Journal of Robotic Surgery (2019) 13:231–237
https://doi.org/10.1007/s11701-018-0842-1

ORIGINAL ARTICLE

Robotic-assisted right posterior segmentectomies for liver lesions: single-center experience of an evolutional method in left semi-lateral position

Chao-Ying Wu[1] · Po-Da Chen[2] · Chih-Yuan Lee[2] · Jin-Tung Liang[2] · Yao-Ming Wu[2]

Received: 13 September 2017 / Accepted: 4 July 2018 / Published online: 11 July 2018

Abstract
Despite the popularity of minimally invasive surgery (MIS) for hepatectomy, limitations in the approach of the right posterior section of the liver remain. Although skills and approach techniques have been developed for hepatectomy of lesions in the posterior segments of the liver, most are performed laparoscopically and are limited to few experienced hands using rigid laparoscopic instruments. In this study, we tried a different approach area via the aid of a flexible robotic system. Since 2012, we have successfully completed more than 200 robotic hepatectomy procedures in our institution. Two different patient settings have been applied for right posterior segment lesions, including supine position as general setting in early cases and left semi-lateral decubitus setting in our later cases. The demographic data and perioperative outcomes between the two groups were analyzed in regard to different positioning. A total of 25 patients with right posterior segment lesions underwent robotic-assisted resection, 13 were placed in supine position and 12 in left semi-lateral position. The left semi-lateral group had significantly shorter operation time (306.0 versus 416.8 min, $p=0.023$), less blood loss (203.9 versus 1092.3 mL, $p=0.030$), and lower transfusion rates (0 versus 46.2%, $p=0.015$). We described an evolutionary technique for robotic right posterior segmentectomies with the patient placed in left semi-lateral position. This method can be applied for most patients easily and is demonstrated as a safe and feasible approach in selected patients owing to its ability to overcome the difficulty of MIS hepatectomy for right posterior lesions.

Keywords Robotic hepatectomy · Minimally invasive surgery · Right posterior segment · Left semi-lateral position

Introduction

Minimally invasive techniques for hepatectomy, including conventional laparoscopic and robotic-assisted methods, were reported to be feasible for liver lesions in selected patients [1–6]. However, such procedures are limited by a steep learning curve, and according to important consensus, only solitary lesions less than 5 cm and are located at the peripheral segments (segments 2, 3, 4b, 5, and 6) are recommended for routine minimally invasive liver resection [7, 8]. Moreover, it was difficult for minimally invasive surgery (MIS) to manage tumors in the posterosuperior segments, and some cases were even treated with major hepatectomies because of limitation in parenchymal-sparing hepatectomy technique [9, 10].

To obtain a better functional liver reserve in a patient with right posterior lesion and insufficient liver function, many efforts have been reported for parenchymal-sparing surgery. Yoon and colleagues [11, 12] initialized the analysis of tumor location and approach technique and suggested a modified liver-hanging maneuver. Since Tomishige et al. [13] reported a case using left lateral position for a better view of the cutting surface, different settings of patient positioning have been discussed, including left decubitus position by Casciola et al. [9], semiprone positioning by Ikeda et al. [14, 15], and video-assisted thoracoscopy by Murakami et al. [14, 15]. However, these documented reports were limited by the use of conventional MIS instruments, which implies the need for steep learning curve, and

✉ Yao-Ming Wu
wyaoming@gmail.com

1 Department of Surgery, National Taiwan University Hospital, Yunlin Branch, Yunlin, Taiwan

2 Department of Surgery, National Taiwan University Hospital, College of Medicine, No. 7, Chung-Shan South Road, Taipei 100, Taiwan

lacked statistical analysis of the solid evidence in position setting.

The robotic system was introduced to overcome some limitations of conventional laparoscopy [16, 17]. The flexibility of the system was considered to be the key in dealing with hepatic lesions deep in the difficult approach area, the right posterior segments [9]. In our institution, we have performed more than 200 robotic-assisted liver resections since 2012. However, the lesions are in the right posterior segments, which is a major limitation in our series. A usual patient positioning, i.e., reverse Trendelenburg with 30° tilted to the left, did not provide good exposure for the right posterior lesions and hence resulted in the difficulty in using functional and flexible robotic arms. Therefore, we changed the patient position of the later cases in our series, and we found that it exposes the right posterior liver when the patient is placed in a left semi-lateral position. In this study, we introduced robotic-assisted liver resections of tumors in the right posterior segments of the liver with the patients in left semi-lateral position and compared the perioperative outcomes between different patient positioning groups.

Materials and methods

Patient selection

Between February 2012 and September 2016, more than 200 robotic-assisted hepatectomies were performed in our institution. All procedures were approved by the institution's supervisory committee, and this study was approved by the institutional review board. Patient's informed consent was also obtained before the operation. Among these robotic procedures, we had 93 parenchymal-sparing hepatectomies for lesions over segments 2–7, 68 robotic-assisted hepatectomies for pure peripheral segments (segments 2, 3, 4b, 5, and 6), and 25 operations for right posterior segments. In consideration of the cases of right posterior segmentectomies, 13 cases were placed in supine position and the other 12 cases were placed in left semi-lateral position. The Brisbane 2000 Terminology of Liver Anatomy and Resections was applied for the nomenclature of the hepatic resection in this article [18]. Patients who fit the selection criteria based on the Louisville Statement [7], i.e., tumors less than 10 cm in size, were given the option of undergoing MIS. Patients were given the option of undergoing MIS hepatectomy after they discussed the surgical risk with our team.

Surgical technique

Patient positioning for right posterior segmentectomies

The patients, under general anesthesia, were in left semi-lateral position, with an approximate angle of 30° between the patient's back and the operating table and 30° of reverse Trendelenburg posture (Fig. 1a). One pillow was placed between the patient's arms, which were elevated and in front of the face. This positioning facilitated the exposure of the right lobe of the liver due to the gravitational retraction of the bowel loops. After the right lobe of the liver was dissected from the retroperitoneum, the right posterior segments would be easily exposed due to the gravitational effects (Fig. 2).

Port placement for right posterior segmentectomies

The trocar locations were redesigned (Fig. 1b). The camera port was placed along the right mammillary line, and the three working ports were placed at the right mid-axillary line (for the first arm) and the right subcostal regions (for the second and third arms). The distances between the robotic ports should be kept more than 8 cm. The assistant port was inserted between the second arm port and the camera port but more caudally. The table assistant stood on the left side

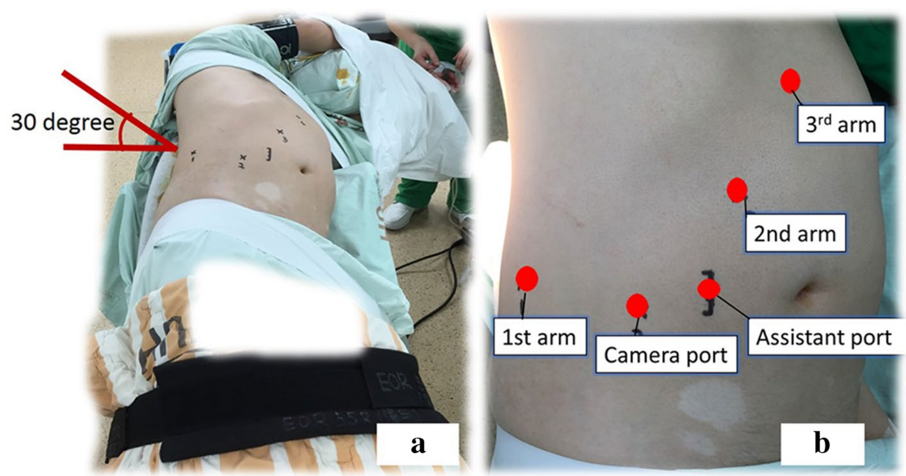

Fig. 1 Left semi-lateral position in robotic hepatectomy of lesions in the right posterior segments. **a** Left semi-lateral position, with an angle of approximately 30° between the patient's back and the operating table. **b** Disposition of trocars for lesions in the right posterior segments. Compared with traditional trocar hepatectomy positions, these ports are placed more laterally at the right abdomen

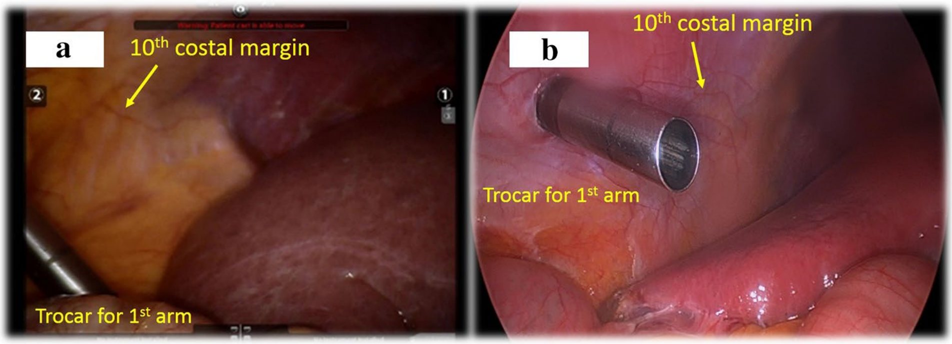

Fig. 2 Relative position of the lateral working port and liver border in different patient positioning. **a** The semi-lateral position gives a better view and working space for a lateral instrument, as the right side of the liver drops and turns medially because of the gravitational effect of the left semi-lateral position. **b** Laparoscopic view in normal supine position. The working port lies near the right lobe of the liver, which results in limitation of the approach angle and difficulty in mobilizing and exposing the right posterior lesion

of the patient, which was different from when the patient was placed in supine position. We docked four robotic arms for hepatectomy with the patient cart coming over the patient's head. To operate the robotic arms smoothly, it is important to optimize the range of motion and avoid collisions. We applied the robotic operation to perform liver mobilization, parenchymal division, bleeding control, and setup of a drainage system.

Mobilization of the right lobe of the liver and parenchymal division

While mobilizing the liver, the first and second robotic arms were equipped with monopolar electrocautery and forceps, respectively. The third robotic arm was mostly used for retraction and exposure of the operation field. With the steady retraction with robotic arm and the gravitational effect of patient positioning, the right posterior section of the liver could be exposed well.

While dividing the liver parenchyma, Pringle maneuver was not performed. We equipped two of the robotic arms with a robotic harmonic device and robotic Maryland forceps, separately. We used the Maryland forceps for bipolar electrocautery or applying the clamp-crushing technique. Larger vessels and bile ducts noted during parenchymal division were transected after ligation with robotic Hem-o-lok clips, laparoscopic clips, staplers, or robotic sutures when appropriate.

The detailed techniques of robotic hepatectomy were documented in our previous article [19].

Statistics analysis

In this study, continuous data were expressed as means ± standard deviation. Either an independent *t* test or a χ^2 test was used where appropriate to compare the group variables. For all statistical evaluations, a p value < 0.05 was considered significantly different. All statistical works were carried out with Statistical Package for Social Sciences (SPSS)® version 23 (IBM Corporation, Armonk, NY, USA).

Results

In view of robotic hepatic segmentectomy and bisegmentectomy, 68 patients underwent robotic hepatectomy of pure peripheral segments and 25 patients received robotic hepatectomy of the right posterior segments in our institution. The group of peripheral segments has shorter operation time (256.7 versus 363.6 min), less blood loss (210.7 versus 665.9 mL), and less need for blood transfusion (5.9 versus 24%) (Table 1). A total of 25 patients underwent robotic hepatectomy for the right posterior segments, with 13 in supine position and 12 in left semi-lateral position. For cases of hepatic tumors located in the right posterior section, 1 (4%) had segmentectomy of segment 7, 20 (80%) had right posterior sectionectomy, and 4 (16%) had right posterior sectionectomy with segmentectomy of segment 5. Malignant disease was the main indication in this study (92%), including 21 hepatocellular carcinomas, 1 cholangiocarcinoma, and 1 colorectal liver metastasis.

Under laparoscopic view, with the patient in left semi-lateral position, we could expose the right posterior section with more ease (Fig. 2). Furthermore, the right lobe of the liver turned medially and the trocar of the first arm could be set more laterally under this circumstance, which left more space for the manipulation of the first arm.

Comparing the demographic data between the supine position and left semi-lateral position (Table 2), the supine position group had longer international normalized ratio and lower albumin level, yet there was no significant difference in terms of Child–Pugh score and histological

Table 1 Operation details and short-term outcomes between the two robotic hepatectomy groups (pure peripheral segments versus right posterior segments)

	Pure peripheral segments (n=68)	**Right posterior segments (n=25)**	***p* Value**
Sex (male/female)	49:19	21:4	0.288
Operation time (minutes)	256.7 ± 97.9	363.6 ± 124.7	< 0.001*
Blood loss (mL)	210.7 ± 423.7	665.9 ± 1041.5	0.003*
Blood transfusion	4 (5.9)	6 (24)	0.002*
Conversion	0	1 (4)	0.269
Postoperative hospital stay (day)	5.9 ± 3.0	6.5 ± 1.7	0.349
Perioperative death	0	0	–
Patients with complication	2 (2.9)	0	0.687
Postoperative bleeding (Clavien–Dindo classification II)	1 (1.4)	0	
Biloma with infection (Clavien–Dindo classification II) [30]	1 (1.4)	0	

Values are given as median ± standard deviation or *n* (%)

*Statistically significant, $p < 0.05$

Table 2 Comparison of demographic data between the two groups (supine position versus left semi-lateral position)

	Supine position group ($n=13$)	Left semi-lateral position group ($n=12$)	*p* value
Age (years)	58.1 ± 12.8	58.6 ± 9.8	0.915
Sex (male/female)	10:3	11:1	0.593
BMI	24.3 ± 4.0	25.4 ± 2.5	0.420
HBsAg positive	6 (46.2)	8 (66.7)	0.428
HCV positive	2 (15.4)	1 (8.3)	1.000
Cirrhosis	4 (30.8)	3 (25)	1.000
Total bilirubin (mg/dL)	0.91 ± 0.25	0.89 ± 0.36	0.843
Serum AST	32.9 ± 21.7	48.3 ± 61.5	0.407
Serum ALT	40.1 ± 36.9	70.8 ± 116.4	0.374
ICG retention at 15 min (%)	10.0 ± 4.7	10.6 ± 7.6	0.813
INR	1.06 ± 0.08	0.98 ± 0.05	0.010*
Albumin (mg/dL)	4.3 ± 0.3	4.6 ± 0.3	0.029*
Hemoglobin (mg/dL)	14.4 ± 1.7	14.8 ± 1.0	0.461
Platelet count ($\times 10^9$/L)	179.4 ± 62.8	196.8 ± 38.6	0.416
Tumor size (cm)	4.1 ± 3.0	3.1 ± 1.3	0.323

Values are given as median ± standard deviation or *n* (%)

AST aspartate aminotransferase, *ALT* alanine aminotransferase, *BMI* body mass index, *HBsAg* hepatitis B virus, *HCV* hepatitis C virus, *ICG* indocyanine green, *INR* international normalized ratio

*Statistically significant, $p < 0.05$

confirmed cirrhosis. The operation time was significantly shorter in the left semi-lateral position group (416.8 versus 306.0 min, $p = 0.023$; Table 3). The blood loss of the left semi-lateral position group was less than that of the supine position group (203.9 versus 1092.3 mL, $p = 0.030$; Table 3). In addition, there was a significantly more need for blood transfusion in the supine position group (46.2 versus 0%, $p = 0.015$; Table 3).

Moreover, we had one conversion (7.7%) in the supine position group. In this case, bleeding control was difficult during the robotic operation because of injury to the right hepatic vein, and the total blood loss was about 5000 mL. There was no perioperative complication in our study.

Discussion

Despite the recent popularity of MIS techniques worldwide, inherent limitations in approaching hepatic lesions in the right posterior segments remain [20]. As pioneers working for minimally invasive right posterior segmentectomy, we encountered difficult situations, as presented in this study.

Table 3 Operation details and short-term outcomes between the two groups (supine position versus left semi-lateral position)

	Supine position group ($n = 13$)	Left semi-lateral position group ($n = 12$)	p value
Robotic-assisted procedures			0.618
Segment 7 segmentectomy	1 (7.7)	0	
Segments 6–7 segmentectomy	10 (76.9)	10 (83.3)	
Segments 6–7 segmentectomy + partial Segment 5 resection	2 (15.4)	2 (16.7)	
Specimen weight (g)	233.7 ± 252.4	137.8 ± 89.8	0.230
Operation time (minute)	416.8 ± 135.0	306.0 ± 84.1	0.023*
Blood loss (mL)	1092.3 ± 1316.1	203.9 ± 172.3	0.030*
Blood transfusion	6 (46.2)	0	0.015*
Packed RBC (units)	2.4 ± 4.9	0	0.108
Platelet (unit)	1.9 ± 4.5	0	0.175
Fresh frozen plasma (units)	2.7 ± 6.7	0	0.170
Conversion	1 (7.7)	0	1.000
Postoperative hospital stay (day)	6.7 ± 1.5	6.3 ± 2.0	0.359
Perioperative death	0	0	–
Patients with complication	0	0	–

Values are given as median ± standard deviation or n (%)

*Statistically significant, $p < 0.05$

Robotic hepatectomy for right posterior lesions needed longer operation time, had more blood loss, and needed more blood transfusion, with a significant difference compared with the group of pure peripheral segments. Yet, the difficulty in handling right posterior lesions seemed to be overcome by changing the patient position to left semi-lateral position.

The right posterior segments are located at the deepest site of the right upper abdomen, and their approach is hindered, especially in MIS with conventional patient position. According to the liver anatomy, the right posterior section is difficult to be seen entirely by conventional laparoscopy views, and the right lobe of the liver is more difficult to be mobilized by MIS techniques than by open methods. Moreover, bleeding control in the right posterior segmentectomies is more challenging for minimal invasive surgery because of its poor exposure and the rigidity of conventional instruments in deep area. Therefore, most lesions of the right posterior segments were resected with major hepatectomies with excessive parenchymal sacrifice during the development period of MIS hepatectomy [9, 10]. However, major hepatectomy is associated with higher risks of hepatic failure in patients with borderline functional liver reserve, and therefore, some patients were left with no other choice. Thus, parenchymal-sparing hepatectomy of MIS would bring benefit to more patients.

In our experience, the left semi-lateral group had significantly better perioperative results in some aspects, such as shorter operation time, less blood loss, and less need of blood transfusion. With the patient in conventional supine position, the resection line of hepatectomy would be interfered by the anterior segments. If the patient was placed in left semi-lateral position, as described in this article, the right lobe of the liver would drop and turn medially after dividing the ligaments of the right lobe of the liver due to gravity and the right posterior section could be better exposed. In addition, an even better exposure of the resection line would be obtained not only by avoiding being hindered by the right anterior segments, but the patient positioning also resulted to more distance for the resected part to be laterally retracted to the Morison pouch (Fig. 2). That is, we could achieve better parenchymal division and better bleeding control under this circumstance.

Robotic surgery developed rapidly in recent years and enhanced MIS skills in several ways, such as its magnified three-dimensional projection of surgical views, wristed instruments with 7 degrees of freedom, filter of tremor, and precise operation, etc. According to the literatures, robotic liver resection is considered to be a feasible and safe procedure for experienced surgeons [16, 17, 21]. The perioperative and oncological outcomes of robotic surgery are comparable to open and laparoscopic methods in selected cases [1, 6, 17, 22–26]. Based on its advantages mentioned above, some reports have addressed the benefits of robotic system especially in handling hepatic tumors in the posterior section [17, 26]. There was a report on conversion from laparoscopic wedge resection of segments 7 and 8 to robotic-assisted method for vascular repair because of stapler malfunction-related caval injury under laparoscopy [27]. However, in our experience, the adoption of flexible robotic arms could not deal all problems in facing the lesion of posterior segment. The position adjustment could be another key point in the advancement of MIS hepatectomy.

We did not perform Pringle maneuver during parenchymal dissection. Less blood loss could be achieved by Pringle maneuver, especially in patients with liver cirrhosis [9, 20, 28]. However, the procedure might cause ischemic injury to the residual liver and intestinal congestion [2, 12, 29]. Instead, we performed the clamp-crushing technique for delicate parenchymal dissection and thereby minimized blood loss. The technique could be performed with the assistance of more flexible and delicate robotic instruments, which might circumvent the problems encountered when using rigid instruments in conventional laparoscopy. Furthermore, the surgical field of the right posterior section would be better exposed by our patient positioning methods and the robotic assistance. Therefore, we did not apply Pringle maneuver even in cirrhotic patients.

Although MIS advancement in managing right posterior lesions was achieved in our institution, there were some limitations in this study. The procedures of the different positioning groups were not performed in the same time period. Twelve patients in the left semi-lateral group underwent surgery after we encountered difficulties in treating the initial 13 patients placed in the conventional supine position. This might result in statistical bias because some perioperative results could be improved by accumulated experience. In Fig. 2, we exhibited a better exposure of the right posterior section and a wider manipulating space for the robotic instruments. We could thereby manage these lesions with more effectiveness. However, these effects of exposure and space could not be quantized for statistical analysis. In addition, this was not a prospective study, and further studies enrolling more centers and surgeons should be undertaken to overcome these limitations.

Although successful robotic or laparoscopic hepatectomies for tumors in the posterior section were reported, pure minimally invasive techniques for these lesions were initially suggested to be reserved for very experienced surgeons and specialized centers [20]. However, our experiences for approaching the right posterior section may encourage more surgeons to treat these kinds of lesions and thereby help more patients. This article described an evolutionary technique using robotic surgery for the treatment of tumors in the right posterior segments of the liver with the patient placed in left semi-lateral position, which was found to be feasible and safe in selected patients. Moreover, this position change improves the operation in some aspects, such as less blood loss, less need for blood transfusion, and shorter operation time.

Compliance with ethical standards

Conflict of interest Chao-Ying Wu, Po-Da Chen, Chih-Yuan Lee, Jin-Tung Liang, and Yao-Ming Wu declare that they have no conflict of interest.

Ethical standards All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). Informed consent was obtained from all patients for being included in the study.

References

1. Ho CM et al (2013) Systematic review of robotic liver resection. Surg Endosc 27(3):732–739
2. Yoon YS et al (2010) Total laparoscopic liver resection for hepatocellular carcinoma located in all segments of the liver. Surg Endosc 24(7):1630–1637
3. Hart ME, Precht A (2013) Robotic liver resection technique. Cancer J 19(2):147–150
4. Nguyen KT, Gamblin TC, Geller DA (2009) World review of laparoscopic liver resection—2,804 patients. Ann Surg 250(5):831–841
5. Rowe AJ et al (2009) Perioperative analysis of laparoscopic versus open liver resection. Surg Endosc 23(6):1198–1203
6. Qiu J, Chen S, Chengyou D (2016) A systematic review of robotic-assisted liver resection and meta-analysis of robotic versus laparoscopic hepatectomy for hepatic neoplasms. Surg Endosc 30(3):862–875
7. Buell JF et al (2009) The international position on laparoscopic liver surgery: the Louisville Statement, 2008. Ann Surg 250(5):825–830
8. Cherqui D (2003) Laparoscopic liver resection. Br J Surg 90(6):644–646
9. Casciola L et al (2011) Robot-assisted parenchymal-sparing liver surgery including lesions located in the posterosuperior segments. Surg Endosc 25(12):3815–3824
10. Cho JY et al (2009) Outcomes of laparoscopic liver resection for lesions located in the right side of the liver. Arch Surg 144(1):25–29
11. Yoon YS et al (2006) Total laparoscopic right posterior sectionectomy for hepatocellular carcinoma. J Laparoendosc Adv Surg Tech A 16(3):274–277
12. Cho JY et al (2008) Feasibility of laparoscopic liver resection for tumors located in the posterosuperior segments of the liver, with a special reference to overcoming current limitations on tumor location. Surgery 144(1):32–38
13. Tomishige H et al (2013) Caudal approach to pure laparoscopic posterior sectionectomy under the laparoscopy-specific view. World J Gastrointest Surg 5(6):173–177
14. Ikeda T et al (2014) Laparoscopic liver resection in the semiprone position for tumors in the anterosuperior and posterior segments, using a novel dual-handling technique and bipolar irrigation system. Surg Endosc 28(8):2484–2492
15. Murakami M, Aoki T, Kato T (2011) Video-assisted thoracoscopic surgery: hepatectomy for liver neoplasm. World J Surg 35(5):1050–1054
16. Leung U, Fong Y (2014) Robotic liver surgery. Hepatobiliary Surg Nutr 3(5):288–294
17. Wu YM et al (2014) Robotic-assisted minimally invasive liver resection. Asian J Surg 37(2):53–57

18. Strasberg SM (2005) Nomenclature of hepatic anatomy and resections: a review of the Brisbane 2000 system. J Hepatobiliary Pancreat Surg 12(5):351–355
19. Chen PD et al (2016) Robotic liver donor right hepatectomy - a pure, minimally invasive approach. Liver Transpl 22:1509–1518
20. Mostaedi R et al (2012) Laparoscopic liver resection: current role and limitations. World J Gastrointest Oncol 4(8):187–192
21. Choi GH et al (2012) Robotic liver resection: technique and results of 30 consecutive procedures. Surg Endosc 26(8):2247–2258
22. Giulianotti PC et al (2011) Robotic liver surgery: results for 70 resections. Surgery 149(1):29–39
23. Yu YD et al (2014) Robotic versus laparoscopic liver resection: a comparative study from a single center. Langenbecks Arch Surg 399(8):1039–1045
24. Ocuin LM, Tsung A (2015) Robotic liver resection for malignancy: current status, oncologic outcomes, comparison to laparoscopy, and future applications. J Surg Oncol 112(3):295–301
25. Tsung A et al (2014) Robotic versus laparoscopic hepatectomy: a matched comparison. Ann Surg 259(3):549–555
26. Tranchart H et al (2014) Traditional versus robot-assisted full laparoscopic liver resection: a matched-pair comparative study. World J Surg 38(11):2904–2909
27. Boggi U et al (2009) Robotic suture of a large caval injury caused by endo-GIA stapler malfunction during laparoscopic wedge resection of liver segments VII and VIII en-bloc with the right hepatic vein. Minim Invasive Ther Allied Technol 18(5):306–310
28. Cho JY et al (2008) Experiences of laparoscopic liver resection including lesions in the posterosuperior segments of the liver. Surg Endosc 22(11):2344–2349
29. Ikeda T et al (2013) Pure laparoscopic hepatectomy in semiprone position for right hepatic major resection. J Hepatobiliary Pancreat Sci 20(2):145–150
30. Clavien PA et al (2009) The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg 250(2):187–196