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Intraoperative ultrasound for liver tumor resection in children

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ABSTRACT

Background: Primary hepatic neoplasms in children are rare tumors. All malignant and medically refractive benign primary pediatric liver tumors ultimately require surgical resection for cure. Accurate preoperative imaging including multidetector helical computerized tomography or magnetic resonance imaging (MRI) is necessary to determine resectability. In the literature intraoperative ultrasound (IOUS) has proven to be a vital adjunct to liver surgery in adults, but this is not well established in children.

Materials and methods: Between April 2003 and November 2014, children (<18-y-old) with a primary liver neoplasm, preoperatively evaluated with multidetector helical computerized tomography or MRI, who had IOUS used at the time of surgery were retrospectively reviewed.

Results: Preoperative evaluation with high-resolution MRI and IOUS were discordant in 4 of 19 patients (21%). In one case, right hepatic vein involvement was not accurately assessed with MRI. Two cases showed tumor involvement in segment IV by MRI; however, IOUS revealed no medial segment involvement. The final patient had a large (>5 cm), solitary hepatic adenoma on MRI, but IOUS in this case revealed diffuse adenomatosis. The operative management was altered in three of these cases.

Conclusions: Although MRI can provide a detailed view of the hepatic anatomy and is an invaluable tool for preoperative planning for the pediatric patient with a primary liver neoplasm, IOUS may provide further and more up to date delineation of tumor extent and should be considered a crucial element in operative planning for hepatectomy in children.

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1. Introduction

Primary hepatic neoplasms have an incidence of 2–2.5 cases per million children each year. Approximately two-thirds of these are malignant, including hepatoblastoma and hepatocellular carcinoma, which represents 1.1% of pediatric malignancies annually. The remainder includes benign tumors such as hemangiomas and hepatic adenomas [1–4]. For liver malignancies, the only curative treatment is surgical removal via margin-negative resection or liver transplantation. Benign tumors are often managed nonoperatively; however, surgical resection may be required because of the risk of malignant transformation and other serious sequelae such as high output heart failure, hemorrhage, or consumptive coagulopathy [2,5].

Because complete surgical removal is the only curative intervention for malignant and medically refractive benign tumors, accurate imaging is essential should an operative therapy be attempted. Tumor location, extent, and relationship to the hepatic and portal vasculature must be accurately delineated to determine resectability and aid in operative planning. As imaging technology has improved and new imaging techniques have emerged, preoperative imaging now provides more complete and accurate diagnostic and staging information [6]. Because there is no consensus as to whether multidetector helical computed tomography (MDCT) or magnetic resonance imaging (MRI) yields superior definitive preoperative imaging for these tumors, both modalities are used frequently, and the choice of modality is based on availability, radiology expertise, and institutional preference [6–12].

In addition to preoperative MDCT and/or MRI, intraoperative ultrasound (IOUS) of the liver has gained widespread use in adult oncologic liver resections [13,14]. Since its first documented use in the late 1970s, IOUS has repeatedly been shown to provide additional detail regarding tumor margins and vascular involvement leading to changes in operative management in spite of advances in preoperative imaging. Currently, the literature supporting the use of IOUS for resection of benign and malignant liver tumors in children is limited [15–17]. This study details a single tertiary care institution's experience with IOUS for resection of malignant and benign primary pediatric hepatic neoplasms in the era of high-resolution preoperative imaging.

2. Material and methods

Between April 2003 and November 2014, children (<18-y-old) at a single tertiary care pediatric hospital who were taken to the operating room for potential resection for a primary liver neoplasm and evaluated with both standard preoperative imaging and IOUS of the liver were reviewed. Each patient received definitive preoperative imaging of the liver with either MDCT or MRI as well as a full staging workup for patients with suspected malignant lesions. After initial workup, patients with tissue-proven malignant tumors were staged according to the International Childhood Liver Tumors Strategy Group (SIOPEL) Pretreatment Tumor Extension (PRETEXT) staging system [18]. Chemotherapeutic regimens consistent with either the SIOPEL or Children's Oncology Group guidelines were chosen at the discretion of each patient's medical oncologist. All patients with hepatoblastoma received cisplatin-based chemotherapy with regimen intensity and surgical timing based on tumor risk stratification. Posttreatment extent of disease (POSTTEXT) staging [18] and operative plan was determined from each patient's final preoperative imaging. Ultrasonography was routinely performed and interpreted in the operating room by an experienced pediatric radiologist to rule out the presence of additional or satellite lesions, confirm the tumor location and segment involvement, and assess the tumor relationships with the hepatic and portal vasculature. When appropriate, the operative plan was then amended as necessary in light of the IOUS data. Retrospectively, preoperative and IOUS imaging was further reviewed by an experienced pediatric radiologist for any tumor measuring <2 cm from any major hepatic vessel to evaluate the consistency of tumor-vasculature margins across imaging modalities.

3. Results

Of the 19 patients evaluated with IOUS, four (21%) had discordant preoperative and IOUS imaging (Table). Preoperative imaging was obtained within 30 d before resection in all but three patients. The mean time between preoperative imaging and IOUS was 22 d. Thirteen of 14 patients with malignant tumors had imaging within 30 d of resection, and the

Table – Demographics, tumor and imaging characteristics of discordant cases.

Patient	Age/sex	Histology	Tumor stage	POI segment involvement	Surgery planned	Surgery performed
1	9 mo/M	HB	POSTTEXT 2	II, III, IV	L hemihepatectomy	L lateral sectionectomy
2	12 mo/M	HB	POSTTEXT 1	VI, VII	R posterior sectionectomy	R hemihepatectomy
3	10 mo/M	HB	POSTTEXT 3	II, III, IV, VI	L hemihepatectomy and segment VI segmentectomy	L lateral sectionectomy and segment VI segmentectomy
4	14 y/F	Adenoma	NA	IV	Segment IVb segmentectomy	Segment IVb segmentectomy

HB = hepatoblastoma; NA = not applicable.
Summary table of patient demographics, histologies, POI segment involvement, operations planned, and operations performed for patients with pre-operative and IOUS imaging discordance.