Review Article

Laparoscopic and robotic approach for hepatocellular carcinoma—state of the art

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Abstract: Hepatocellular carcinoma (HCC) is the sixth most common malignant tumor worldwide and the most common primary liver cancer, in over 80% of cases HCC grown on a cirrhotic liver. Laparoscopic liver resection (LLR) is now worldwide accepted considering the excellent results shown. Minimally invasive surgical approach for HCC is increasing continuously and in specialized centers seems to become the first-line approach for those patients. The aim of this review presents and discusses state of the art in the laparoscopic and robotic surgical treatment of HCC. An electronic search was performed to identify all studies dealing with HCC resected with laparoscopy or robotic approach. Indications for laparoscopic resection, robotic assisted and totally robotic resection of HCC will be doubtless increased in future years. LLR and robotic approach for HCC is safe and feasible.

Keywords: Laparoscopic liver resection (LLR); robotic liver; hepatocellular carcinoma (HCC); cirrhosis; meld

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Introduction

Hepatocellular carcinoma (HCC) is the sixth most common malignant tumor worldwide and the most common primary liver cancer, in over 80% of cases HCC grown on a cirrhotic liver (1,2). Possible curative treatments are liver resection (LR), liver transplantation (LT), and local ablation (3). Since the first reported laparoscopic hepatectomy in 1993, minimally invasive surgical technique in liver surgery has continuously developed. Laparoscopic liver resection (LLR) is now worldwide accepted considering the excellent results shown. Minimally invasive surgical approach for HCC is increasing continuously and in specialized centers seems to become the first-line approach for those patients (2-4). This review presents and discusses state of the art in the laparoscopic and robotic surgical treatment of HCC.

Methods

An electronic search was performed to identify all studies dealing with HCC resected with laparoscopy or robotic approach.

The PubMed/MEDLINE database on December 2015 was searched. The search strategy was ("laparoscopic" OR "robotic") AND ("hepatocellular carcinoma" OR "hcc"). We found over 600 papers, all study typologies, including case reports and small series were considered if the articles report some new techniques or strategies for HCC resection. We resumed all reported cohort of more than 50 LLR for HCC in *Table 1*, and the robotic cases are resumed in *Table 2*.

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Table 1 Laparoscopic HCC resection. Complication according with Clavien-Dindo classification

Authors (ref.)	Patients (n)	Child	Surgery	Complications	Mean tumor size (cm, range)
Chen [2008] (5)	116 (92 M, 24 F)	98 Child A; 18 Child B	92 resections of less than two segments, 19 resections greater than two segments	II: 8	2 [65]
Cho [2008] (6)	52 (M/F n.d.)	48 Child A; 3 Child B; 1 Child C	32 anterolateral segments, 20 posterosuperior segments	I: 3, II: 2, IIIa: 5	n.d.
Yoon [2009] (7)	69 (50 M, 19 F)	62 Child A; 6 Child B; 1 Child C	44 anterolateral segments, 25 posterosuperior segments (8 major resection)	I: 15, II: 23	3.1±1.5
Belli [2011] (8)	65 (38 M, 27 F)	58 Child A; 7 Child B	23 subsegmentectomies, 17 left lateral sectionectomies, 19 segmentectomies, 6 major resection	I: 5, II: 3, IIIb: 2, V: 1	3.8 (1.0–9.0)
Ker [2011] (9)	116 (92 M, 24 F)	98 Child A; 17 Child B; 1 Child C	97 segmentectomy or less, 7 left lateral segmentectomy, 4 left lobectomy, 8 right anterior sectionectomy	I: 7	2.5±1.2
Yoon [2012] (10)	107 (78 M, 29 F)	94 Child A; 12 Child B; 1 Child C	18 resection and/or LRFA, 46 nonanatomical resection, 12 left lateral sectionectomy, 3 left hemihepatectomy, 7 right hemihepatectomy, 19 right posterior sectionectomy, 1 right anterior sectionectomy, 1 central bisectionectomy	I: 7, II: 11	3.0±1.6
Kobayashi [2013] (11)	56 (41 M, 15 F)	48 Child A; 8 Child B	47 partial hepatectomy (26 hybrid laparoscopic hepatecomy—21 pure laparoscopic hepatectomy), 6 segmentectomy (hybrid laparoscopic hepatecomy—3 pure laparoscopic hepatectomy)	I: 2, IIIa: 1	2.0 (1.0–9.0)
Soubrane [2013] (12)	361 (260 M, 91 F)	275 Child A; 8 Child B; 1 Child C	36 major hepatectomy (20 right hepatectomy, 14 left hepatectomy, 2 central hepatectomy), 92 left lateral sectionectomy, 83 segmentectomy, 140 wedge resection	I: 35, II: 21, IIIa: 3, IIIb: 8, IVa: 5, IVb: 1, V: 6	3.5 (0.5–17.0)
Ai [2013] (13)	97 (75 M, 22 F)	59 Child A; 38 Child B	64 segmentectomy, 24 nonanatomical resection	I: 3, II: 7	7.85±2.15
Long [2013] (14)	169 (M/F n.d.)	n.d.	139 anterior segment, 16 posterior segmentectomy, 14 major hepatectomy	I: 2, II: 2	3.73 (2.00–10.00)
Kim [2013] (15)	70 (58 M, 12 F)	n.d.	31 wedge resection, 18 segmentectomy, 12 left lateral sectionectomy, 5 posterior sectionectomy, 2 left hepatectomy, 2 right hepatectomy	I: 4, II: 1	2.58±1.44
Yoon [2014] (16)	58 (45 M, 13 F)	53 Child A; 5 Child B	4 right hepatectomy, 5 right posterior segmentectomy, 6 left hepatectomy, 28 left lateral segmentectomy, 15 partial hepatectomy	I: 3, II: 1, IIIa: 1	2.87 (0.70–4.90)

Table 1 *(continued)*

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Table 1 *(continued)*

Authors (ref.)	Patients (n)	Child	Surgery	Complications	Mean tumor size (cm, range)
Yamashita [2014] (17)	63 (48 M, 15 F)	59 Child A; 4 Child B	13 left lateral segmentectomy, 1 medial segmentectomy, 5 right posterior segmentectomy, 8 subsegmentectomy (II2, III1, V1, VI2, VIII1, V + VI 1), 36 partials	I: 2, II: 1	2.5±1.0
Han [2015] (18)	83	83 Child A	3 right hemihepatectomy, 2 left hemihepatectomy, 14 segmentectomy, 21 left lateral sectionectomy, 43 wedge resection, 7 major liver resection, 40 anatomical liver resection	I–II: 8, IIIa: 1, IIIb: 1	2.51±1.14
Shehta [2015] (19)	232 (156 M, 67 F)	212 Child A; 16 Child B; 3 Child 3	195 minor resection, 37 major resection	I: 9, IIIa: 17, IIIb: 5, V: 2	2.69
Song [2015] (20)	78 (70 M, 8F)	78 Child A	71 minor resection, 8 half hepatic resection	I: 20, II: 2	n.d.
Ettorre [2015] (21)	90 (67 M, 23 F)	85 Child A; 5 Child B	18 left lobectomy, 1 left hepatectomy, 71 segmentectomy/wedge	I: 7, II: 9, IVa: 1	2.9 (0.40–10.0)
Takahara [2015] (22)	118 (87 M, 31 F)	115 Child A; 3 Child B	23 major, 95 minor	I: 14, II: 6, IVa: 3, V: 2	4.13
Xiang [2015] (23)	126 (103 M, 23 F)	110 Child A; 16 Child B	70 anterior segment, 56 posterior segment (24 major hepatectomy)	n.d.	4

Table 2 Robotic HCC resection. Complication according with Clavien-Dindo classification

Author (ref.)	N PZ	Sex	Child/meld	Dimension	Surgery	Complications
Buchs [2013] (24)	2	1 male, 1 female	2 Child A	n.d.	Segmentectomy IVb, segmentectomy III	I: 1
Choi [2008] (25)	1	Female	Child A	2.2	Left lateral sectionectomy	None
Eric [2011] (26)	9	n.d.	9 Child A	2.5±1.6	6 wedge resection, 3 left lateral sectionectomy	None
Panaro [2011] (27)	1	Male	Child A	3.4	Segmentectomy III	None
Pessaux [2013] (28)	1	n.d.	n.d.	n.d.	Segmentectomy V	None
Croner [2015] (29)	4	n.d.	n.d.	4.5	Left lateral, segment III	None
Choi [2012] (30)	13	–	–	3.0 [0.8–5.0]	6 minor resection, 7 major resection	I: 1, II: 1, IIIb: 2
Han [2015] (18)	16	–	A: 16	2.51±1.14	10 major resection, 3 left lateral sectionectomy, 2 segmentectomy, 1 wedge	n.d.
Lee [2015] (31)	10	7 males	n.d.	2.5 (1.0–7.0)	1 major, 3 segmentectomy, 6 bisegmentectomy	grade I: 5; grade II: 1; grade III: 1
Guerra [2015] (32)	2	2 females	–	10.5 (6.0–15.0)	6 segmentectomy, 1 left lateral	grade I: 1

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Laparoscopic approach

Before Louisville

Initially, the experience of LLR was restricted to benign pathologies, and peripheral lesions/left lateral sectionectomy. Since the first LLR, surgical teams consider non-compensated cirrhosis as a contraindication for LR and thereby for LLR (12,33,34). Nonetheless, Ettorre *et al*. compared LLR (38 were HCC) in two groups with underlined liver disease and normal liver, without detecting differences in terms of morbidity and mortality risks (4). For the first experiences reported, most cases in the laparoscopic group were segmentectomies or subsegmentectomies located in segments II, III, IV, V, or VI (or anterior segment). Since the beginning of 2000 years LLR increased in many centers worldwide. Also, tumor size, type, and location are important in determining indications for LLR for HCC (35,36).

First consensus conference

Considering the worldwide procedures were increasing, the first international consensus conference on LLR was held in 2008 in Louisville. This consensus of experts suggested that the best indications for laparoscopy were solitary lesions less than 5 cm, located in the anterior segments. Nonetheless, adequacy of margins is obtained keeping an adequate distance of the nodule from the line of transection; also, LLR should be far from the hepatic hilum, and the vena cava (37). However, surgical indications for LLR for HCC continued to evolve. Many authors described personal experience for LLR over the Louisville indications. Laparoscopic resection of lesions of the right hepatic lobe poses particular technical challenges (7). Yeung *et al*. suggests that laparoscopic anatomic monosegmentectomy of HCC located at all segments of right hepatic lobe is feasible (38). Therefore, limitation of the posterior localization of the HCC has been now overpassed. Intercostal trocars can be helpful to easily access the operative field and manipulate the instruments (39,40). However, intercostal approach may be more invasive than traditional abdominal laparoscopy.

Morioka consensus conference

The Second International Consensus Conference on LLR was held in Morioka, Japan, in 2014 to evaluate the current status of laparoscopic liver surgery and to provide strong recommendations to aid its future development (41). Moreover, tumor size limits have been overpass. HCC with a tumor size of >10 cm has been considered to be a contraindication for LLR because of concerns that the radical resection rate may be lower, and the inherent limitations of the operative procedure. However a Chinese group suggested pushing up to 10 cm of diameter the limit of HCC treatable (13). Also LLR for HCC in patients with advanced portal vein tumor thrombus has been described as a safe and feasible procedure in selected patients, when performed by surgeons with expertise in hepatic surgery and minimally invasive techniques (42).

Laparoscopic advantages and future perspectives

Concerning the morbidity, LLR generally results in improved short-term outcomes without compromising the long-term oncological outcome. In addition, the incidences of postoperative ascites and liver failure are reduced with LLR for HCC (43). Pure laparoscopic hepatectomy results in minimal postoperative ascites production, which leads to a lower risk of disturbance in water and/or electrolyte balance and hypoproteinemia. It leads to lower complications that could potentially lead to postoperative serious liver failure (44).

In very little cases some authors suggest to perform the Associating liver partition and portal vein ligation for staged hepatectomy (ALPPS) for HCC. ALPPS procedure has been described with good results with traditional access (45,46). Totally laparoscopic ALPPS is described as feasible but must be performed by experienced hands (47,48). Furthermore, performing the initial HCC resection by laparoscopy could facilitate a subsequent LT (49). It has been shown that when the initial LR is done by laparoscopy, the subsequent salvage transplantation is associated with reduced operative time, blood loss, and transfusion requirements (50,51).

Robotic approach

Since the commercialization of the da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA, USA), robotic approach is now being used for even the most complex minimally invasive surgeries. First report of robotics in liver surgery dates back to 2003 and the first series of left lateral sectionectomy to 2008 (25,52). Many study demonstrated that robotic LR is feasible and a safe procedure (30,53,54).

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Advantages and disadvantages

As a minimally invasive approach, the use of robotic systems has some hypothetical advantages over traditional laparoscopy. The several limitations and drawbacks to conventional laparoscopy, including limited movement, the inability to perform high-precision sutures, unnatural positions for the surgeon and flat vision, may be overcome by robotic surgery (55). In fact the 3-dimensional view of the operative field along with 7° of freedom and tremor filtration allows the surgeon to performed delicate dissection and precise intra-corporeal suturing. Using this technology, hepatobiliary surgeon was allowed to performed resection of all liver segments and to perform complex hilar dissection, LRs requiring biliary-enteric reconstruction (56). Overall, surgical indications for robotic approach for HCC are the same of LLR. Nonetheless, the use of a robotic system can improve certain steps of minimally invasive major hepatectomy (53). Lesions located in the posterosuperior segments are with robotic system easier to perform than in laparoscopy (57). Technical limitations of LLR to achieved safe LR of posterosuperior segments overcome thanks to the ability given by the robotic system using articulated instruments and the execution of ultrasonography using dedicated robotic probes (58). Wakabayashi described robotic resection of HCC located to segment 8 with a thoracoscopic trough the diaphragm approach (59). Lai *et al.* recently reported two cases of robot-assisted laparoscopic partial caudate lobe resection in patients with HCC, both of them with a Child A score (60). The most convincing indications for robotic surgery are procedures that involve a small, deep, fixed operating field or when fine dissection and parenchyma sparing is required as in cirrhotic patients.

The main limitation of robotic system is the higher cost between laparoscopy. Besides, the range of instruments available for robotic liver surgery is currently much smaller than for laparoscopic or open techniques.

Prospective view

The latest innovative procedures with robot are augmented reality (28), and the single incision approach (61). As for the LLR, robotic LR for HCC has been described as a bridge to LT (27). The stable magnified field, 3-D vision, and enhanced instrument articulation facilitate the vascular and biliary dissection of the right pedicle, and this helps in deciding the point of transaction (62). We discuss about totally laparoscopic ALPPS, however, robotic ALPPS may have a place for HCC patients (63).

Conclusions

Indications for laparoscopic resection, robotic assisted and totally robotic resection of HCC will be doubtless increased in future years. LLR and robotic approach for HCC is safe and feasible. Prospective comparative study should be designed to confirm the advantages and indications of laparoscopy and robotic management of HCC.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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