in both groups and did not differ significantly. Early-infancy surgery does not appear inferior to surgery in older children in terms of early postoperative safety. The infant group's early-

complication rates (ileus 1.2%, fluid collection 0%, HJ anastomotic leak 2.5%) were consistent with ranges reported in recent cohorts of early-infancy MIS CC excision [9,11,12]. In the infant group, hospital stay was slightly longer (median 9 vs 8 days), but this was not related to any specific complication. Regarding liver function, abnormal preoperative values in both age groups normalized to within the institutional reference range (AST/ALT ≤40 U/L) and remained there through the final follow-up, suggesting that surgical treatment achieved adequate biliary drainage regardless of age at surgery.

The incidence of cholangitis, pancreatitis, HJ stricture or leak, and pancreatic-duct or remnant CBD stone was not statistically different between groups, with the infant group showing numerically lower rates across all four categories (2.5% vs 2.6%, 1.2% vs 3.7%, 2.5% vs 4.2%, and 2.5% vs 5.3%). These rates were comparable to ranges reported in prior pediatric CC series comparing long-term biliary complications across surgical approaches [20].

In contrast, there was a difference in long-term fatty liver incidence. Fatty liver developed in 0 of 81 infants versus 10 of 189 older children ($p=0.036$). When stratified by surgical age, no fatty liver developed among the 148 patients operated on at or before 36 months of age. The proportion was 4.8% among those operated on between 3 and 6 years and 11.9% among those operated on after 6 years of age, showing a trend of increasing fatty-liver detection with increasing age at surgery. However, the age at fatty-liver detection ranged from 5.4 to 25.4 years, overlapping with adolescence and early adulthood, when metabolic steatosis becomes more prevalent. Nevertheless, the identification of fatty liver on ultrasonography in the context of normal liver biochemistry in both groups suggests that incorporating routine ultrasound surveillance alongside blood tests may be considered during post-CC-excision follow-up.

Taken together, early-infancy CC excision in our cohort showed outcomes similar to, or numerically more favorable than, those in the >6-month group across preoperative, operative, early postoperative, and long-term aspects, though transfusion was more frequently required in the infant group. Our findings are consistent with the recent trend of expanding laparoscopic and robotic CC-surgery indications to neonates, infants under 3 months of age, and infants weighing less than 6 kg [9–13], and provide data directly comparing ≤6-month and >6-month age groups across four aspects in a laparoscopic long-term cohort.

This study has several limitations. Selection bias from the retrospective single-center design cannot be fully excluded. Our analysis stratified patients only by age without separately considering the emergence of different surgical approaches over time or surgeon learning curves associated with newer techniques [21]. Recent network meta-analyses have reported that short-term outcomes across open, laparoscopic, and robotic approaches overlap substantially [22,23], and a direct comparison across approaches lies beyond the scope of our data. Our data only included transfusion status, and the exact amount of transfusion was not recorded. However, review of medical records confirmed that no patient required massive transfusion. Fatty liver status could be assessed only among patients who underwent ultrasonography during follow-up. In our institutional records, no patient had any documented history of treatment related to fatty liver or its common contributors (obesity, metabolic disease, corticosteroid exposure), although clinical records from outside institutions could not be obtained. In this context, prospective, multicenter studies with explicit metabolic-risk measurement and standardized surveillance protocols are needed to establish long-term hepatic outcomes in this population.

## Conclusions

For antenatally or neonatally diagnosed, medically stable infants, early surgery may be considered as an option when the clinical status permits operation, rather than waiting to reach weight or age thresholds. Routine ultrasound surveillance alongside liver function testing during long-term follow-up may help detect post-CC-excision hepatic changes that are not reflected in liver biochemistry alone.

## List of abbreviations

ALT, alanine aminotransferase

AST, aspartate aminotransferase

CBD, common bile duct

CC, choledochal cyst

CI, confidence interval

ENBD, endoscopic nasobiliary drainage

ERCP, endoscopic retrograde cholangiopancreatography

HJ, hepaticojejunostomy

IQR, interquartile range

IRB, Institutional Review Board

MIS, minimally invasive surgery

OR, odds ratio

STROBE, Strengthening the Reporting of Observational studies in Epidemiology

## Declarations

*Ethics approval and consent to participate*

The study was conducted in accordance with the Declaration of Helsinki and was reviewed and approved by the Institutional Review Board of Asan Medical Center (IRB approval No. 2023-0837). Informed consent was waived by the Institutional Review Board because of the retrospective nature of the study.

*Consent for publication*

Not applicable.

*Availability of data and materials*

The datasets generated and analysed during the current study are not publicly available due to institutional data-sharing policies and participant privacy considerations but are available from the corresponding author on reasonable request, subject to approval by the Institutional Review Board of Asan Medical Center.

*Competing interests*

The authors declare no competing interests related to this study.

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316 *Authors' contributions*

317 DB and JMN contributed equally to this work as first authors. DB and SG led the data collection
318 and performed the primary data analysis. JMN, HK and YJC contributed to patient care and
319 critical revision of the manuscript. SG and YJK contributed equally to this work as
320 corresponding authors. SG, JMN and YJK designed the study, supervised the analysis, and
321 drafted the manuscript. All authors read and approved the final manuscript.

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# Tables

## Table 1. Baseline characteristics (preoperative conditions) by age at surgery

| Characteristic | ≤6 months (n=81) | >6 months (n=189) | p-value |
|---|---|---|---|
| Age at surgery (months), median (IQR) | 0.5 (0.3–1.6) | 45.3 (27.2–86.9) | <0.001 |
| Female, n (%) | 61 (75.3) | 149 (78.8) | 0.526 |
| Weight at surgery (kg), median (IQR) | 3.50 (3.14–4.30) | 15.80 (12.30–24.18) | <0.001 |
| Todani type, n (%) | | | |
| Type I | 73 (90.1) | 157 (83.1) | |
| Type IVa | 7 (8.6) | 28 (14.8) | |
| Type Other | 1 (1.2) | 4 (2.1) | |
| Preoperative ERCP, n (%) | 0 (0.0) | 55 (29.1) | <0.001 |
| Preoperative ENBD, n (%) | 0 (0.0) | 15 (7.9) | 0.007 |
| Peritoneal signs on exam, n (%) | 0 (0.0) | 30 (15.9) | <0.001 |
| Image-confirmed perforation, n (%) | 1 (1.2) | 15 (7.9) | 0.045 |
| Preoperative AST (U/L), median (IQR) | 35.0 (29.0–50.0) | 34.0 (27.0–52.5) | 0.438 |
| Preoperative ALT (U/L), median (IQR) | 13.0 (10.0–26.0) | 26.5 (12.0–69.2) | <0.001 |
| Preoperative total bilirubin (mg/dL), median (IQR) | 7.70 (3.30–10.80) | 0.40 (0.30–0.80) | <0.001 |

| | | | |
|---|---|---|---|
| Preoperative amylase (U/L), median (IQR) | 8.0 (5.0–12.0) | 81.5 (53.0–125.8) | <0.001 |
| Preoperative lipase (U/L), median (IQR) | 14.0 (12.0–18.0) | 56.0 (27.0–121.0) | <0.001 |

*Values are presented as median (IQR) or n (%). Group comparisons used the Mann–Whitney U test for continuous variables and Fisher's exact test for categorical variables. IQR, interquartile range; CC, choledochal cyst; ERCP, endoscopic retrograde cholangiopancreatography; ENBD, endoscopic nasobiliary drainage; MIS, minimally invasive surgery; AST, aspartate aminotransferase; ALT, alanine aminotransferase.*

## Table 2. Operative outcomes by age at surgery

| | ≤6 months (n=81) | >6 months (n=189) | p-value |
|---|---|---|---|
| Operative time (min), median (IQR) | 253 (214–286) | 312 (264–363) | <0.001 |
| Intraoperative or postoperative transfusion, n (%) | 19 (23.5) | 19 (10.1) | 0.007 |
| Open conversion, n (%) | 6 (7.4) | 15 (7.9) | 1.000 |
| Reoperation, n (%) | 4 (4.9) | 14 (7.4) | 0.598 |

*Values are presented as median (IQR) or n (%). Group comparisons used the Mann–Whitney U test for operative time and Fisher's exact test for binary outcomes. Odds ratios are reported for binary outcomes. IQR, interquartile range; OR, odds ratio; CI, confidence interval; MIS, minimally invasive surgery; HJ, hepaticojejunostomy.*

## Table 3. Early postoperative outcomes by age at surgery

| | ≤6 months (n=81) | >6 months (n=189) | p-value |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Hospital stay (days), median (IQR) | 9 (8–12) | 8 (7–9) | <0.001 |
| Ileus, n (%) | 1 (1.2) | 6 (3.2) | 0.678 |
| Fluid collection, n (%) | 0 (0.0) | 1 (0.5) | 1.000 |
| HJ anastomotic leak, n (%) | 2 (2.5) | 5 (2.6) | 1.000 |
| In-hospital mortality, n (%) | 0 (0.0) | 0 (0.0) | — |

*Values are presented as median (IQR) or n (%). Group comparisons used the Mann–Whitney U test for hospital stay and Fisher's exact test for complications. IQR, interquartile range; HJ, hepaticojejunostomy.*

**Table 4. Long-term biliary outcomes by age at surgery**

| | **≤6 months (n=81)** | **>6 months (n=189)** | **p-value** |
|---|---|---|---|
| Cholangitis, n (%) | 2 (2.5) | 5 (2.6) | 1.000 |
| Pancreatitis, n (%) | 1 (1.2) | 7 (3.7) | 0.442 |
| HJ stricture or leak, n (%) | 2 (2.5) | 8 (4.2) | 0.728 |
| Pancreatic-duct or remnant CBD stone, n (%) | 2 (2.5) | 10 (5.3) | 0.520 |
| Fatty liver, n (%) | 0 (0.0) | 10 (5.3) | 0.036 |

**Values are presented as n (%). Group comparisons used Fisher's exact test. HJ, hepaticojejunostomy; CBD, common bile duct.*

**Table 5. Pre-operative versus last follow-up liver function (paired within each age group)**

| | Pre-operative, median (IQR) | Last follow-up, median (IQR) | p-value |
|---|---|---|---|
| ≤6 months (n=81) | | | |
| AST (U/L) | 35.0 (29.0–50.0) | 32.0 (28.0–39.0) | 0.041 |
| ALT (U/L) | 13.0 (10.0–26.0) | 15.0 (11.0–24.0) | 0.831 |
| Total bilirubin (mg/dL) | 7.70 (3.30–10.80) | 0.30 (0.20–0.40) | <0.001 |
| >6 months (n=189) | | | |
| AST (U/L) | 34.0 (27.0–52.5) | 28.0 (24.0–32.0) | <0.001 |
| ALT (U/L) | 26.5 (12.0–69.2) | 12.0 (10.0–15.2) | <0.001 |
| Total bilirubin (mg/dL) | 0.40 (0.30–0.80) | 0.40 (0.30–0.60) | <0.001 |

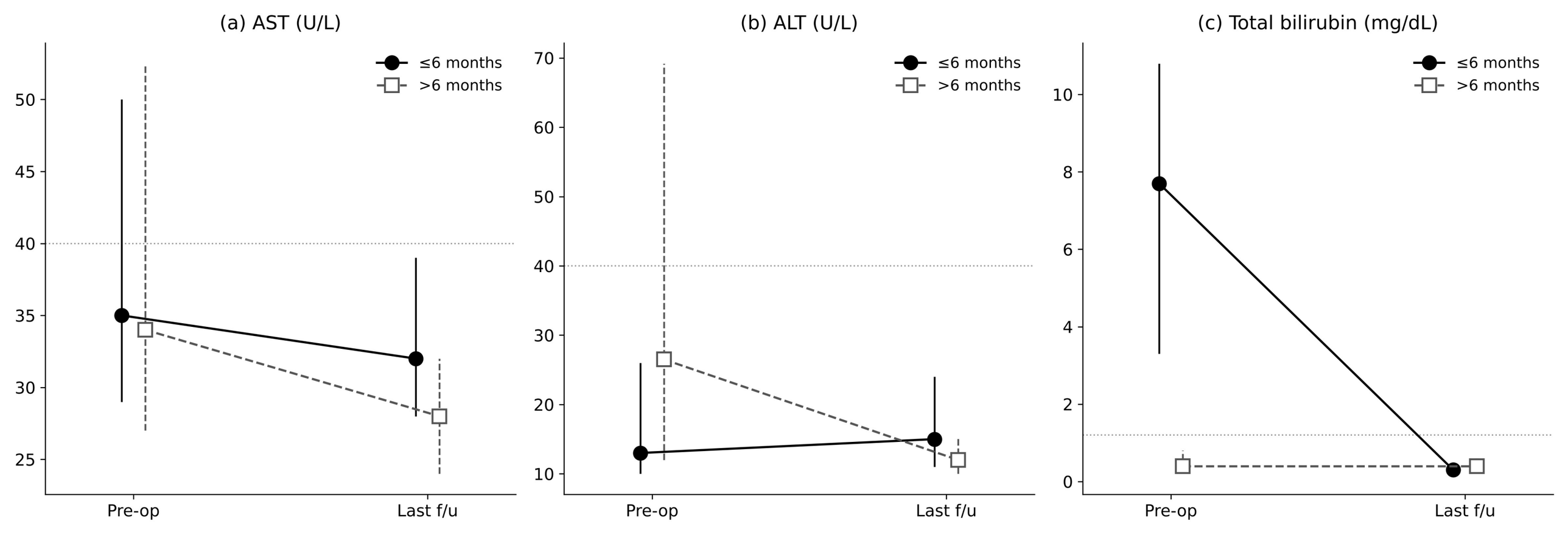
**Values are presented as median (IQR). Within-group paired comparisons used the Wilcoxon signed-rank test. Variation of AST or ALT within the institutional reference range (≤40 U/L) is not clinically meaningful. IQR, interquartile range; AST, aspartate aminotransferase; ALT, alanine aminotransferase.*

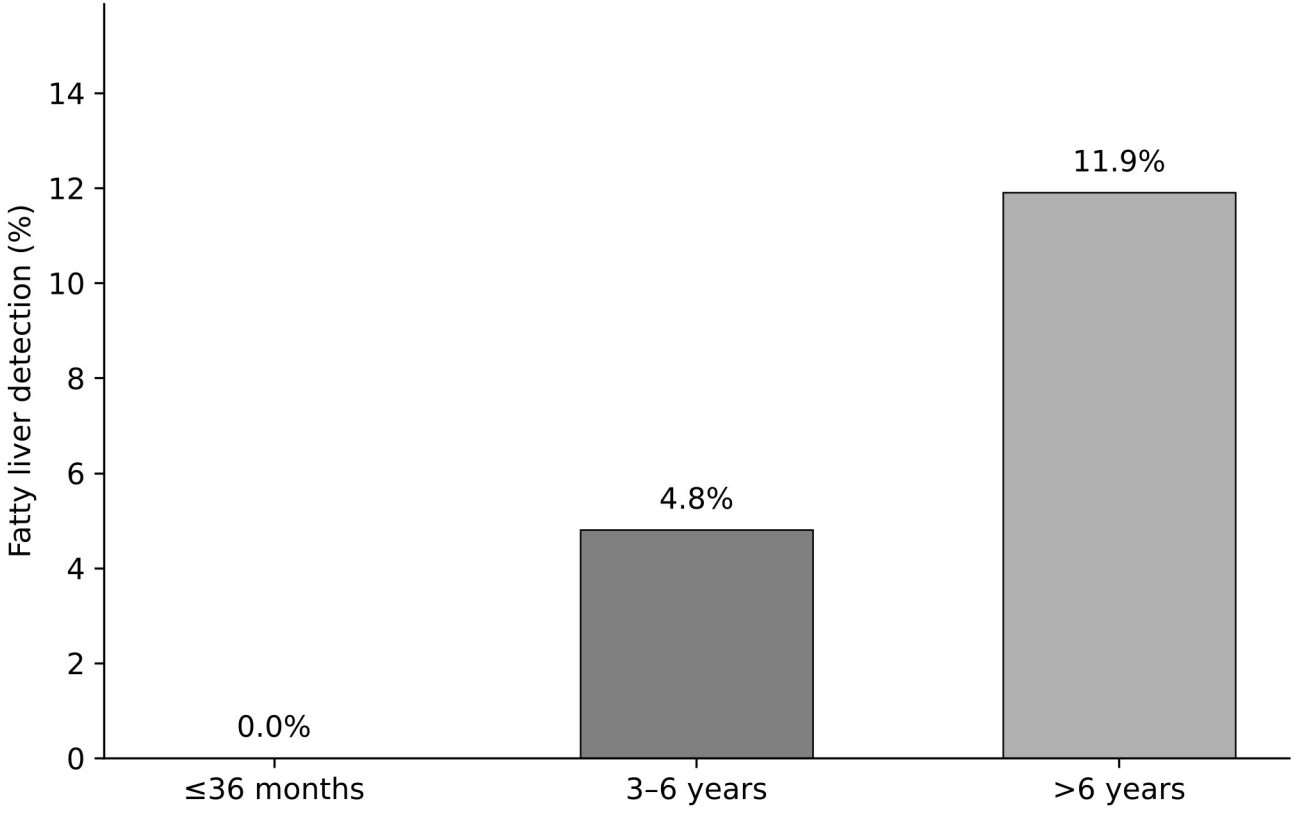
## Figure legends

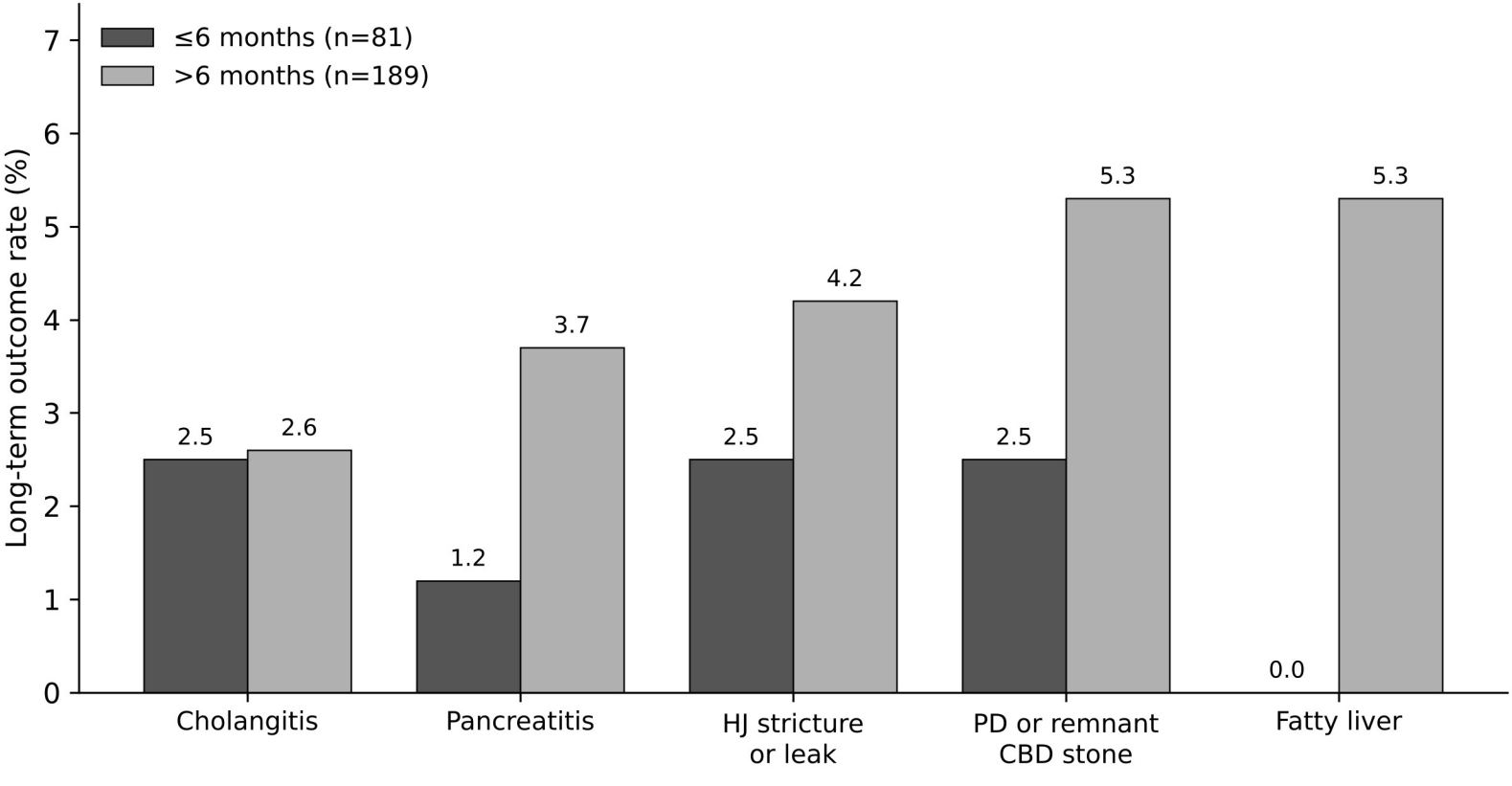
**Figure 1.** Pre-operative to last follow-up liver function recovery in each age group. (a) AST. (b) ALT. (c) Total bilirubin. Markers show median and vertical lines show IQR. Dotted horizontal lines indicate the institutional reference upper limit (AST/ALT 40 U/L, total bilirubin 1.2 mg/dL). AST, aspartate aminotransferase; ALT, alanine aminotransferase.

**Figure 2.** Fatty liver detection at long-term follow-up (≤36 months, 3–6 years, >6 years).

**Figure 3.** Long-term biliary outcomes compared between ≤6-month and >6-month age groups. HJ, hepaticojejunostomy; CBD, common bile duct.


(a) AST (U/L)
≤6 months
>6 months
50
45
40
35
30
25
Pre-op
Last f/u
(b) ALT (U/L)
≤6 months
>6 months
70
60
50
40
30
20
10
Pre-op
Last f/u
(c) Total bilirubin (mg/dL)
≤6 months
>6 months
10
8
6
4
2
0
Pre-op
Last f/u


Fatty liver detection (%)
0
2
4
6
8
10
12
14
0.0%
4.8%
11.9%
≤36 months
3–6 years
>6 years


≤6 months (n=81)
>6 months (n=189)
Long-term outcome rate (%)
0
1
2
3
4
5
6
7
2.5
2.6
1.2
3.7
2.5
4.2
2.5
5.3
0.0
5.3
Cholangitis
Pancreatitis
HJ stricture or leak
PD or remnant CBD stone
Fatty liver