Tumor and tumor-like lesions in the liver with biliary atresia

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Purpose

Biliary atresia (BA), an inflammatory cholangiopathy of infancy, affects about 5-10/100,000 live births, leading to progressive fibrosis and obliteration of the bile ducts with development of secondary biliary cirrhosis [1]. Although Kasai portoenterostomy (KP), usually performed in the first three months of life in the children with BA, has increased the survival [2, 3], liver transplantation (LT) is the main indication for BA in the pediatric age. In current practice, imaging is routinely performed for both monitoring and pretransplant work-up in the post-Kasai patients with BA. With progressive liver fibrosis, children with BA might be at increased risk of hepatic malignancy [4-8]. Discovery of a liver tumor in these patients is challenging in diagnosis and management, sometimes affecting the plan for LT. The literature reports only cases of hepatocellular carcinoma (HCC), hepatoblastoma and cholangiocarcinoma in children with BA. Focal nodular hyperplasia (FNH) is also reported to develop in the BA liver [4, 5, 7-12]. Large regenerating nodules (LRN) developing in the cirrhotic liver are known to mimic HCC in imaging [9]. In fact, confident diagnosis of liver tumors is very important in the post-Kasai survivors awaiting LT. However, until now, there have been no large series studies of liver tumors in pediatric patients with BA. Therefore, we conducted this retrospective study to review our experience of tumors and tumor-like lesions in BA patients and to investigate the prevalence, radiologic and pathological features.

Methods and Materials

Patients

The Institutional Review Board approved this study, and informed consent was not required because this was a retrospective study. The registry of pediatric surgery patients who had undergone KP at our institution was accessed to identify all patients diagnosed with BA between January 1997 and August 2012. Out of 180 patients diagnosed with BA who underwent KP, 157 patients (110 received KP followed by LT and 47 patients KP alone) who had been adequately followed with imaging were included in the initial study database. Adequate follow-up was defined as having regular imaging exams using at least one of three imaging modalities (US, CT and MRI) that included the entire liver. From review of the radiologic and pathologic report in these 157 patients, we identified 13 patients who had finally confirmed tumors and tumor-like lesions in the liver pathologically and/or clinicoradiologically (Fig 1).
Fig. 1: Flow chart of the selected patients

Note. - BA = biliary atresia, KP = Kasai portoenterostomy, LT = liver transplantation, HCC = hepatocellular carcinoma

References: Radiology, Samsung medical center - Seoul/KR

From the patient’s medical records, data including gender, age at the time of discovery of liver tumor and time between KP and mass detection, alpha fetoprotein (AFP), pathological diagnosis, and outcome were obtained.

Imaging Analysis

Imaging modalities used in the enrolled patients were as follows: US (n=13), triphasic (arterial, portal, and delayed phase scans, n=5) or monophasic CT scan (portal phase scan, n=8) and MRI (n=1).

All US examinations were performed by pediatric radiologists. The equipments used were US systems of various vendors (HDI 5000, Philips Medical Systems, Best, the Netherlands; Sequoia, Siemens Healthcare, Erlangen, German) with high resolution.
5-12-MHz linear-array transducer and 5-10-MHz curved-array transducer. CT was performed using MDCT scanners (LightSpeed16 GE, Medical Systems Milwaukee, WI, or Brilliance 40, Philips Medical Systems, Best, the Netherlands) using a low-dose technique based on patient weight and automatic exposure control. The triphasic (arterial, portal and delayed phase) or single portal phase was obtained after injecting intravenous contrast material (2 mL/kg, maximum 120 mL) with a 5 mm slice thickness. MRI was performed in the selected patient using a 3-T MRI system (Intera Achieva 3 T, Philips Healthcare) and a phased-array coil. The liver was imaged in the axial plane both before and after administration of gadoxetic acid (Primovist, Bayer-Schering Pharma, Berlin, Germany) at a dose of 0.1 mL/kg (0.25 mmol/mL). The MRI protocol included a T1-weighted turbo field-echo in-phase and opposed sequence, a breath-hold multishot T2-weighted sequence, and a respiratory- triggered heavily T2-weighted sequence. For gadoxetic acid-enhanced dynamic imaging, unenhanced, arterial (20-35 seconds), portal (60 seconds), delayed (3 minutes), and 20-minute hepatobiliary phase were obtained using a T1-weighted 3D turbo-field-echo sequence (T1 high-resolution isotropic volume examination, THRIVE, Philips Healthcare).

Imaging studies of the enrolled patients were reviewed from the picture archiving and communicating system (PACS) (GE Medical Systems Integrated Imaging Solutions, Mt Prospect, Ill) by consensus of two pediatric radiologists (S.Y.Y and T.Y.J), and they evaluated the location, size (the largest diameter), echogenicity and vascularity on US, attenuation/signal intensity with enhancing pattern on CT or MRI, presence of necrosis, calcification and central scar.

Images for this section:
Fig. 1: Flow chart of the selected patients

Note. - BA = biliary atresia, KP = Kasai portoenterostomy, LT = liver transplantation, HCC = hepatocellular carcinoma
Results

Thirteen patients were identified who had developed a new liver tumor or tumor-like lesion (10 girls and 3 boys; median age at initial diagnosis, 10 months; range, 2~192 months). Of 13 patients, 10 patients received LT (median age 7 months, range, 2~156 months) and 3 patients received KP alone. One of the latter three patients underwent biopsy for pathologic confirmation of a liver nodule. Therefore, confirmation of the liver tumor was based on pathologic results in 11 and clinicoradiologic features in two (FNH and HCC). The median time between KP and mass detection was 16 months, ranging from 3.5 to 193 months.

The overall prevalence of new liver tumors in our series is 8.2% (13/157). Ten were benign, FNH being the most common (n=6), followed by LRN (n=3), and adenoma (n=1). The prevalence of malignancy is 1.9 % (3/157), including HCC (n=2) and cholangiocarcinoma (n=1).

The size of the liver lesions varied from 0.6 to 5.7 cm (mean 2.5 cm). No lesions had segmental predilection. All FNH lesions showed subcapsular location with bulging contour and were homogenously iso- or hyperechoic on US with increased vascularity. CT attenuation of each lesion was variable and central scar was observed in none. Three proven FNH lesions were radiologically interpreted as malignancy including HCC or hepatoblastoma, because they appeared as poorly enhancing masses on CT. One such lesion showed enhancement on arterial phase and delayed washout becoming low-attenuated on delayed phase like HCC (Fig. 2, case No. 1), while another was accompanied with abnormally increased AFP at initial lesion detection.
Fig. 2: Focal nodular hyperplasia in a 5-month-old infant with biliary atresia. Grayscale (A) and power Doppler US (B) show a round, subcapsular, hyperechoic mass with increased vascularity. Triphasic CT scan (C = arterial; D = portal; E = delayed phase) reveals arterial enhancement and delayed washout of the mass (arrows), simulating hepatocellular carcinoma.

References: Radiology, Samsung medical center - Seoul/KR

Three proven LRNs showed variable radiologic findings on CT and US. One such lesion demonstrated an isoechoic mass with hypervascularity on US and ill-defined mass-like lesion on CT. Another was a hypoechoic mass on US but, invisible on CT (Fig 3, case No. 8).
Fig. 3: Large regenerating nodule in a 4-year-old girl with biliary atresia. The lesion appears as a well-defined hypoechoic nodule (arrows).

References: Radiology, Samsung medical center - Seoul/KR

The third one was a slightly hypoechoic nodule with vascularity on US and a strongly enhancing nodule on CT.

Two HCC lesions which occurred in a 7 month and a 16 year-old girl (case No. 11 and 12) showed hypoechoic nodules on US. In one patient, gadoxetic acid-enhanced MRI was performed for further characterization of the mass, and the lesion had typical MRI findings of HCC: low signal intensity on T1 weighted image, intermediate high signal intensity on T2 weighted image, and arterial enhancement and delayed wash out on dynamic study and, low signal intensity on 20-minute hepatobiliary phase. This lesion was treated with radiofrequency ablation without recurrence for 15 months follow-up period (Fig 4).
Fig. 4: Hepatocellular carcinoma in a 16-year-old girl with biliary atresia. MR images with Primovist contrast agent show typical MRI findings of HCC: low signal intensity on T1 weighted image (A), intermediate high signal intensity on T2 weighted image (B), and arterial enhancement (C) and delayed wash out (D) on dynamic study and, low signal intensity on 20-minute hepatobiliary phase (E). AFP was in normal range (1.7 ng/ml).

References: Radiology, Samsung medical center - Seoul/KR

The other HCC which occurred in a 7 month-old boy was initially detected as a subcentimeter sized hypoechoic nodule by US. However, it was invisible on subsequent single phase post-contrast CT and AFP was in normal range. With deterioration of hepatic function, early LT was planned in this patient. There was no concern for malignancy during pretransplant work up. Eventually, pathologic examination of the explanted liver revealed HCC [13].

The cholangiocarcinoma case (case No. 13) showed a lobulating isoechoic mass on US and a low-attenuating mass on portal and delayed phase with surrounding bile lakes on CT. This mass was radiologically interpreted as a malignancy (Fig 5).
**Fig. 5:** Cholangiocarcinoma of a 13-year-old girl with biliary atresia. Arterial (A), portal (B) and delayed phase (C) scan show a central, lobulating mass (arrows) with surrounding bile lakes. Portal (B) and delayed phase (C) scan demonstrate low-attenuation of the mass compared with surrounding liver parenchyma.

**References:** Radiology, Samsung medical center - Seoul/KR

The case of adenoma (case No. 10) showed a 4cm hyperechoic lesion on US and persistent low attenuation on triphasic postcontrast CT. This lesion was also radiologically classified as a malignancy and AFP was in normal range. Targeted biopsy was performed and histopathology revealed an adenoma. On follow up US, the lesion size decreased.

All 13 patients had underlying biliary cirrhosis and seven patients additionally had bile lakes. AFP was available in 11 patients and all patients were in normal range except in one patient with FNH (17540 ng/ml). The details of the enrolled patients and the lesions including radiologic features are summarized in Table 1 on page 14.
Table 2: Condensed table of clinical and radiologic features in 13 patients

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<th>Benign</th>
<th>Malignant</th>
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<td>LRN</td>
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<td>0.6~5</td>
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<td>Iso~Hyper</td>
<td>Hypo~Iso</td>
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<td>Delayed WO(1), all low on 3-p CT(1)/hypo(1)/hyper(3)</td>
<td>Iso~Hyper</td>
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<td>Associated Rx findnigs</td>
<td>BC(6)/BL(4)</td>
<td>BC(3)/BL(2)</td>
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</table>

2 FNHs and an adenoma: Radiologically Dx. → Malignancy

References: Radiology, Samsung medical center - Seoul/KR

Images for this section:
Fig. 2: Focal nodular hyperplasia in a 5-month-old infant with biliary atresia. Grayscale (A) and power Doppler US (B) show a round, subcapsular, hyperechoic mass with increased vascularity. Triphasic CT scan (C = arterial; D = portal; E = delayed phase) reveals arterial enhancement and delayed washout of the mass (arrows), simulating hepatocellular carcinoma.
Fig. 3: Large regenerating nodule in a 4-year-old girl with biliary atresia. The lesion appears as a well-defined hypoechoic nodule (arrows).
Fig. 4: Hepatocellular carcinoma in a 16-year-old girl with biliary atresia. MR images with Primovist contrast agent show typical MRI findings of HCC: low signal intensity on T1 weighted image (A), intermediate high signal intensity on T2 weighted image (B), and arterial enhancement (C) and delayed wash out (D) on dynamic study and, low signal intensity on 20-minute hepatobiliary phase (E). AFP was in normal range (1.7 ng/ml).

Fig. 5: Cholangiocarcinoma of a 13-year-old girl with biliary atresia. Arterial (A), portal (B) and delayed phase (C) scan show a central, lobulating mass (arrows) with surrounding bile lakes. Portal (B) and delayed phase (C) scan demonstrate low-attenuation of the mass compared with surrounding liver parenchyma.

Table 1: Summary of clinical and radiologic features in 13 patients Note-FNH=focal nodular hyperplasia, HCC=hepatocellular carcinoma, HBL=hepatoblastoma, LRN=large regenerative nodule, CCC=cholangiocarcinoma, A-phase=arterial phase, D-phase=delayed phase *This small nodule was not detected by either CT or MRI. †Triphasic CT scan was performed rather than single phasic scan. ‡This lesion treated with RFA without pathologic confirmation. §This lesion was pathologically confirmed by percutaneous liver biopsy.

<table>
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<th>Age(months)/Sex</th>
<th>Size (cm)</th>
<th>Location (segment)</th>
<th>Subcapsular location with bulging contour</th>
<th>US echogenicity</th>
<th>Enhancement on CT</th>
<th>MRI T1W/T2W/C+</th>
<th>AFP at initial lesion detection (ng/ml)</th>
<th>Radiologic diagnosis</th>
<th>Histopathologic diagnosis</th>
<th>LT</th>
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<td>HCC or HBL</td>
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<td>FNH</td>
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<td>CCC</td>
<td>Yes</td>
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</table>
Table 2: Condensed table of clinical and radiologic features in 13 patients Note- FNH=focal nodular hyperplasia, LRN= large regenerative nodule, HCC=hepatocellular carcinoma, CCC=cholangiocarcinoma, 3-p=triphase, Rx=radiologic, BC=biliary cirrhosis, BL=bile lakes
Conclusion

Our study results has four main findings: 1) Liver tumors are relatively uncommon in children with BA (8.2%, 13/157); 2) Benign nodules such as FNH or LRN are more frequent than malignant tumors in the liver with BA and may simulate malignancy; 3) Some new hepatic lesions showed nonspecific radiologic findings which make tumor differentiation difficult; 4) However, FNH tended to have a predilection for peripheral area, manifested as a homogeneous mass with bulging contour and variable CT attenuation and US echogenicity with lack of central scar.

Occasional case reports have described new hepatic tumors or tumor-like lesions including LRN, HCC, cholangiocarcinoma and FNH in BA [4-12, 14], but there have been no studies on its relative prevalence in a large cohort. In this study, we found generalized prevalence of new liver lesions in patients with BA after KP (8.9%).

In this study, the most frequent lesion was FNH. The mechanism for an occurrence of FNH during a long follow-up for BA is unknown. Generally, an FNH occurs within the histologically normal or nearly normal liver [15], but several investigators [16-20] have recently reported FNH-like nodules in the cirrhotic liver. These nodules are macroscopically, microscopically, and immunohistochemically identical to FNH seen in the noncirrhotic liver. The pathogenesis of FNH-like nodules has been reported as a reaction secondary to a localized vascular anomaly, vascular injury, high sinusoidal pressure or increased flow [21-23]. In our cases, all patients had biliary cirrhosis and underwent KP; thus we hypothesized that the vascular changes induced by not only biliary cirrhosis but also KP, and the consequent blood flow alterations might induce the development of the FNH. Therefore, FNHs in this study can be strictly classified into FNH-like nodules. The common radiologic feature of all FNHs in our study was subcapsular location with a bulging mass. One recent study by Lee et al. showed that increased hepatic subcapsular flow on color Doppler US caused by the increased number and diameter of hepatic arterial branches proved by pathologic examination were seen in all BA patients [24]. We, therefore, speculate that the subcapsular predilection of FNH observed in our study could be explained by vascular alteration in the liver with BA which makes peripheral hepatic territories vulnerable site of FNH or FNH-like nodules. Radiologically, three FNHs in our study were misdiagnosed as malignancy without the classical findings of FNH. Previous reports found that FNHs in children with BA demonstrated hypodense post-contrast enhancement and sometimes FNH-like lesions mimic HCC [11, 20]. Similarly, there have been several reports about atypical radiologic features of FNH or FNH-like lesions in both children and adults [16, 18, 25]. Moreover, since pediatric patients usually take single phase CT rather than triphasic CT considering radiation dose in clinical practice, am enhancing pattern may not be taken into consideration for differential diagnosis. Based on our results, if the hepatic mass
appears as a homogenous lesion with subcapsular location in patient with BA, FNH or FNH-like lesion should be considered in the differential diagnosis.

In general, cirrhotic liver often accompanies regenerative nodule, dysplastic nodules, and/or adenomatous hyperplasia. These nodules are recognized as precancerous lesions and may occur in long standing BA patients with cirrhosis [26]. In our study, radiologic findings of HCC, LRN, and adenoma were not specific and differentiation between the three entities was not possible in that they showed variable radiologic features. In one infant (7 month old, case No. 11 in Table 1 on page 17), HCC was demonstrated as a small nonspecific hypoechoic nodule on US, and even that was invisible on post-contrast CT. In fact, HCC was not suspected until the total hepatectomy specimen was examined after LT. This experience suggests that all children, even young age patients with BA should be regarded as having a potential for HCC development and urgently should consider next diagnostic step for lesion differentiation.

In summary, liver tumor in pediatric patients with BA is infrequent and benign nodules such as FNH and LRN are more common than malignant tumors. Although radiologic features can be overlap both in benign and malignant lesions in these patients, the knowledge of the differential diagnosis could be helpful for guiding further work-up and proper management.

Images for this section:

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (months)</th>
<th>Sex</th>
<th>Size (cm)</th>
<th>Location (segment)</th>
<th>Subcapsular location with bulging contour</th>
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<td>No</td>
<td>Hyperoechoic</td>
<td>3.4</td>
<td>CCC or HCC</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Summary of clinical and radiologic features in 13 patients Note-FNH=focal nodular hyperplasia, HCC=hepatocellular carcinoma, HBL=hepatoblastoma, LRN=
large regenerative nodule, CCC=cholangiocarcinoma, A-phase=arterial phase, D-phase=delayed phase *This small nodule was not detected by either CT or MRI. †Triphasic CT scan was performed rather than single phasic scan. ‡This lesion treated with RFA without pathologic confirmation. §This lesion was pathologically confirmed by percutaneous liver biopsy.
References


**Personal Information**