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Laparoscopic resection of liver tumors in children

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ABSTRACT

Background: Laparoscopy for the resection of liver tumors in children has remained undeveloped in comparison to adults. Most of the indications for pediatric laparoscopic hepatic surgery have been limited to diagnostic laparoscopy (biopsy). Over the past ten years, however, laparoscopic liver resections for pediatric hepatic diseases have been performed successfully, and many case reports have been published.
Methods: The authors report 6 cases of laparoscopic hepatic resection of benign tumors in children. The most important aspects of surgical technique are presented. There were 3 boys and 3 girls, with age between 4 months and 16 years. The lesions were located in the following segments: II and III (4 patients), I (1), V (1). The maximum tumor size was 7 cm.
Results: One anatomical (left bisegmentectomy) and 5 nonanatomical resections were performed. Conversion to laparotomy was necessary in 1 patient owing to bleeding from the posterior branch of the right hepatic artery. There were no postoperative complications and patients were discharged on postoperative day 4, 5, 5, 5, 7 and 3 accordingly. The postoperative pathology of the specimens confirmed their benign nature: infantile hemangioendothelioma (1), nested stromal epithelial tumor (1), focal nodular hyperplasia (3), mixed benign tumor (hamartoma + vascular malformation) (1).
Conclusions: This report demonstrates the feasibility of a laparoscopic hepatic resection in children. On the other hand, laparoscopic liver resection is challenging and teamwork and specific training are necessary.

Laparoscopy for the resection of liver tumors in children has remained undeveloped in comparison to adults [1–6]. Most of the indications for pediatric laparoscopic hepatic surgery have been limited to diagnostic laparoscopy and laparoscopic biopsy. Over the past ten years, however, laparoscopic liver resections for pediatric hepatic diseases have been performed successfully, and many reports have been published [7–14]. The authors report 6 cases of laparoscopic hepatic resection of benign tumors.

1. Material and methods

From January 2010 to January 2016, laparoscopic resection of liver tumor was performed in 6 patients. There were 28 open resections in the study period. There were 3 boys and 3 girls, with age between 4 months and 16 years. The lesions were located in the following segments: II and III—4 patients, I—1 patient, V—1 patient. The maximum tumor size measured on the surgical specimen was 7 cm (Fig. 1). The diagnosis was confirmed preoperatively in one case. The biopsy of large exophytic tumor revealed FNH. In the remaining children the diagnosis was confirmed postoperatively. In 2 cases an indication for surgery was suspected malignant tumor (hepatoblastoma) based on imaging. In 3 children the indication for surgery was tumor greater than or equal to 5 cm (suspected FNH in 2 and suspected vascular tumor in 1). The patients' demographics and clinical data are shown in Table 1.

2. Important aspects of surgical technique

Patients were placed in the supine position, with lower limbs apart (in older children). The surgeon was between the legs or at the end of the operating table. We prefer 10-mm port in umbilicus and 30° laparoscope. 2–3 additional ports (5–10 mm) were inserted. Port placement depended on surgeon's preference, lesion location, tumor size, and the body habitus of the patient. In all patients, the liver was explored visually and by laparoscopic ultrasound. Ultrasound guidance was used to mark resection margins. It reveals liver anatomy, locates lesion, and defines tumor connections with vascular and biliary structures. It is very

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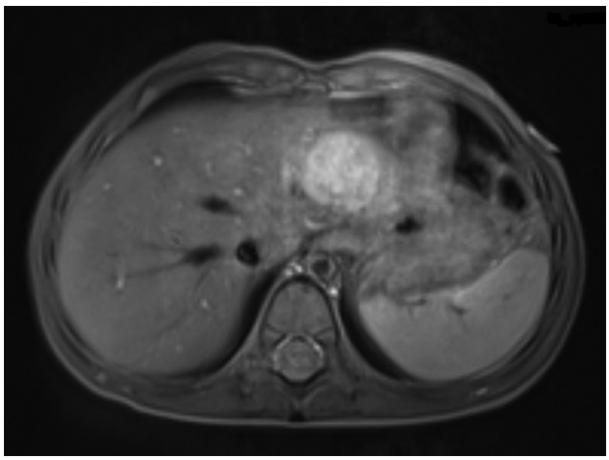

Fig. 1. Preoperative CT scan of solid tumor (3.24 × 2.59 cm) in a 3 year old patient (patient 2).

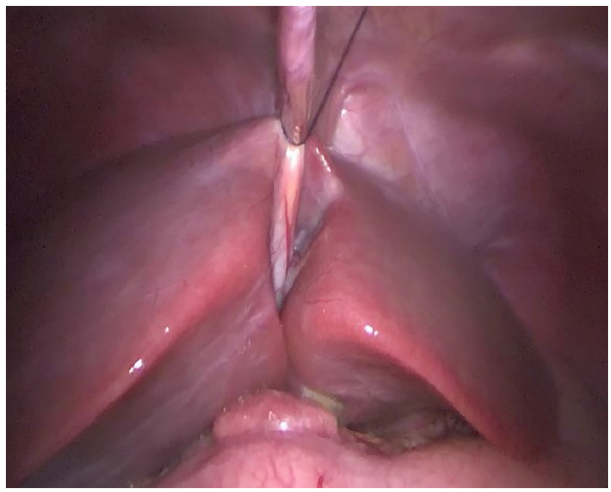

Fig. 2. A single percutaneous stitch was put around the ligament to elevate the liver.

important in terms of oncological safety. The main aspects of operative technique are shown in Table 2.

In 2 patients a tape was placed around the porta hepatis and passed through a rubber drain (tourniquet) as a preparation for the Pringle maneuver. It was applied in 1 patient for 25 min. An anatomical resection (left bisegmentectomy) was performed in this patient. The transection plane was exposed through the traction of the round ligament. We put a single percutaneous stitch around the ligament to elevate the liver (Fig. 2).

Liver transection was performed using a harmonic scalpel (4 cases), water jet (1 case), and both devices (1 case). In 3-year-old girl in whom an anatomical resection had been decided segment 3 and 2 pedicles were identified and divided after application of metallic clips. The hepatic vein was divided at the end of parenchymal transection using Hem-O-Lok clips. We use a variety of methods to control the bleeding: bipolar cautery (for minor bleeding), Ligasure, BiClamp and clips (for larger structures). The resected specimen was placed in a bag and removed through an enlarged umbilical incision. The incision was made long enough to allow easy removal of the specimen without fragmentation. Finally, the resection surface was checked for bleeding or bile leak. It was secured by using laparoscopic Argon Beam Coagulation and TachoSil.

3. Results

One anatomical (left bisegmentectomy) and 5 nonanatomical resections were performed. The mean operative time was 177 (range, 90–270) min. In 4 cases the intraoperative bleeding was irrelevant and these children did not require a blood transfusion. In a 12-year-old boy with FNH the estimated blood loss was 800 ml. He received 2 U of RBCs intraoperatively. The last patient's blood loss was about 300–400 ml and this 11-year-old girl with FNH received 1 U of RBCs. In this patient *conversion to laparotomy* was necessary owing to bleeding from the posterior branch of the right hepatic artery. There were no intraoperative complications in other cases (see: Table 2). The lesions were benign in all patients. The postoperative pathology of the specimens confirmed their benign nature: (1) infantile hemangioendothelioma — 1, (2) nested stromal epithelial tumor — 1, (3) focal nodular hyperplasia — 3, (4) mixed benign tumor (hamartoma + vascular malformation). The resection margins were

Table 1
Demographic and clinical data of patients.

n	Age	Sex	Max tumor size (cm)	Biopsy	Indications for hepatic resection	Final diagnosis
1	12 y	Male	6.5	Yes	FNH, exophytic tumor 6.5 cm	FNH
2	3 y	Female	3	No	Hepatoblastoma strongly suspected on imaging	Nested stromal epithelial tumor
3	11 m	Male	2.2	No	Hepatoblastoma strongly suspected on imaging	Hemangioendothelioma
4	16 y	Female	5	No	FNH on imaging, tumor 5 cm	FNH
5	4 m	Male	4.5	No	Vascular tumor of the liver was suspected, tumor diameter > 5 cm	Mixed benign tumor
6	11 y	Female	7	No	FNH on imaging, tumor 7 cm	FNH

FNH, focal nodular hyperplasia.
[1] Conversion to laparotomy owing to bleeding.

Table 2
Surgical technique.

n	Locations of trocars	Sizes of trocars (mm)	Time of surgery (min)	Blood loss (ml)	Blood loss (ml/kg)	Transfusion
1	Umbilicus, middle epigastrium, right midabdomen, below the left costal margin	10, 5, 5, 5	240	800	16.7	2 U of RBC concentrate
2	umbilicus, left and right midabdomen, below the xiphoid process	10, 5, 5, 5	270	<50	4.2	No
3	Umbilicus, left and right midabdomen, right hypogastrium	10, 5, 5, 5	135	<50	4.5	No
4	Umbilicus, middle epigastrium, left midabdomen	10, 5, 10	90	<50	0.9	No
5	Umbilicus, right and left epigastrium, left midabdomen	5, 5, 5, 10	160	<50	8	No
6[a]	Umbilicus, right midabdomen, middle epigastrium, below the xiphoid process	10, 5, 5, 5	170	~300–400	6.7-8.9	1 U of RBC concentrate

[a] Conversion to laparotomy owing to bleeding.

Table 3
Laparoscopic solid liver tumors resection in children—a review.

Study/year	*n*	Type of resection	Diagnosis
Waldhausen 2000 [18]	3	Chemotherapy/resection, no further details	HB
Yoon 2006 [7]	1	Lap, nonanatomic resection	MHL
Yeung 2006 [8]	1	Lap, nonanatomic resection	FNH
Dutta 2007 [9]	1	Lap, nonanatomic resection	MHL
Chan 2007 [10]	1	Lap, no further details	FNH
Kim 2011 [11]	2	Lap, nonanatomic resection	HB
Yada 2014 [12]	1	Hybrid procedure, nonanatomic resection	HB
Veenstra 2016 [13]	36	Lap (31), hybrid procedure (5), segmentectomy (11), sectionectomy (5), hemihepatectomy (20)	HB (20), FL-HCC (1), hemangioma (6), cyst (6), other benign (3)
Cortes-Cerisuelo 2019 [14][a]	1	Lap, segmentectomy	Adenoma

Lap, pure laparoscopy; HB, hepatoblastoma; MHL, mesenchymal hamartoma of the liver; FNH, focal nodular hyperplasia.
[a] Unpublished case.

disease-free in all cases. There were no postoperative complications and patients were discharged on postoperative day 4, 5, 5, 5, 7 and 3 accordingly.

4. Discussion

Although laparoscopic techniques are widely used in pediatric oncological surgery for various diseases, they are rarely applied for liver tumors [15,16]. One of the causes is the rare occurrence of primary benign and malignant liver tumors in children. On the other hand it is difficult for surgeons to accumulate experience in both liver surgery and minimally invasive techniques. There are very few reports regarding laparoscopic liver resections in the English literature. Most of the published reports are based on one or few patients [14,17]. The biggest series of minimally invasive liver resection (MILR) for both benign and malignant tumor came from Veenstra et al. [13]. In this retrospective review 36 patients with benign and malignant (hepatoblastoma, hepatocellular carcinoma) were presented. The authors performed MILR by pure laparoscopy ($n = 31$) or hybrid techniques ($n = 5$). There were 11 segmentectomies, 5 sectionectomies and 20 hemihepatectomies. Existing literature for MILR in children is summarized in Table 3.

To our best knowledge, this is the second largest report of MILR in children. Even though we are the reference center for pediatric liver nontransplant surgery in Poland, only 6 liver tumors during 6 years were done laparoscopically. MILR can be applied only in carefully selected patients. Not all liver tumors can be easily removed via laparoscopy. In large tumors and those close to the vascular structures, centrally or posteriorly located, the open approach remains the gold standard. The acceptable indication for MILR is solitary lesion up to 5 cm in diameter located in segments II–VI [17,19]. Even if laparoscopic resection for larger lesions has been reported it should be avoided because of difficult tumor mobilization and the risk of its rupture and/or incomplete resection. Moreover, large tumors require a formal laparotomy to remove the specimen. The question arises whether it is still a minimally invasive surgery. The incisions most commonly used for liver resection in children have included a bilateral rooftop incision with or without a vertical extension, a transverse incision and a chevron incision. The actual length of the incision could range from 15 cm to 20 cm (or even more). In our series the incision was definitely shorter (4–5 cm) but long enough to allow easy removal of the specimen. The cosmetic advantage of LLR seems obvious in this respect. Of course, as long as safety and the completeness of resection are secured. Regardless of the method of liver resection, fragmentation of the tumor should be avoided. Removing the tumor in one piece allows for a proper histologic assessment [10].

The three most important aspects of MILR should be highlighted once again. First is experience in both open hepatobiliary surgery and laparoscopy. There are no "magic numbers" to reach proficiency in laparoscopic surgery (learning curve is essential). Second is the appropriate armamentarium of surgical devices. One of the main problems is controlling the bleeding during parenchymal transection. The methods range from ultrasonic energy, radiofrequency energy, water jet, to surgical staplers. It is necessary to be familiar with different strategies and be able to apply them properly, but the most important determinant of device choice is the personal experience.

The aim is to reduce blood loss and transfusion requirements, and the increased postoperative complications associated with each [20]. Third is maintenance of oncological principles. Complete tumor resection is the key factor for survival [16]. Oncological safety should be in the first place. Advantages of MILR including decreased pain, shorter length of stay, and better cosmesis should take a back seat.

5. Conclusions

In summary, this report demonstrates the feasibility of a laparoscopic hepatic resection in children with small benign tumors. Laparoscopic liver resection is challenging and teamwork and specific training are necessary. Its role in malignant liver tumors remains controversial, particularly with regard to oncological safety (long-term disease-free survival) [9,16]. There are no prospective studies in this field.

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