Journal of Pediatric Surgery 55 (2020) 2177–2182

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Comparison of the outcomes of biliary atresia with cystic degeneration and isolated biliary atresia: A matched-pair analysis

Kyong Ihn [a], In Geol Ho [a], Ji Hee Lee [b], Younghyun Na [c], Dongeun Lee [a], Seok Joo Han [a,*]

[a] Department of Pediatric Surgery, Severance Pediatric Liver Disease Research Group, Severance Children's Hospital, Department of Surgery, Yonsei University College of Medicine, Seoul, Republic of Korea
[b] Department of Pathology, Yonsei University College of Medicine, Seoul, Republic of Korea
[c] Division of Pediatric Surgery, Department of Surgery, Korea University Guro Hospital, Korea University College of Medicine, Seoul, Republic of Korea

ARTICLE INFO

Article history:
Received 29 September 2019
Received in revised form 31 January 2020
Accepted 21 February 2020

Key words:
Biliary atresia
Kasai portoenterostomy
Liver fibrosis
Prognosis
Cystic degeneration
Matching

ABSTRACT

Background: Patients with biliary atresia (BA) with extrahepatic cystic degeneration (BACD) have a unique pathophysiology; however, clinical outcomes and progression of perinatal degeneration are not well-defined. We aimed to investigate the differences in clinical characteristics and outcomes between BACD and isolated BA (IBA).
Methods: We performed a retrospective analysis of patients with BA who underwent Kasai portoenterostomy (KPE) from August 1997 to January 2018 and compared the clinical features and outcomes between BACD ($n = 21$) and IBA ($n = 237$). Matched-pair analysis for age and sex was performed between BACD and IBA groups to reduce confounding.
Results: Before matched-pair analysis, we found that BACD patients were younger at KPE (45 vs. 64 days, $p = 0.008$), showed lower total bilirubin at the 3-month follow-up (0.5 vs. 1.4 mg/dL, $p = 0.002$), and higher 5-year native liver survival rate (95.2% vs. 61.4%, $p = 0.006$) than IBA patients. After matching, the BACD group showed significantly lower total bilirubin levels at the 3-month follow-up (0.5 vs. 1.5 mg/dL, $p = 0.036$) and higher 5-year native liver survival rate (95.2% vs. 57.5%, $p = 0.006$) than the IBA group.
Conclusion: BACD demonstrated higher bilirubin clearance and native liver survival rates than IBA.
Levels of Evidence: Treatment Study, Level III.

Biliary atresia (BA) is the most common etiology of neonatal or early infantile progressive liver disease. Experimental studies have shown that the pathophysiological mechanisms of BA are based on perinatal disarrangement. Immunologic, inflammatory, and infectious insults appear to be a central element in the pathophysiology of BA and can be attributed to primary biliary obstruction or secondary obstruction caused by chronic inflammation or fibrotic changes [1,2]. However, BA with extrahepatic cystic degeneration (BACD, commonly known as cystic biliary atresia) accounts for 5% to 10% of all BA cases and may be clinically important to understand the different intrauterine developmental etiologies [3,4].

Although prenatal ultrasonography has become a nearly-routine procedure during pregnancy, there are limited numbers of reports of BACD because of very low incidence. Therefore, BACD continues to present many challenges; pediatricians and surgeons lacking experience and information on this condition often miss the crucial period for performing definitive Kasai portoenterostomy (KPE) owing to erroneously diagnosing BACD as a choledochal cyst [5]. The unintended gap between early prenatal detection of the cyst and delayed postnatal confirmatory diagnosis (and subsequent bypassing of the crucial treatment period) may stem from the difficulty in considering BACD in the differential diagnosis and lack of awareness regarding the pathophysiology of BACD.

This study attempts to investigate the operative outcomes of BA, with particular attention to the challenges encountered in BACD, as well as compare the outcomes of a counterpart cohort of patients with isolated BA (IBA) who also underwent KPE.

1. Methods

1.1. Patient selection and study design

We performed a single-institution retrospective review of patients with BA treated with KPE from July 1997 to January 2018 at a tertiary referral center with approval from the Institutional Review Board/Ethics Committee of Severance Hospital (approval number: 4–2016-0995). The diagnosis of BA was confirmed by intraoperative cholangiography, which assessed the presence of BACD. In addition to intraoperative cholangiography, a thorough review of preoperative imaging studies

* Corresponding author at: Department of Pediatric Surgery, Severance Children's Hospital, Department of Surgery, Yonsei University College of Medicine, 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, Republic of Korea. Tel.: +82 2 2228 2130; fax: +82 2 313 8289.
E-mail address: sjhan@yuhs.ac (S.J. Han).

https://doi.org/10.1016/j.jpedsurg.2020.02.054
0022-3468/

(i.e., magnetic resonance cholangiopancreatography, ultrasonography, and hepatobiliary scintigraphy) was conducted to classify the types of BA [6,7]. Diagnostic protocols for BA were uniform throughout the study period. Ultrasonography was performed in all patients with suspicious BA, followed by hepatobiliary scintigraphy and magnetic resonance cholangiopancreatography (MRCP). The most definitive procedure for establishing the diagnosis of BA is operative cholangiography, usually performed at the same time as a liver biopsy during the KPE. We excluded patients who presented with various congenital anomalies, such as polysplenia/asplenia, preduodenal portal vein, interrupted vena cava with azygous continuation, or intestinal malrotation, indicating pathogenesis in early pregnancy [8]. Patients with syndromic BA were excluded from this study as well to maintain pathophysiological homogeneity, as patients with syndromic BA do not produce sufficient bile from the early intrauterine period and subsequently have been reported to have poorer outcomes [8]. Therefore, our comparative analysis focused only on BACD and IBA that were not associated with additional major congenital abnormalities.

The surgical technique was consistent throughout the study period. All procedures were performed by a single surgeon (S.J. Han) as a conventional extended portoenterostomy, regardless of the type of BA. Dissection of the porta hepatis reached the dissection of the proximal part of the fibrotic biliary remnant, with ligation of the small portal veins that drained into the caudate lobe. Portoenterostomy was performed using anastomosis with interrupted 5–0 or 6–0 multifilament absorbable sutures. Other postoperative care protocols are described in more detail in our previous publication [9].

1.2. Assessments

Maximal bile ductule diameter of fibrotic portal mass; laboratory values, including serum total bilirubin (TB) at 3 and 6 months post-KPE, alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma-glutamyl transpeptidase (GGT), and platelet count (PLT); and information on patient characteristics, such as sex, gestational age, birth weight, and date of birth were obtained from the electronic medical records. Preoperative laboratory variables were obtained within 5-days prior to KPE. The aspartate aminotransferase-to-platelet ratio index (APRi) was used to assess hepatic fibrosis. The APRi was calculated as the serum AST level (IU/L) /normal upper limit (50 IU/L) × 100 / platelet count (10^3/μL) [10,11]. The normal range of APRi was considered to be <1; a higher value indicates hepatic fibrosis [12,13].

A portion of the portal mass and extrahepatic bile duct were harvested during KPE and placed in 10% neutral buffered formalin. Formalin-fixed tissues were embedded in paraffin, sectioned, and stained with hematoxylin and eosin (H & E) and/or Masson's trichrome stain. The H & E stained slides were reviewed by a pathologist (J.H. Lee) in a blinded fashion. Histologic analysis included evaluation of the epithelial lining of the cystic mass, replacement fibrosis and smooth muscle content by staining for desmin.

1.3. Statistical analysis

Baseline patient characteristics and clinical parameters were summarized using medians and interquartile ranges (IQR) for continuous variables, and frequencies and proportions for categorical variables. We made comparisons using linear mixed models for continuous variables, and generalized estimating equations (GEE) for categorical variables. To minimize selection bias and confounding, the matched-pair method was applied for sex (exact match) and age at KPE (± 7 days). Fifty-seven patients were retained by matched-pair analysis (greedy algorithm using the MatchIt package version 3.0.1 on R 3.4.3, R Foundation for Statistical Computing, Vienna, Austria). Statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). The Kaplan–Meier method and stratified log-rank tests were used to estimate the native liver survival rates as a function of time. Native liver survival was estimated from the time of KPE to death or liver transplantation. Regarding the endpoint, if a patient had not experienced either event (death or liver transplantation), the patient was censored at the date of last follow-up (July 2018).

2. Results

2.1. Patient characteristics and outcomes

Over the 20-year period, 269 infants with BA were identified. The subjects were classified by morphologic type in three ways: BACD (n = 21), IBA (n = 237), and syndromic BA associated with major congenital anomalies (n = 11). Of these, the BACD and IBA groups are summarized in Table 1. We found that the median age at KPE of patients in the BACD group was significantly lesser than that of the patients in the IBA group (45 vs. 64 days, $p = 0.008$).

As for the preoperative laboratory variables of the BACD versus matched-IBA groups, BACD was associated with lower AST (90 vs. 155 IU/L, $p = 0.007$), ALT (54 vs. 110 IU/L, $p = 0.029$) levels, and lower calculated APRi (0.40 vs. 0.73, $p = 0.016$). After matching analysis, there were no significant differences between the BACD and matched-IBA groups except for preoperative TB, DB, and GGT.

Table 2 illustrates the postoperative biochemical changes, pathological result of resected fibrotic portal mass, and surgical outcomes in the matched-groups. TB taken 3 months after KPE in the BACD group was significantly lower than that in the IBA group (0.5 vs. 1.4 mg/dL, $p = 0.002$). Despite the matching protocol, significant differences between the BACD group and the matched-IBA group persisted in TB 3 months after KPE (0.5 vs. 1.5 mg/dL, $p = 0.036$). There were significant differences in other variables such as DB, AST, ALT, and APRi at 6 months, regardless of matching analysis; however, PLT, APRi at 3 months, and maximal bile ductule diameter of the fibrotic portal mass did not show any significant differences. The estimated percentage of the visible intrahepatic bile duct during operative cholangiography in BACD was significantly higher than that of IBA significantly (42.9% vs.

Table 1
Patient characteristics and preoperative laboratory variables before and after matched-pair analyses.

	BACD (n = 21)	IBA (n = 237) *p* value (vs. BACD)	Matched-IBA (n = 57) *p* value (vs. BACD)
Sex, male	4 (19.0%)	95 (40.1%) 0.057	12 (21.1%) 0.934
Age at KPE, days	45 (23–64)	**64 (44–78) 0.008**	45 (26–62) 0.902
Age at KPE ≤ 60 days	15 (71.4%)	**107 (45.2%) 0.021**	41 (71.9%) 0.925
Pre-op AST (IU/L)	90 (48–192)	**155 (103–242) 0.007**	119 (67–176) 0.984
Pre-op ALT (IU/L)	54 (27–172)	**110 (61–190) 0.029**	71 (36–152) 0.899
Pre-op TB (mg/dL)	7.5 (4.5–8.8)	8.1 (6.5–9.9) 0.137	**8.1 (5.7–11.2) 0.005**
Pre-op DB (mg/dL)	5.3 (3.5–6.9)	6.3 (4.7–7.8) 0.088	**6.1 (4.0–7.9) 0.011**
Pre-op GGT (IU/L)	368 (212–403)	393 (222–596) 0.281	**377 (220–590) 0.020**
Pre-op PLT (10^3/μL)	374 (317–509)	439 (350–516) 0.665	491 (394–545) 0.484
Pre-op APRi	0.40 (0.20–0.90)	**0.73 (0.44–1.24) 0.016**	0.51 (0.26–0.91) 0.765

Values are median (interquartile range) or n (%).
Bold typeface represents statistically significant p values, ($p < 0.05$).
BACD: Biliary atresia with cystic degeneration, IBA: Isolated biliary atresia, KPE: Kasai portoenterostomy, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, TB: Total bilirubin, DB: Direct bilirubin, GGT: Gamma-glutamyl transpeptidase, PLT: Platelet, APRi: Aspartate aminotransferase-to-platelet ratio index.

Table 2
Postoperative laboratory variables, pathologic results, and surgical outcomes before and after matched-pair analyses.

	BACD (n = 21)	IBA (n = 237) *p* value (vs. BACD)	Matched-IBA (n = 57) *p* value (vs. BACD)
TB at 3 months (mg/dL)	0.5 (0.3–1.8)	**1.4 (0.6–4.3)** **0.002**	**1.5 (0.7–4.2)** **0.036**
TB at 6 months (mg/dL)	0.3 (0.2–0.6)	**0.6 (0.3–2.4)** **0.003**	**0.7 (0.3–3.5)** **0.001**
DB at 3 months (mg/dL)	0.3 (0.2–1.9)	**1.2 (0.4–3.2)** **0.005**	**1.3 (0.5–3.7)** **0.017**
DB at 6 months (mg/dL)	0.2 (0.1–0.4)	**0.4 (0.2–2.2)** **0.003**	**0.5 (0.1–3.4)** < **0.001**
AST at 3 months (IU/L)	55 (45–114)	**117 (83–170)** < **0.001**	**117 (85–166)** **0.017**
AST at 6 months (IU/L)	46 (40–64)	**104 (66–164)** < **0.001**	**111 (66–177)** < **0.001**
PLT at 3 months (10^3/μL)	390 (303–460)	**296 (206–376)** **0.004**	314 (241–404) 0.050
PLT at 6 months (10^3/μL)	348 (195–382)	231 (167–312) 0.087	265 (162–327) 0.061
APRi at 3 months	0.32 (0.21–0.53)	**0.81 (0.46–1.43)** < **0.001**	0.68 (0.44–1.27) 0.281
APRi at 6 months	0.27 (0.22–0.58)	**0.96 (0.51–1.63)** < **0.001**	**0.96 (0.40–0.51)** **0.002**
Maximal duct diameter at the porta hepatis (μm)	76 (35–140)	75 (50–150) 0.751	72 (45–150) 0.396
Visible intrahepatic bile duct on operative cholangiography	9 (42.9%)	**9 (3.8%)** < **0.001**	**2 (3.5%)** < **0.001**
Follow-up, months	67 (19–135)	76 (31–136)	78 (29–146)
Five-year native liver survival rate	95.2%	**61.4%** **0.006**	**57.5%** **0.006**

Values are median (interquartile range) or n (%).
Bold typeface represents statistically significant p values, ($p < 0.05$).
BACD: Biliary atresia with cystic degeneration, IBA: Isolated biliary atresia, TB: Total bilirubin, DB: Direct bilirubin, AST: Aspartate aminotransferase, PLT: Platelet, APRi: Aspartate aminotransferase-to-platelet ratio index.

3.8%, $p < 0.001$). A significantly higher rate of the visible intrahepatic bile duct was seen in BACD after matching analysis (42.9% vs. 3.5%, $p < 0.001$).

2.2. Comparison of native liver survival

Native liver survival in the BACD, IBA, and matched-IBA groups was evaluated using the Kaplan–Meier method (Fig. 1). The five-year native liver survival after KPE was significantly higher among patients with BACD than that among patients with IBA (95.2% vs. 61.4%, log-rank $p = 0.006$). The five-year native liver survival was also higher in the BACD group than that in the matched-IBA group (95.2% vs. 57.5%, log-rank $p = 0.006$). In the BACD group, one patient died because of uncontrolled variceal bleeding at five months of age.

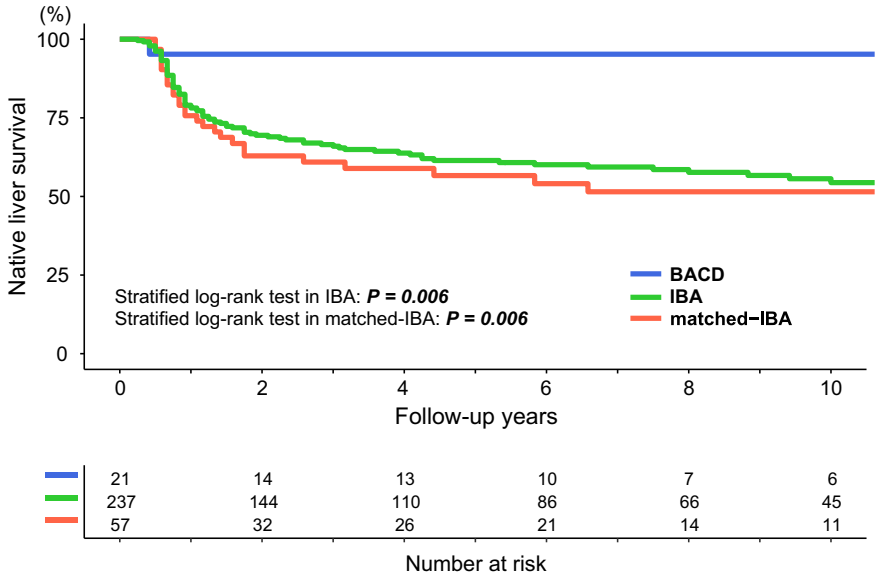

Fig. 1. Kaplan-Meier survival estimation before and after matched-pair analyses comparing native liver survival in biliary atresia with cystic degeneration and that in isolated biliary atresia ($p = 0.006$ for stratified log-rank test). Numbers plotted on the x-axis show the number of patients who are still alive with native livers and whose follow-up extends at least that far into the curve. BACD: Biliary atresia with cystic degeneration, IBA: Isolated biliary atresia.

2.3. Radiological and histological findings of extrahepatic cystic mass in BACD

In one case of BACD, preoperative MRCP findings showed dysmorphic gallbladder with about 1.1 cm sized cystic lesion inferior to the hepatic hilum without a visible common bile duct (Fig. 2A). The gross appearance of the resected extrahepatic bile duct and portal mass are shown in Fig. 2B. Pathologic features are described in Fig. 2(C–F). Immunostaining showed fibromyxoid connective tissue combining with a cystic change without lining epithelium and mural smooth muscle, which was confirmed by cytokeratin 7 (CK7) and desmin immunohistochemical staining. As for the histologic features of the portal mass, we found fibrous tissue containing duct-like structure in BACD. These pathologic patterns were similar to those of the portal mass of IBA (Fig. 2F).

3. Discussion

In this study, we found that patients with BACD had significantly higher rates of postoperative bilirubin clearance and native liver survival even after adjusting for factors, such as age and sex. We observed no statistically significant differences between patients with BACD and age/sex-matched patients with IBA in the preoperative liver profiles (AST, ALT, and PLT) or maximal bile ductule diameter of the fibrotic portal mass. Such a phenomenon might suggest the unique

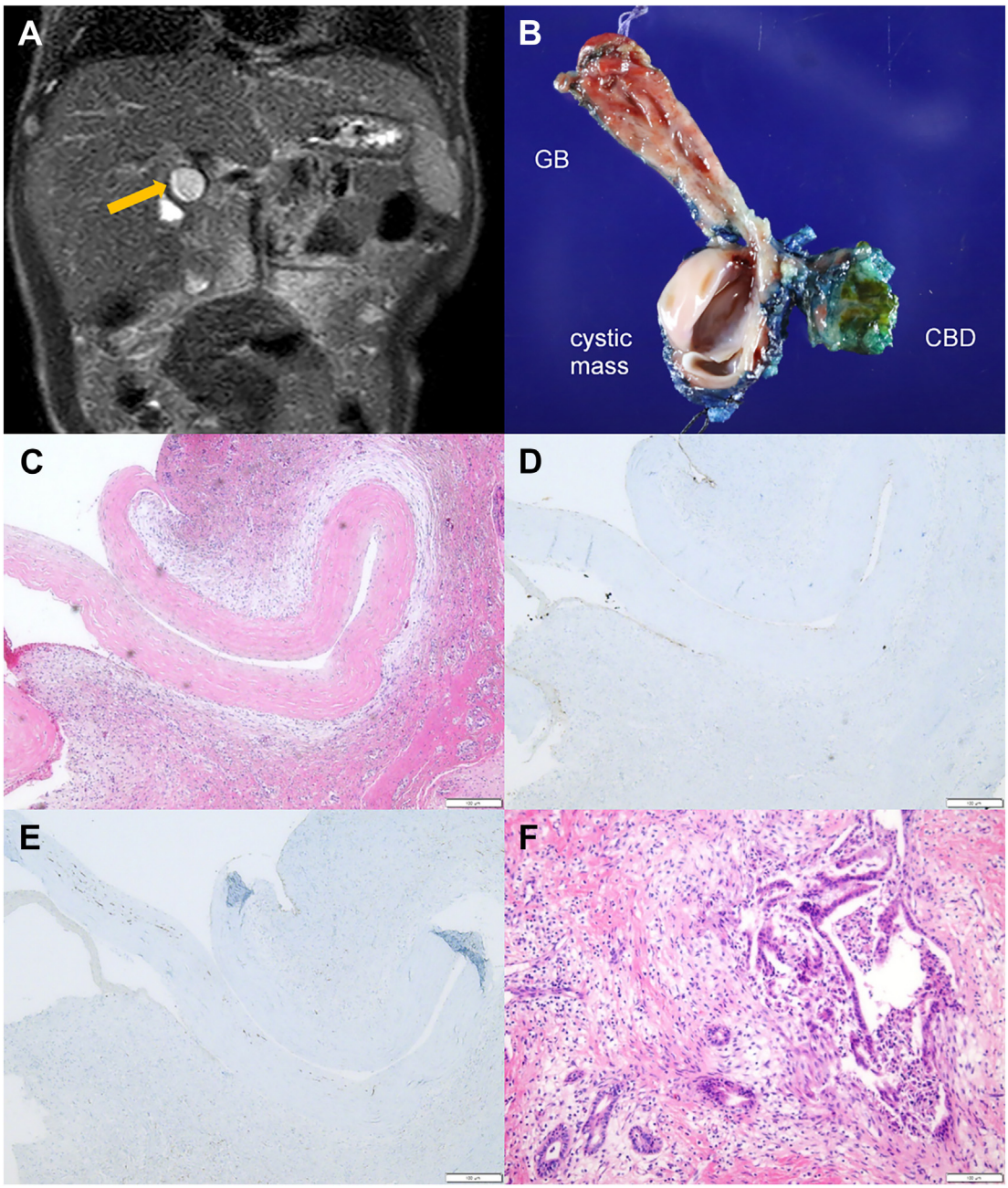

Fig. 2. Radiological and histological findings of extrahepatic cystic mass in biliary atresia with cystic degeneration (BACD). (A) Coronal view of magnetic resonance cholangiopancreatography (MRCP) image. The arrow represents the portion of extrahepatic cystic degeneration. (B) Gross appearance of resected portal mass and the portion of extrahepatic cystic degeneration. (C) Cystic wall shows dense fibrous and sclerotic layer with focal detachment without definite epithelium lining (hematoxylin and eosin (H & E) stain × 40). (D) Cytokeratin 7 immunohistochemical staining reveals lack of epithelium lining (H & E stain × 40). (E) Desmin immunohistochemical staining reveals very focal positivity in the cystic wall, which means lack of smooth muscle layer (H & E stain ×40). (F) Portal mass shows fibrous tissue containing duct-like structure (maximal diameter: 150 um). BACD: Biliary atresia with cystic degeneration, MRCP: Magnetic resonance cholangiopancreatography, H/E: Hematoxylin and eosin.

pathophysiology of BACD wherein the cystic phenotype may be associated with a different degenerative mechanism of the extrahepatic duct and better bile flow.

The results of this study differ from those of previous studies, which suggest that early recognition and KPE showed better outcomes in patients with BACD than those in patients with IBA [4]. The percentage of patients who underwent KPE earlier than 60 days of age was 71.4% and 45.2% in BACD and IBA, respectively. However, paradoxically, two patients with BACD were operated on after 100 days after birth. This demographic discrepancy required comparison based on the adjustment for confounding factors, such as age and sex [14]. We focused our analysis on BACD patients and performed a head-to-head comparison of their outcomes to those of contemporaneous IBA patients with similar demographic backgrounds. In order to adjust for baseline characteristics that might impact outcomes, we pair-matched BACD patients with IBA patients for age at KPE and sex to allow for adequate analysis of the native liver function. The matched-pair study did not demonstrate any significant differences with regard to the preoperative variables, such as AST, ALT, and PLT; however, significant differences in postoperative liver function and native liver survival after KPE were observed. This may not only indicate that the beneficial effects of earlier KPE on survival outcomes were more evident in BACD than those in IBA, but also that the superior outcomes of BACD are less affected by age at KPE than those of IBA.

According to the preoperative laboratory findings before matched-pair analysis, the APRi value in BACD was statistically lower than that in IBA. This result could be interpreted as a superior result of earlier KPE in the beginning stages of hepatic fibrosis in BACD as indicated by the lower median age at KPE among patients with BACD than that among patients with IBA. However, even though the difference in APRi disappears after adjusting for factors, such as age and sex, lower TB levels after KPE, and higher 5-year native liver survival rate in BACD demonstrate that the difference in prognosis between groups cannot simply be explained by the difference in the progression of hepatic fibrosis at the time of KPE. Patients in the BACD group showed increased bile flow and prolonged native liver survival than the matched-IBA patients.

Based on one of our index cases, we suggest that some BACD patients may be diagnosed during a period of slow degeneration of the bile duct that started from each end of the extrahepatic bile duct on the verge of total occlusion. In this specific case, an extrahepatic cystic mass was detected by prenatal ultrasonography at 23 + 1 weeks' gestation but disappeared by the last prenatal ultrasonography. Despite this, the patient was referred to our center owing to apparent jaundice and whitish stool at the age of 2 months. Intraoperative cholangiography showed BA with a cystic degeneration. We inferred that the obliterative fibrotic changes occurred from both ends of the extrahepatic bile duct and moved toward the center (cephalocaudal and/or caudocephalic direction) in BACD, finally forming a confined cyst in the middle of the common bile duct (Fig. 3). Masumoto and Fujishiro et al. also documented unusual cases wherein prenatally-detected cysts at the hepatic hilum progressed to completely occlude the common hepatic duct [15,16]. We reason that slower and more serial degenerative obliteration of the extrahepatic bile duct in patients with BACD might be associated with better bile flow and lesser progression of hepatic fibrosis than that in patients with IBA.

We recognize that single-timepoint operative cholangiography has limitations when observing the exact flow and cyst-filling pattern of the radiopaque dye via the atretic bile duct. Based on our intraoperative cholangiographic findings (Fig. 4), dynamic fluoroscopic intraoperative cholangiography provided valuable information by providing better

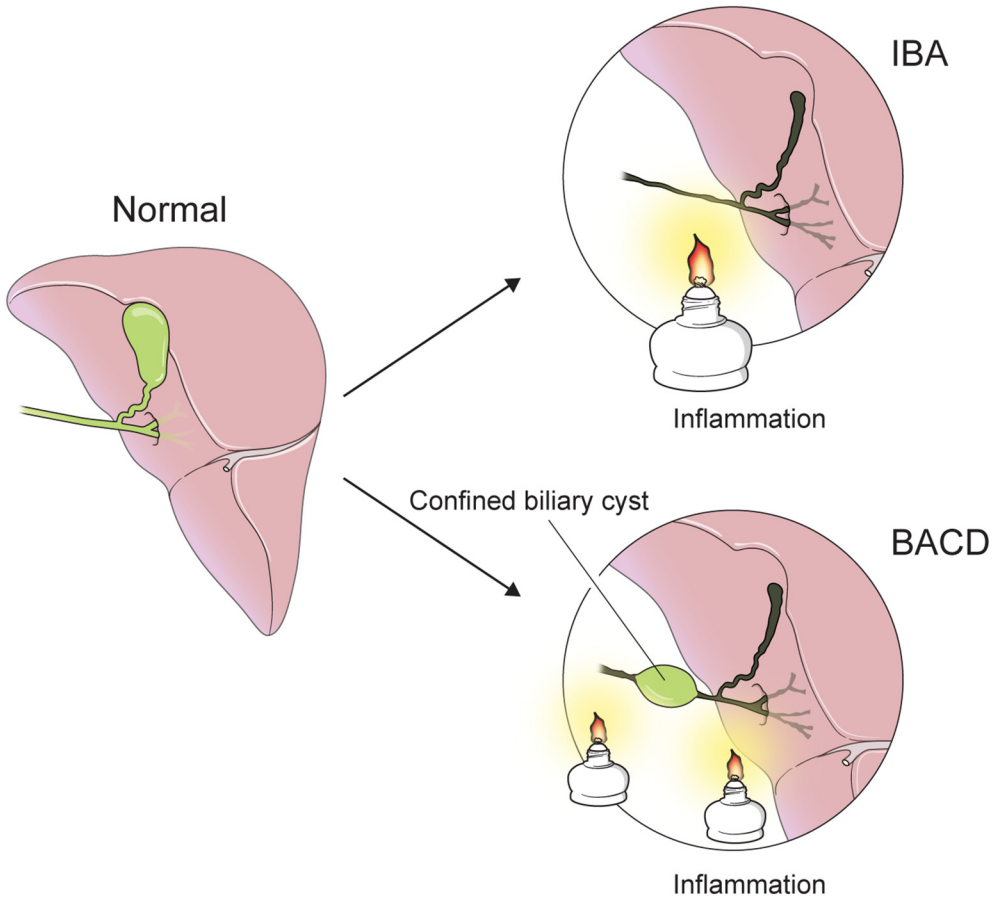

Fig. 3. Illustrations depicting the hypothesis of progressive inflammation of biliary atresia with cystic degeneration (BACD) that developed from both ends of the extrahepatic bile duct and that moved towards the center (bottom right), compared with the isolated biliary atresia (IBA) inflammatory process (top right). BACD: Biliary atresia with cystic degeneration, IBA: Isolated biliary atresia.

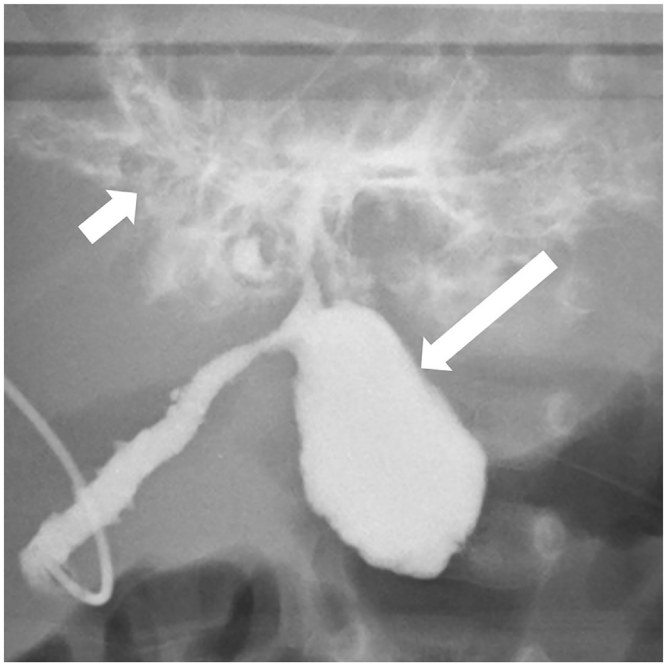

Fig. 4. Dynamic fluoroscopic intraoperative cholangiography showing cystic extrahepatic degeneration (long arrow) and atretic intrahepatic biliary tract (short arrow).

visualization of cloudy or tree-like intrahepatic, extremely-narrow bile ducts [17,18]. We recommend the use of fluoroscopic operative cholangiography for the differential diagnosis because the contrast flow pattern can be visualized in real-time while finely adjusting the manual pressure when BACD is suspected on preoperative ultrasonography or MRCP.

Through the fluoroscopic operative cholangiography, the estimated percentage of the visible intrahepatic bile duct in BACD was significantly higher than that of matched-IBA (42.9% vs. 3.5%, $p < 0.001$, Table 2). Given the higher rate of the visible intrahepatic bile duct and evidence for the slow progression of fibrotic change in extrahepatic bile duct in index BACD cases, the varying degrees of extrahepatic bile duct inflammation and obstruction may have preceded the change in cholestasis, thus contributing to the superior outcomes in BACD.

The following limitations should be noted when considering the findings of the current study. Firstly, this analysis used observational, retrospective data from a single-center registry. To reduce selection bias and confounding factors, matched-pair analysis was applied between the BACD and IBA groups. Although differences remained in terms of the variation in postoperative care over the past 20 years, adjustments were made based on patients' demographic characteristics and not the type of BA. Additionally, improper diagnosis of patients with BACD owing to leakage of the contrast dye during intraoperative cholangiography could have occurred. However, with the advent of improved preoperative magnetic resonance cholangiopancreatography and ultrasonography imaging techniques, all patients suspected with BACD were thoroughly examined during operation, and all porta hepatis tissue samples obtained at the time of KPE were histopathologically inspected.

4. Conclusions

In conclusion, patients with BACD treated with KPE demonstrated better bile flow and higher native liver survival rates than those with IBA, regardless of age or sex. In addition, significant findings, such as atretic degeneration starting from each end of the extrahepatic biliary tract, but incomplete progression in some patients, might serve as a clue for understanding the etiology of BACD. However, despite the distinct differences in clinical outcomes, the underlying pathophysiology of the different inflammatory processes and the degree of fibrotic change in BACD remains unclear. Further fundamental researches will be necessary to determine the pathophysiology associated with different inflammatory changes in extrahepatic bile duct in BACD patients and to determine the optimal approach for the care of this patient population.

Acknowledgments

The authors thank Medical Illustration & Design, a section of the Medical Research Support Services of Yonsei University College of Medicine, for all artistic support related to this work. We also thank Ha Yan Kim for contributions to the management of data analytics and other members of Biostatistics Collaboration Unit, Department of Biomedical Systems Informatics, Yonsei University College of Medicine.

Declaration of interests

None.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

[1] Feldman AG, Mack CL. Biliary atresia: cellular dynamics and immune dysregulation. Semin Pediatr Surg 2012;21(3):192–200.
[2] Verkade HJ, Bezerra JA, Davenport M, et al. Biliary atresia and other cholestatic childhood diseases: advances and future challenges. J Hepatol 2016;65(3):631–42.
[3] Jiexiong F, Minju L, Hongfeng T, et al. Clinical and pathological characteristics of cystic lesions of extrahepatic bile duct in neonates. Acta Paediatr 2003;92(10):1183–9.
[4] Caponcelli E, Knisely AS, Davenport M. Cystic biliary atresia: an etiologic and prognostic subgroup. J Pediatr Surg 2008;43(9):1619–24.
[5] Hill SJ, Clifton MS, Derderian SC, et al. Cystic biliary atresia: a wolf in sheep's clothing. Am Surg 2013;79(9):870–2.
[6] Kim J, Yoon H, Lee MJ, et al. Clinical utility of mono-exponential model diffusion weighted imaging using two b-values compared to the bi- or stretched exponential model for the diagnosis of biliary atresia in infant liver MRI. PLoS One 2019;14(12):e0226627.
[7] Kim YH, Kim MJ, Shin HJ, et al. MRI-based decision tree model for diagnosis of biliary atresia. Eur Radiol 2018;28(8):3422–31.
[8] Davenport M, Tizzard SA, Underhill J, et al. The biliary atresia splenic malformation syndrome: a 28-year single-center retrospective study. J Pediatr 2006;149(3):393–400.
[9] Ihn K, Na Y, Ho IG, et al. A periodic comparison of the survival and prognostic factors of biliary atresia after Kasai portoenterostomy: a single-center study in Korea. Pediatr Surg Int 2019;35(3):285–92.
[10] Kim SY, Seok JY, Han SJ, et al. Assessment of liver fibrosis and cirrhosis by aspartate aminotransferase-to-platelet ratio index in children with biliary atresia. J Pediatr Gastroenterol Nutr 2010;51(2):198–202.
[11] Grieve A, Makin E, Davenport M. Aspartate aminotransferase-to-platelet ratio index (APRi) in infants with biliary atresia: prognostic value at presentation. J Pediatr Surg 2013;48(4):789–95.
[12] Suominen JS, Lampela H, Heikkila P, et al. APRi predicts native liver survival by reflecting portal fibrogenesis and hepatic neovascularization at the time of portoenterostomy in biliary atresia. J Pediatr Surg 2015;50(9):1528–31.
[13] Yang LY, Fu J, Peng XF, et al. Validation of aspartate aminotransferase to platelet ratio for diagnosis of liver fibrosis and prediction of postoperative prognosis in infants with biliary atresia. World J Gastroenterol 2015;21(19):5893–900.
[14] Redkar R, Davenport M, Howard ER. Antenatal diagnosis of congenital anomalies of the biliary tract. J Pediatr Surg 1998;33(5):700–4.
[15] Masumoto K, Kai H, Oka Y, et al. A case of cystic biliary atresia with an antenatally detected cyst: the possibility of changing from a correctable type with a cystic lesion (I cyst) to an uncorrectable one (IIId). Pediatr Surg Int 2011;27(1):99–102.
[16] Fujishiro J, Iwanaka T, Arai M, et al. Disappearing cyst of the hepatic hilum in uncorrectable biliary atresia. Pediatr Surg Int 2005;21(2):116–8.
[17] Nio M, Sano N, Ishii T, et al. Long-term outcome in type I biliary atresia. J Pediatr Surg 2006;41(12):1973–5.
[18] Suzuki T, Hashimoto T, Hussein MH, et al. Biliary atresia type I cyst and choledochal cyst [corrected]: can we differentiate or not? J Hepatobiliary Pancreat Sci 2013;20(5):465–70.