Single port laparoscopy for minor and major liver resections

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Background: The laparoscopic approach has proven beneficial in liver resections. Single port laparoscopic hepatectomy is technically challenging, but offers possible benefits for the patient. Some enhancements are mandatory for feasibility and safety. This matched pairs analysis compares procedural strategies in single port minor (SPMIN) versus single port major (SPMAJ) hepatectomy.

Methods: Between 2008–2018 a total of 25 SPMAJ were performed in selected patients; 25 SPMIN were matched for age, weight, BMI, and liver cirrhosis to evaluate the impact of procedural difficulty. Differences in procedural steps were documented. Intraoperative parameters served as the primary endpoint. Secondary endpoints were complications and pathohistological outcome.

Results: All resections were able to be completed without converting to open surgery. Time for hepatectomy differed between SPMIN (112 min) and SPMAJ (161 min), P=0.016. The umbilical incision was appropriate in all SPMIN but was changed towards a right subcostal incision in 11 patients with SPMAJ. Pre-coagulation was sufficient in all SPMIN, but failed in 28% of SPMAJ (P=0.010). Blood loss >50 mL (in mean 202 mL) occurred in six patients with SPMAJ whereas no significant bleeding was noted in SPMIN. One intestinal laceration (SPMAJ) accounted for the only intraoperative complication; 90-day mortality was zero. Postoperative complications were noted in total 20.6% and 4% of patients for SPMAJ and SPMIN, respectively. No incisional hernia occurred. During a median oncologic follow-up at 61 and 63 months (SPMAJ and SPMIN, respectively) no local tumor recurrence was observed.

Conclusions: SPMAJ requires a modified procedural strategy when compared to SPMIN. An individualized approach and more sophisticated hemostasis techniques other than pre-coagulation ensure operative safety. In selected patients the low complication rate and the favorable oncologic outcome justify the performance of SPMIN and SPMAJ in expert centers.

Keywords: Hepatectomy; single port laparoscopy; hemostasis

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Introduction

High expectations of surgical outcome have motivated hepatic surgeons to apply minimally invasive techniques in more advanced procedures. The scientifically proven benefits of laparoscopic hepatectomy have become increasingly obvious and justify the effort to further develop the technique (1). Single-port laparoscopy (SP) is currently regarded as the least invasive approach in liver surgery. This concept of aligning the entire procedure only via the incision that is necessary to retrieve the specimen has been sufficiently evaluated in various organ systems of the gastrointestinal and hepatobiliary tract (2,3). Intrinsic benefits of the reduced abdominal wall trauma are better wound healing and therefore a more rapid recovery when compared to the multiport or open technique. Safety and feasibility have been proven in simple and advanced hepatic procedures. However, although literature provides several advantages in single port (SPMIN) over multiport (MPMIN) minor liver surgery difficulties such as limited instrument manipulation and exposure of the surgical field prohibited wide acceptance to use the single port approach in major liver resections (SPMAJ).

These limitations negatively affect two of the main tasks of the surgical approach, namely optimal access to the pathologic target and safe hemostasis during parenchymal transection. In particular, the access to posterior segments is anatomically complex and has encouraged surgeons to develop transthoracic or lateral routes, concepts that might promote tumor cell spillage in malignancies. On the other hand, it has to be addressed that blood loss is one of the main adverse prognostic parameters for short-term and long-term outcome. Pre-coagulation by means of intraoperative radiofrequency ablation of the resection plane allows for ideal blood vessel sealing, but might cause an increase in biliary complications. We were previously able to demonstrate that SPMIN benefits from the possibility to use inline pre-coagulation (4).

This study was conducted to assess technical differences in the performance of SPMIN and SPMAJ to evaluate the impact of procedural difficulty on the choice of the intraoperative management. We present the following article in accordance with the STROBE reporting checklist (available at http://dx.doi.org/10.21037/ls-20-115).

Methods

From September 2008 to November 2018 a total of 96 SP liver resections were performed at the surgical department of the St John of God Hospital, Salzburg, Austria. This accounts for 22.4% of all hepatic resections (n=429) and 1.9% of the SP patient cohort (n=5,095) in that period of time.

Procedures were categorized as minor and major liver resection according to the 2nd International Consensus Conference for Laparoscopic Liver Surgery (5). Major liver resection was defined as removal of >2 Couinaud segments or resections including at least one of the segments I, IVa, VII, VIII. A total of 34 single-port laparoscopic major hepatectomies (SPMAJ) were consecutively performed during the study period.

During the observational period 62 single-port laparoscopic minor hepatectomies (SPMIN) were executed. Accounting for covariates impeding the surgical performance (age, weight, BMI, ASA score and liver cirrhosis), 25 matched pairs of patients undergoing SPMIN and SPMAJ were compared to evaluate the technical differences and risks that have to be overcome when performing either SPMIN or SPMAJ resections.

All types of benign and malignant liver diseases requiring surgical treatment were considered for enrollment in the study. Prior abdominal surgery, higher age, obesity or unfavorable ASA scoring were not regarded as a contraindication for the SP approach. Exclusion criteria were defined as follows: Child-Pugh B or C cirrhosis, future liver remnant volume <50%, tumor growth in close approximation to vital pedicles and at the surgeon's discretion.

Preoperative routine testing, including CT and MRT, was performed according to international guidelines. Indication for the operation was confirmed by the local Tumor Board in all malignant cases. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional and local Ethics Committee of Salzburg (No. 415-EP/73/25-2011) and informed consent was taken from all the patients. All SP procedures were performed by surgeons trained in both hepato-bilio-pancreatic surgery and advanced SP laparoscopy.

Procedure

Patients were placed in the reverse Trendelenburg position (20° head up) with their legs apart (French position) for the transumbilical approach to reach the anterior hepatic segments or for hemihepatectomies. For posterior or

Figure 1 Image of the abdominal scar following hepatic bisegmentectomy 6, 7.

right lateral resections a 45° left lateral decubitus position alleviated exposure. Single-port access was obtained through the umbilicus, pre-existing scars in the upper abdomen (midline or subcostal) or a right subcostal incision in the midclavicular line (*Figure 1*). All procedures were strictly performed transabdominally to prevent spillage of pathologic material into the thorax.

Disposable ports such as the GelPort™ (Applied Medical, Rancho Santa Margarita, CA, USA), OctoPort™ (DalimSurgNET, Frankenman Group, Seoul, Korea) or SILS-Port™ (Medtronic, Dublin, Irland) and the AirSeal™ System (SurgiQuest, Milford, CT, USA) were used to maintain the pneumoperitoneum at 12 mmHg.

A 10 mm, 30° extra-long optic and at least one articulating grasper were used throughout all procedures. Suction or retraction was controlled by the surgical assistant guiding one or two additional instruments through the same port. Suspending sutures for the triangular ligament were placed as needed. Laparoscopic ultrasound ensured the proper resection margin. Pringle maneuver was not used routinely although a sling encircling the hepatoduodenal ligament was prepared in SPMAJ (right anterior segmentectomies, right and left hepatectomies).

Exposure of central pedicles was mastered by means of bipolar cautery and clips. Prior to parenchymal transection inline pre-coagulation was primarily accomplished with the HABIB 4× bipolar resection device (RITA Medical Systems, AngioDynamics, Latham, NY, USA). Liver packing was performed to prevent thermal injury to surrounding organs or the diaphragm as described previously (6). Parenchymal transection was subsequently performed with monopolar scissors or the LigaSureV™ (Medtronic, Dublin, Ireland) device. The CUSA (Cavitron Ultrasonic Surgical Aspirator; Medtronic, Dublin, Ireland), hemoclips, parenchymal sutures or vascular staplers served as second line devices as needed.

Specimen retrieval was realized with a tear-proof bag (Espiner Medical, Clevedon, England) allowing tissue compression to minimize the incisional length according to the minimal diameter of the specimen and guarantee correct pathohistological assessment.

Hemostatic matrix foam (Flowseal™, Baxter, Deerfield, IL, USA) or TachoSil™ fibrin sealant patch (Baxter, Deerfield, IL, USA) were applied at the surgeon's discretion. Wound closure was done with monofilament, non-reabsorbing fascial running sutures and intra-cuticular stitches. No drainage was installed routinely.

Technical parameters such as the access-site, additional trocars and conversion served as the primary endpoints. Secondary endpoints were intra- and postoperative complications and pathohistological outcome.

Statistics

Data were prospectively collected and documented in an Access database (Microsoft Corporation, Redmond, WA, USA). The dataset was completed for all study patients. A mathematician (TH) not involved in data collection performed the statistical analyses using R, version 3.4.1. Continuous data are presented as mean ± SD with min-max, categorical data as n (%). Differences between groups were assessed using Welch's Two Sample *t*-test for continuous variables and Fisher's Exact test (where applicable) or Pearson's Chi-squared test for categorical variables. A P value <0.05 was considered statistically significant.

Results

Demographic and surgical parameters of the 50 patients included are summarized in *Table 1*. The surgical approach was established at the midline (umbilicus or midline scar) or at the right subcostal midclavicular line in 25/0 and 14/11 patients in SPMIN and SPMAJ, respectively (P<0.001). Types of liver resections with respect to the incision site are given in *Table 2*. Non-anatomical resections (subsegmentectomies or combined segment resections) were carried out in 20 patients. Numbers of resected segments are depicted in *Figure 2*.

Additional trocars were used in two patients (8.0%) in each group for better exposure in obese patients (n=3) and a combined procedure (cholecystectomy). Conversion to open surgery was not necessary in any patient.

Table 1 Matched-pairs analysis of SPMIN and SPMAJ

Variables	SPMIN	SPMAJ	Estimate with 95% CI	P value
Number	25	25		
Female gender (n)	13 (52%)	11 (44%)	0.73 (0.21 to 2.53)	0.776
Age (years), mean (SD)	62.64 (±14.31)	62.76 (±12.19)	0 (−7.6 to 7.5)	0.998
Weight (kg), mean (SD)	79.02 (±21.44)	79.60 (±15.96)	−0.6 (−11.4 to 10.2)	0.914
BMI (kg/m²), mean (SD)	27.31 (±5.78)	26.86 (±4.19)	0.5 (−2.4 to 3.3)	0.753
ASA (I/II/III/IV/V)	3/8/7/7/0	3/5/14/2/1		0.121
Liver cirrhosis Child-Pugh A (n)	2 (8%)	3 (12%)	1.55 (0.16 to 20.28)	1
Previous surgery (n)	13 (52%)	17 (68%)	0.52 (0.14 to 1.85)	0.387
Malignant underlying disease	15 (60%)	20 (80%)	0.38 (0.08 to 1.55)	0.217
Future remnant liver volume (%, SD)	86 (±7.64)	79.32 (±14.49)	6.7 (0 to 13.3)	0.050
Surgery time (min), mean (SD)	112 (±58)	161 (±72)	−49 (−88 to −10)	0.016
Difficulty index, mean (SD)	3.6 (±1.80)	6.8 (±1.8)	−3 (−4 to −2)	<0.001
Concomitant procedures	18	9		0.022
Blood loss (mL), mean (SD)	None	202 (±627.2)	−202 (−460.9 to 56.9)	0.120
Patients with blood loss >25 mL (n)	None	6 (24%)	0 (0 to 0.96)	0.281
RBC units (n)	1 (4%)	5 (20%)	0.21 (0.01 to 2.02)	0.200
Skin incision (cm), mean (SD)	3.8 (±0.89)	4.38 (±1.0)	−0.6 (−1.1 to 0)	0.069
Maximum specimen diameter (cm), mean (SD)	8.85 (±4.95)	10.1 (±4.92)	−1.2 (−4.1 to 1.7)	0.392
Minimum specimen diameter (cm), mean (SD)	3.78 (±1.61)	4.76 (±2.13)	−1 (−2.1 to 0.1)	0.078

SPMIN single port minor hepatectomy, SPMAJ single port major hepatectomy, BMI body mass index, ASA American Society of Anesthesiologists, RBC red blood cell.

Table 2 Type of procedure according to the access-site

Access site	SPMIN (n=25)		SPMAJ (n=25)	
	Midline	Right subcostal	Midline	Right subcostal
Single segmentectomies	14	–	5	3
Left lateral segmentectomies	11	–	–	–
Left medial segmentectomies	–	–	–	–
Right anterior segmentectomies	–	–	1	–
Right posterior segmentectomies	–	–	3	4
Left hepatectomies	–	–	5	0
Right hepatectomies	–	–	–	4

SPMIN, single port minor hepatectomy; SPMAJ, single port major hepatectomy.

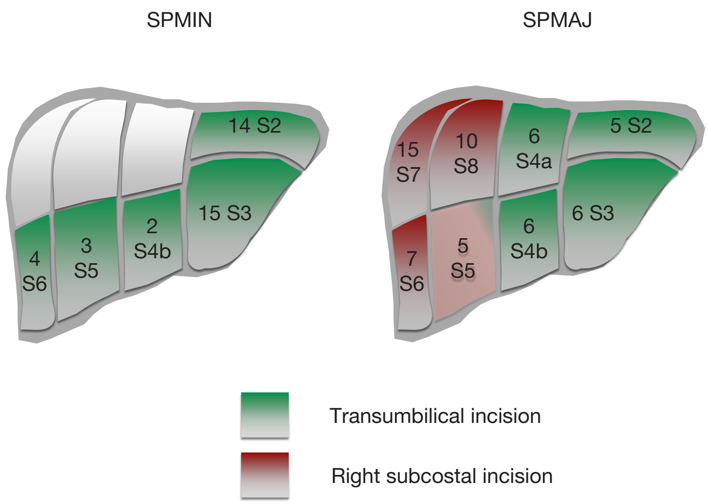

Figure 2 Graphical depiction of resected liver segments (in numbers) in SPMIN (left) and SPMAJ (right). Liver segment one was not resected in any of the study patients. The staining indicates the preferred incision sites (trans-umbilically and midclavicular line at right costal margin). SPMIN, single port minor hepatectomy; SPMAJ, single port major hepatectomy.

Suspending sutures were used in one (SPMIN for cystopexy) and two patients (SPMAJ for retraction on the falciform ligament), P=0.552.

With respect to prior surgical interventions, limited/extended SP adhesiolysis was performed in 6/13 and 5/6 patients in SPMIN and SPMAJ, respectively (P=0.065). Concomitant procedures (18 in SPMIN and 9 in SPMAJ, P=0.022) were carried out using single port laparoscopy comprising cholecystectomies (n=7), right colectomies (n=3), ileostomy reversal (n=2), gastrectomy (n=1) and percutaneous RFA tumor ablations (n=5) in the SPMIN group, whereas single port adnexectomies (n=2), sigmoid resections (n=2), ileal resection (n=1) and percutaneous RFA tumor ablations (n=3) or a Port-A-Cath implantation (n=1) were performed in the SPMAJ cohort. The surgical approach served as the retrieval site in all patients. As proof of principle the incisional length matched the minimum diameter of the specimen (*Table 1*).

Inline radiofrequency ablation provided sufficient bleeding control and prevented bile leakage in all SPMIN patients, whereas the intraoperative technical strategy had to be changed in seven SPMAJ patients, thus allowing optimal safety during parenchymal transection (P=0.010). In those patients staplers, clips and sutures were used to seal portal pedicles and major hepatic veins. Intraoperative blood loss yielded less than 25 mL in all SPMIN patients. Six SPMAJ patients had substantial blood loss of 50–3,000 mL (averaging a mean of 202 mL in the entire SPMAJ group).

One SPMIN patient (four units for intestinal bleeding after ileostomy reversal) and five SPMAJ patients (one unit in three patients and two units in two patients, Grade A according to the definition of the International Study Group of Liver Surgery; ISGLS) received red-blood cell (RBC) units throughout their hospital stay (P=0.200).

No intraoperative complications were observed in minor liver resections, whereas one intestinal injury during adhesiolysis required a suture on the approximated colon, as previously described in one patient undergoing major hepatectomy. Wound closure was documented and evaluated by the surgeon as optimal (n=50), suboptimal (with minor flaws, n=0) or poor (with major flaws, n=0) at the end of each procedure (*Figure 1*). Surgical site infections were not observed in any patient.

The number of patients with postoperative complications was one (4%, Clavien-Dindo 3a) and five (20%, Clavien-Dindo 2 and 3a in one and four patients, respectively) in SPMIN and SPMAJ, respectively (P=0.190). Pleural effusion (one in SPMIN, three in SPMAJ), abscess formation and ascites (one each in SPMAJ) were observed. Mortality was zero during the first 90 days. Hospital stay was comparable in both groups (mean ± SD: 9.24±3.62 days for SPMIN and 9.80±2.99 days for SPMAJ, P=0.554). Late onset complications such as incisional hernia or biloma formation did not occur in any matched patient within a median total follow-up of 69 months.

Table 3 Underlying malignant diseases

Variables	SPMIN	SPMAJ
Benign diseases		
Focal nodular hyperplasia	4	–
Giant hemangioma	2	4
Adenoma	2	–
Caroli syndrome	1	
Abscess formation	1	1
Malignant diseases		
Primary liver tumors		
Hepatocellular carcinoma	3	4
Cholangiocellular carcinoma	2	1
Liver metastases		
Colorectal cancer	6	8
Neuroendocrine tumors	1	3
Pancreatic cancer	–	2
Esophagogastric cancer	2	–
Breast cancer	–	1
Ovarian cancer	–	1
Prostate cancer	1	–

SPMIN, single port minor hepatectomy; SPMAJ, single port major hepatectomy.

Pathology

Pathologic assessment yielded specimens without tumor lacerations in all patients with malignancies. The underlying diseases are listed in *Table 3*. Histology revealed free resection margins in 14 (93.3%) of 15 specimens and 20 (100%) of 20 specimens in SPMIN and SPMAJ patients, respectively. During a median oncologic follow-up of 63 and 61 months (SPMIN and SPMAJ) nine (60%) and four (20%) patients suffered from recurrent diseases (apart from the resection plane or metastatic disease), whereas three patients (20%) in SPMIN and two patients (10%) in SPMAJ died during the observation period.

Costs

The various dissection techniques for bleeding control showed that direct costs for disposables can be reduced by 27.6% when using pre-coagulation instead of staplers (1,050 and 1,450 USD for inline radiofrequency pre-coagulation versus clip and stapler application, respectively).

Discussion

SP laparoscopy has emerged as one of the least invasive techniques for abdominal surgery. In contrast to the remarkable increase of application of this approach in the entire gastrointestinal tract there are substantial obstacles that hamper a wide acceptance of SP in advanced liver resections. Simple anterior segmentectomies, left lateral resections or cyst fenestrations are ideal procedures to get safe access to this technical field. However, when suturing in acute bleeding, complex exposures of tumors in posterior segments or subtle dissection is required, most of the surgeons do not feel comfortable with the limited options of SP techniques. In this study we could identify differences in the procedural strategy of minor and major liver resections that are mandatory to achieve safety and feasibility.

First, posterior segments are easier to resect by changing the incision site from the umbilicus to the right subcostal midclavicular line. Thereby the useful down-to-up approach of laparoscopic hepatectomy can be transposed to SP. Suspension of the triangular ligament together with a 45-degree tilt over to the left allows for good exposure of the posterior segments and the Vena Cava from the dorsal route. In addition, this lateral approach enables sufficient ventral view on the hepatic veins. All procedures could be finished without conversion and specimen retrieval could be carried out exclusively via the initial incision at the navel or the upper abdomen. Meticulous wound closure prevented hernia formation in all patients within a median follow-up of more than five years. This finding strongly questions the need for an additional Pfannenstiel incision in SP hepatectomies.

Second, as reduced bleeding can contribute to prolonged disease-free survival and overall survival (7,8), bleeding control is crucial in all types of liver surgery. Unfortunately, the SP concept is bothersome for the surgeon as it involves an uncommon type of triangulation and a limited number of deployed instruments. Intraabdominal SP suturing has to be trained separately, because the movements are not identical with those used in multi-trocar suturing. Basically, there is no difference to apply an elastic sling for a Pringle maneuver in SP when compared to conventional multi-trocar laparoscopy. However, intermittent occlusion of the hepatic inflow is certainly much more comfortable when a clamp or sling is manipulated via a separate trocar. In our series of SPMAJ and multi-trocar major hepatectomies we did not routinely use a Pringle maneuver for parenchymal transection. Hepatic tissue transection is frequently carried out by use of bipolar cautery, ultrasonic scalpels, LigaSure or clips in non-anatomical resections. For more precise preparation in major hepatectomy the laparoscopic Cavitron Ultrasonic Surgical Aspirator (CUSA) deployment is advocated by most surgeons to identify vital structures and to obtain a sufficient resection margin. Stapling of main branches of the portal vein or hepatic veins is recommended thereafter for the benefit of reduced bleeding, faster operative time and better recovery. The limited degrees of freedom in SP laparoscopy impede the use of CUSA and staplers when the proposed division line runs transversely to the instrumental axis. In this situation radiofrequency pre-coagulation has been shown by our group and others to efficiently assist in averting blood loss in minor SP liver resections (4). A novel finding of the study presented herein is that hemostasis in complex SP hepatic major surgery cannot be performed with pre-coagulation only. Six (24%) out of 25 patients suffered from substantial bleeding during parenchymal transection which required more advanced techniques, such as suturing, clipping and stapling. The argument of direct cost savings of 27.6% (for staplers and clips) using inline pre-coagulation is certainly not tenable in patients with SPMAJ when a risk of perioperative bleeding can be avoided. Delivering additional trocars for procedural safety in 8.0% of interventions did not compensate this disadvantage. It is of note that in literature (9) inline pre-coagulation is associated with a higher rate of postoperative complications (abscesses, biliary fistula, biliary stenosis) when compared to the crush-clamp liver resection. Occasionally, we have experienced biloma formation after open or minimally invasive liver resections utilizing the CUSA or inline pre-coagulation. As we additionally use clips on large bile ducts or bipolar coagulation on small branches with both techniques the biloma rate does not depend on the surgical approach. The complication rates in SPMAJ presented herein reflect the complexity of the underlying disease and seem adequate in comparison to complication rates published for open or laparoscopic major hepatectomies (25.9% and 22.4%) (10).

Third, in contrast to the recommendation not to offer SP to patients with previous or concomitant surgery more than half of the study population met those criteria and underwent a safe and efficient application of this technique. The meta-analysis by Wang *et al.* showed no significant difference in terms of procedural time when comparing conventional laparoscopy and SP liver surgery (11). The median operative time of less than three hours is comparable to procedural times published for multiport laparoscopic and open liver resections (12).

With regard to the oncologic safety we have to note one of the limitations of this study as it comprises a multitude of tumor entities. Therefore only free resection margins, tumor lacerations and the local recurrence rate are found to be valid surrogate parameters. In contrast to non-ablative techniques, it is under debate whether margins extending into the ablation zone should be regarded as R1 resection (which was true in one case of SPMIN). However, none of the patients developed local recurrence at the hepatic resection plane within the follow-up period, which speaks for both the accuracy of the SP technique and the value of inline pre-coagulation as an applicable transection mode.

Expanding the spectrum from SPMIN to SPMAJ requires advanced individual and technical skills. It should be stated that the study design and strict patient selection following the aforementioned exclusion criteria was in part attributed to an intense learning curve and should therefore be regarded as a limiting factor before generalizing these results. In addition, quality of life was not assessed in this study, but it has been reported that SP results in better quality of life (13-15) than does conventional surgery.

Conclusions

SPMAJ and SPMIN represent feasible and safe surgical high-end techniques even for demanding minimally invasive liver resection when modified strategical conditions are respected. The optimal incision site allows access to all segments of the liver. Intraoperative bleeding although not common, in selected patients requires unrestricted manipulation. Inline radiofrequency pre-coagulation as a stand-alone technique is sufficient to control bleeding in SPMIN, but failed in SPMAJ. With sufficient experience in SP and liver surgery, a low complication rate justifies SPMIN and SPMAJ in strictly selected patients.

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References

1. Ciria R, Cherqui D, Geller DA, et al. Comparative Short-term Benefits of Laparoscopic Liver Resection: 9000 Cases and Climbing. Ann Surg 2016;263:761-77.
2. Weiss H, Zorron R, Vestweber KH, et al. ECSPECT prospective multicentre registry for single-port laparoscopic colorectal procedures. Br J Surg 2017;104:128-37.
3. Morales-Conde S, Peeters A, Meyer YM, et al. European association for endoscopic surgery (EAES) consensus statement on single-incision endoscopic surgery. Surg Endosc 2019;33:996-1019.
4. Weiss M, Mittermair C, Brunner E, et al. Inline radiofrequency pre-coagulation simplifies single-incision laparoscopic minor liver resection. J Hepatobiliary Pancreat Sci 2015;22:831-6.
5. Wakabayashi G, Cherqui D, Geller DA, et al. Recommendations for laparoscopic liver resection: a report from the second international consensus conference held in Morioka. Ann Surg 2015;261:619-29.
6. Schullian P, Weiss H, Klaus A, et al. Laparoscopic liver packing to protect surrounding organs during thermal ablation. Minim Invasive Ther Allied Technol 2014;23:294-301.
7. Rao A, Rao G, Ahmed I. Laparoscopic or open liver resection? Let systematic review decide it. Am J Surg 2012;204:222-31.
8. Twaij A, Pucher PH, Sodergren MH, et al. Laparoscopic vs open approach to resection of hepatocellular carcinoma in patients with known cirrhosis: systematic review and meta-analysis. World J Gastroenterol 2014;20:8274-81.
9. Lupo L, Gallerani A, Panzera P, et al. Randomized clinical trial of radiofrequency-assisted versus clamp-crushing liver resection. Br J Surg 2007;94:287-91.
10. Otsuka Y, Kaneko H, Cleary SP, et al. What is the best technique in parenchymal transection in laparoscopic liver resection? Comprehensive review for the clinical question on the 2nd International Consensus Conference on Laparoscopic Liver Resection. J Hepatobiliary Pancreat Sci 2015;22:363-70.
11. Wang YB, Xia J, Zhang JY, et al. Effectiveness and safety of single-port versus multi-port laparoscopic surgery for treating liver diseases: a meta-analysis. Surg Endosc 2017;31:1524-37.
12. Ratti F, Cipriani F, Ariotti R, et al. Laparoscopic major hepatectomies: current trends and indications. A comparison with the open technique. Updates Surg 2015;67:157-67.
13. Shetty GS, You YK, Choi HJ, et al. Extending the limitations of liver surgery: outcomes of initial human

experience in a high-volume center performing single-port laparoscopic liver resection for hepatocellular carcinoma. Surg Endosc 2012;26:1602-8.
14. Tayar C, Subar D, Salloum C, et al. Single incision laparoscopic hepatectomy: Advances in laparoscopic liver surgery. J Minim Access Surg 2014;10:14-7.
15. Hu M, Zhao G, Wang F, et al. Single-port and multi-port laparoscopic left lateral liver sectionectomy for treating benign liver diseases: a prospective, randomized, controlled study. World J Surg 2014;38:2668-73.

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