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Liver tumors in children and young patients: sonographic and color Doppler findings

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Abstract

Background: Liver tumors are a relatively rare pathologic condition in children and young patients. The aim of the present study was to categorize the sonographic (US) and color Doppler results of liver tumors in these patients.

Methods: We retrospectively reviewed the US findings of 23 such cases: malignant tumor (13 cases)—hepatoblastoma (four cases), hepatocellular carcinoma (HCC; four cases), and hepatic metastasis (five cases); benign tumor (10 cases)—hepatocellular adenoma (four cases), focal nodular hyperplasia (two cases), mesenchymal hamartoma (two cases), cystadenoma (one case), and hemangioendothelioma (one case).

Results: There was no specific US findings for each tumor type. HCC usually developed on a normal liver and was imaged as multiple nodules. Color Doppler US helped in differentiating multiple metastatic nodules (hypovascular) from multiple HCC nodules (hypervascular). Presence of intratumoral cystic areas was usually suggestive of benign tumors. Follow-up US was useful for detecting small nodules in high-risk groups (congenital biliary atresia, glycogen storage disease). Color Doppler US helped in diagnosing portal thrombus or intratumoral shunt.

Conclusion: Although there were no highly specific findings, US and color Doppler results contributed, to a certain degree, to the diagnosis of liver tumors in children and young adults by showing intratumoral cystic areas or vascularity.

Key words: Ultrasound—Doppler—Liver—Neoplasm—Children.

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Liver tumors in adult patients have been investigated from various points of view, but reports of liver tumors in children and young adults are relatively rare and deal mainly with histologic findings or surgical procedures [1–5]. Although diverse hepatic diseases have been explored by sonography (US) and more recently by color Doppler US, US or color Doppler findings of liver tumors in children and young patients are rarely reported [6–9]. However, considering the fact that diagnostic exploration of the abdomen usually begins with US, especially in children, these findings need to be determined more precisely. In addition, the diagnostic limitations of US and color Doppler US must also be recognized.

In the present report, we try to determine the role and problems of US and the contribution of color Doppler US in the diagnosis of liver tumors in children and young adults (younger than 20 years). We believe that the results will allow us to draw certain important conclusions to help us to understand the diagnostic procedure of liver tumors in children and young adult cases more precisely.

Patients and methods

The tumor registry of our institution over a 10-year period was retrospectively reviewed for children and young patients (0–20 years-old) who had US performed for pathologically proven liver tumors. Twenty-three cases (12 boys, 11 girls; age range = 0–20 years, average age = 10.2 years) were available for review. The histology of the 23 cases included 13 cases of malignant tumor (hepatoblastoma, four cases, with a male:female ratio of 3:1; hepatocellular carcinoma [HCC], four cases, with a male:female ratio of 3:1; and metastasis, five cases, with a male:female ratio of 3:2) 10 cases of benign tumor (hepatocellular adenoma, four cases, with a male:female ratio of 1:3; mesenchymal hamartoma, two cases, with a male:female ratio of 0:2; focal nodular hyperplasia, two cases, with a male:female ratio of 0:2; hepatic cystadenoma, one case, male; and hepatic hemangioendothelioma, one case, male).

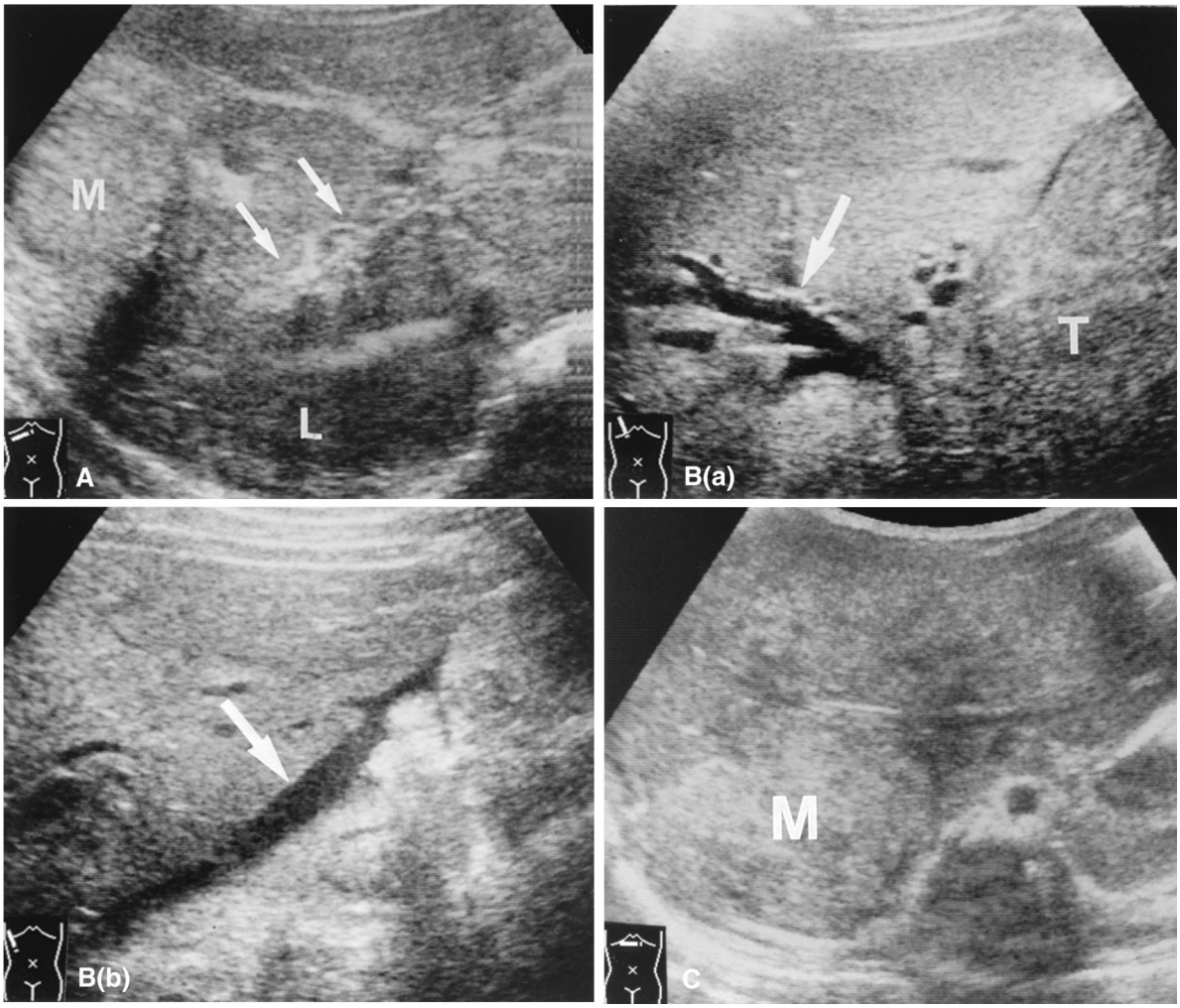

Fig. 1. Representative sonograms of malignant tumors. **A** Hepatoblastoma: An echogenic mass (*M*) associated with portal tumor thrombus (*arrows*). *L* liver. **B** Hepatocellular carcinoma. **B(a)** HCC tumor nodule (*T*) with biliary obstruction (*arrow*). **B(b)** Ascites (*arrow*) secondary to tumor rupture (not shown). The parenchymal echo texture is normal. **C** Liver metastases: multiple echogenic masses (*M*) in the liver.

In all cases, medical records were reviewed and the clinical information (sex, symptoms, laboratory data), diagnostic finding with particular attention paid to US and color Doppler results, treatment, and outcome were evaluated. US was performed in all cases and color Doppler US in 15 patients. For all study subjects, the hepatic lesion was not known before US examination.

The indications for abdominal US were multiple: abdominal distention in nine cases, severe abdominal symptoms in three cases, for a follow-up study in chronic hepatic disease in four cases, as part of a general screening in two cases, and other reasons in four cases. US and color Doppler US were performed mainly with a Toshiba SSA 380 A system (Tokyo, Japan) with a 4.2-MHz convex transducer.

Histologic confirmation of the lesions was obtained in all cases except in four of the five cases of metastasis, by an analysis of surgically resected specimens in 13 cases, by analysis of US-guided biopsy specimen in four cases, and by autopsy in two cases. In four of five metastatic cases, the final diagnosis of hepatic metastasis was based on histologic confirmation of primary tumors and rapid change of hepatic lesions on medical imaging.

Results

Malignant tumors (Fig. 1)

Hepatoblastoma (four cases) (Fig. 1A)

One small (1 cm) hepatoblastoma lesion was incidentally detected in the right hepatic lobe during a follow-up US in a 4-year-old boy with congenital biliary atresia. The lesion was imaged as a round hypoechoic mass. A hepatic transplantation was performed, and histologic examination confirmed this lesion to be a hepatoblastoma. The other three patients presented with a marked hepatomegaly and showed the following US findings. The lesions consisted of a single nodule in the right hepatic lobe in

two cases and of multiple nodules throughout the both lobes in one case. The diameters of the nodules varied from 8 cm to more than 15 cm. The nodules were imaged as markedly hyperechoic, well-demarcated, round masses with a relatively homogeneous internal echo structure accompanied by a weak posterior acoustic attenuation. The surrounding hepatic parenchyma was sonographically normal. Color Doppler US visualized blood flows in the lesion and confirmed that the portal vein filled with tumor thrombus and development of portal collaterals near the tumor. The US findings were histologically confirmed by surgical intervention. All patients were alive, with survival times ranging between 1 and 6 years (average = 4. 0 years)

Hepatocellular carcinoma (four cases) (Fig. 1B)

One small (7 mm) hypoechoic mass was incidentally detected in the right hepatic lobe during a follow-up US in a 3-year-old boy with congenital biliary atresia. Except for this case, the patients were older than 15 years and presented with a sudden severe abdominal symptom (jaundice in two cases and shock due to tumor rupture in one case). In all cases, emergent US detected multiple masses throughout both lobes, with peripheral biliary dilatation in the jaundiced patients and ascites in the tumor rupture patient. The nodules were imaged as hypoechoic, well-demarcated, round masses with a homogeneous internal echo structure when they were small and as poorly defined echogenic masses with a heterogeneous internal echo structure as the masses grew larger. The surrounding hepatic parenchyma was normal. There were very few blood flow signals in the lesions when they were small ($<$1 cm); when the lesions grew larger, they were rich in blood flow. These results prompted appropriate successive treatments (embolization, drainage). Multiple HCCs on normal liver also were histologically confirmed. One of the four patients was alive 7 years after surgery with tumor recurrence and lung metastasis. The other cases deteriorated rapidly and died within 6 months after the diagnosis.

Hepatic metastasis (five cases) (Fig. 1C)

Three of the five patients presented with recently, rapidly increased abdominal distention; in the other two cases, the metastasis was detected by US performed as part of a general screening in malignant tumor patients. The metastatic lesions consisted of multiple nodules throughout both lobes in all cases. The metastatic lesions ranged in size from a few millimeters to more than 10 cm. They were imaged as hyper- or hypoechoic well-demarcated round masses regardless of size. They had a homogeneous internal echo structure when they were small and the internal echo structure became heterogeneous as the lesions grew larger. The echogenicity of metastatic lesions was generally high in patients with neuroblastoma, colonic carcinoma, and choriocarcinoma. It was relatively low in the other metastatic patients (lung, stomach). The lesions exhibited poor blood flow, but they markedly compressed the surrounding vessels when they were large. This series included a newborn boy. He was found to have multiple echogenic masses by US and a few lung and brain nodules by magnetic resonance imaging. His general condition deteriorated rapidly and he died 2 months later. Autopsy confirmed all lesions to be metastases from a choriocarcinoma. US examination of the mother showed a huge choriocarcinoma. The outcome of the other four cases was also poor, with a survival period of less than 6 months.

Benign tumors (Fig. 2)

Hepatocellular adenoma (four cases) (Fig. 2A)

Two of the four patients presented with recently, rapidly increased abdominal distention. In these cases, the cause was undetermined. In both cases,the lesion was solitary, measuring 4 $\times$ 5 cm and 8 $\times$ 9 cm, respectively, and both were situated in the right hepatic lobe. The lesion was slightly hypoechoic, including a central cystic area in one case, and rich in vascularity in both cases. The cystic area was later histologically proven to be a central hemorrhage. In the other two cases, the lesion was detected by US during a follow-up of glycogen storage disease (type 1). The lesions consisted of multiple nodules throughout both lobes in these cases, ranging from a few millimeters to 1 cm. They were imaged as hypoechoic well-demarcated round masses with a homogeneous internal echo structure. The lesions exhibited very rich arterial and venous blood flows regardless of size. All patients were alive 1–7 years after the diagnosis.

Mesenchymal hamartoma (two cases) (Fig. 2B)

In both cases, the lesion was solitary, was situated in the right hepatic lobe, measured about 4 cm, and was composed predominantly of cystic and surrounding thin solid parts. The surrounding hepatic tissue was normal. On color Doppler US, the lesion lacked blood flow signals.

Both patients were alive 5 and 7 years after the diagnosis.

Focal nodular hyperplasia (two cases) (Fig. 2C)

In both cases, the tumor was very large, measuring more than 15 cm, and occupied almost the entire right lobe. The internal structure was complex, composed of many hypo-

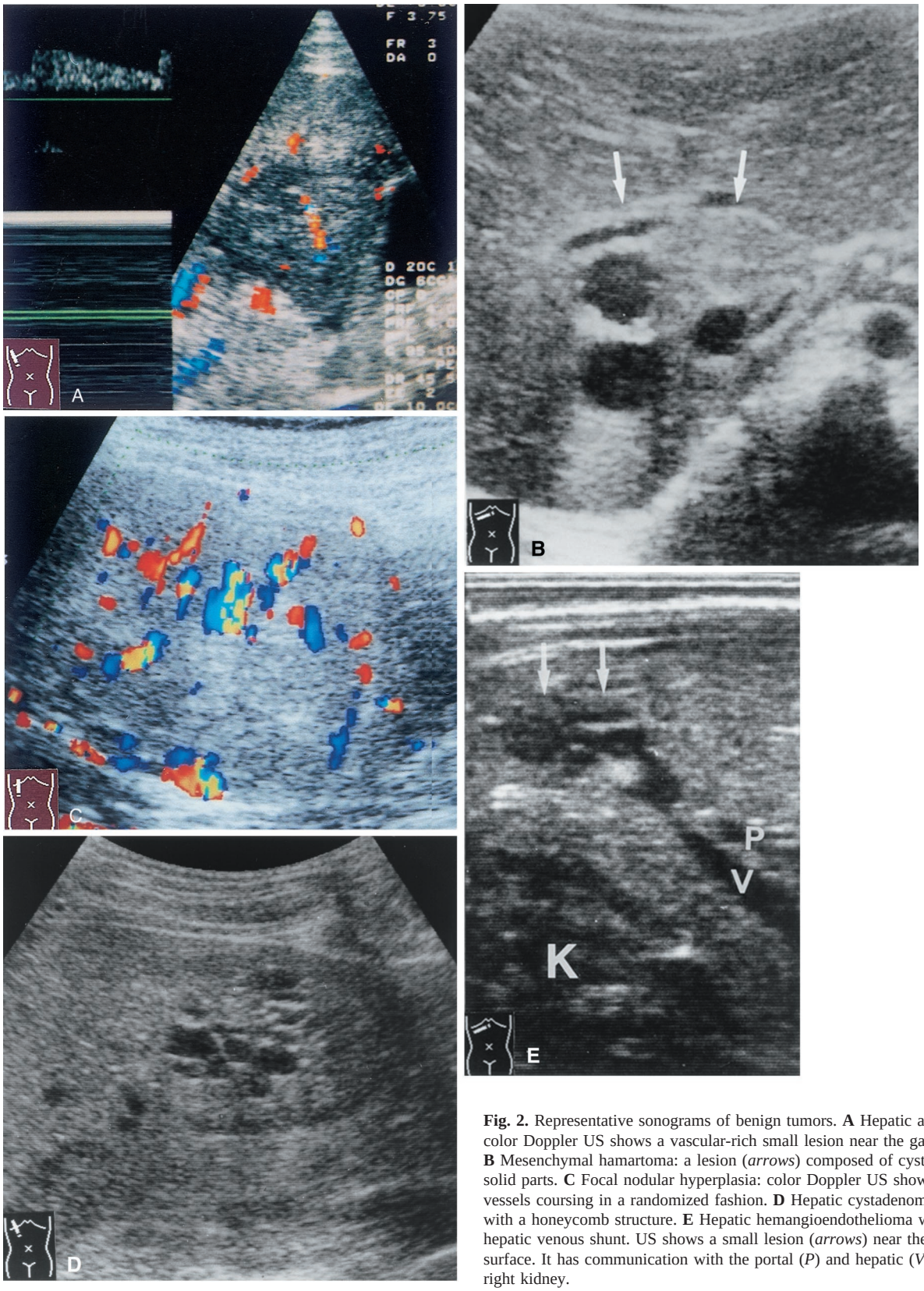

Fig. 2. Representative sonograms of benign tumors. **A** Hepatic adenoma: color Doppler US shows a vascular-rich small lesion near the gallbladder. **B** Mesenchymal hamartoma: a lesion (*arrows*) composed of cystic and solid parts. **C** Focal nodular hyperplasia: color Doppler US shows multiple vessels coursing in a randomized fashion. **D** Hepatic cystadenoma: a lesion with a honeycomb structure. **E** Hepatic hemangioendothelioma with porto-hepatic venous shunt. US shows a small lesion (*arrows*) near the hepatic surface. It has communication with the portal (*P*) and hepatic (*V*) veins. *K* right kidney.

and hyperechoic areas, but a retrospective review of US images could demarcate a central hyperechoic focus and a spoke-wheel appearance in one case. The hepatic parenchyma was normal. The tumor contained many arterial and venous flows, not only in the center but also in the periphery. The flow velocity and resistive index were quite variable, depending on the measuring point. Both patients were alive 1 and 5 years after the diagnosis.

Hepatic cystadenoma (one case) (Fig. 2D)

The lesion (3 × 3. 5 cm), composed of a solid outer layer surrounding central small cystic areas, was incidentally detected in the right lobe by routine US. The lesion compressed fine surrounding vessels, but itself lacked blood flow signals. The patient was alive 2 years after the diagnosis.

Hepatic hemangioendothelioma (one case) (Fig. 2E)

This patient was free of symptoms due to congestive heart failure, coagulopathy, or anemia. A solitary hepatic mass was incidentally detected by US in a 3-year-old boy with transitory hematuria. The mass was situated near the hepatic surface in the right lobe and was composed of an almost isoechoic mass including a central cystic area. US showed connections between the right portal vein and the right hepatic vein through the tumor. A portal–hepatic venous shunt through the tumor was confirmed by color Doppler and angiography. The patient was alive 7 years after the diagnosis.

Discussion

Liver tumors in children and young patients are roughly divided into malignant and benign, as in adult cases. Malignant tumors include hepatoblastoma, HCC, cholangiocarcinoma, sarcoma, and metastases. Benign tumors include hemangioma, hemangioendothelioma, mesenchymal hamartoma, focal nodular hyperplasia, hepatocellular adenoma, and teratoma [2, 9]. Although the number of patients in each tumor group is small in our series, our series covers the majority of these tumors, and our study has revealed some useful information for clinicians seeing children or young patients with liver tumors.

The number of lesions (solitary or multiple) and the presence of a surrounding normal hepatic parenchyma did not help in differentiating HCC from hepatic metastasis. HCC in children and young patients as opposed to adults is relatively rare and has received much less attention in the literature [10]. In addition, HCC in children and young patients has also been investigated from the viewpoint of its relation to the hepatitis virus (B and C) [11], but in our series, in three of the four cases, the etiology was undetermined and multiple HCC nodules developed on normal liver. Thus, the presence of multiple nodules on an otherwise normal liver, usually considered to be liver metastasis, can be an expression of HCC in children and young patients. Color Doppler US helps, to a certain degree, in differentiating these two pathologies (vascular-rich HCC vs. oligovascular metastasis).

The presence of cystic areas can be an US sign suggestive of the benign nature of a tumor. This sign was never seen in malignant tumor cases, including five cases of metastasis (zero of 11), but was frequently seen in benign tumor cases (five of 10). Thus, it can be a key US sign of benign liver tumors in children and young patients. In a clinical setting, however, liver metastasis is clearly visible as cystic areas in adult cases [12]. More children with liver metastasis need to be studied to determine whether cystic areas are rare in these cases.

Follow-up US studies of chronic hepatic disease serve to detect small lesions in children and in adults. In contrast to adult patients, in whom the most common causes of liver cirrhosis are viral hepatitis (B, C) and alcoholism [13], cirrhosis in children and young patients has many etiologies, including Wilson disease, primary Budd–Chiari syndrome, and congenital biliary atresia [14]. Patients with glycogen storage disease (type 1) are also at increased risk for developing hepatocellular adenoma [15]. Thus, patients with such diseases should be followed at regular intervals by US.

Color Doppler US is useful for detecting associated vascular changes. It is now used as part of a routine examination for liver tumors [12]. As was shown in our series, this technique contributes not only to establishing the diagnosis but also to detecting associated secondary vascular complications. Of interest is the portal–hepatic venous shunt seen in a case of hepatic hemangioendothelioma. Multiple arteriovenous shunts have been frequently reported in this tumor in the literature [4, 6]. Although portal–hepatic venous shunts have not been reported, this vascular change must be meticulously sought to fully understand the associated vascular changes of this tumor.

In conclusion, US is now the examination of choice for investigating the abdomen of children and young patients. Thus, we have a greater chance of encountering a liver tumor in this population with US than with other modalities. Knowledge of these US and color Doppler findings helps in making the differential diagnosis of liver tumor in these young patients.

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