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A single-centre experience of 40 laparoscopic liver resections

一間外科手術中心進行了40個腹腔鏡肝臟切除手術的經驗分享

Objective. To review results of laparoscopic liver resections, particularly in those patients with hepatic malignancy and recurrent pyogenic cholangitis.
Design. Retrospective analysis.
Setting. Minimal access surgery training centre, Hong Kong.
Patients. Patients with pathologies located at anterio-inferio-lateral segments (Couinaud segments 2, 3, 4b, 5, 6) for laparoscopic resection were recruited during the period 1998 to 2005. Patients were excluded from review if they had: pathologies at central locations and the superior and posterior segments (4a, 7, 8), large tumours (>5 cm in diameter), and those close to major vasculature or the liver hilum.
Results. During the study period, we attempted 40 such laparoscopic liver resections, excluding marsupialisations and resections for simple liver cysts. There were 20 female and 20 male patients, with a mean age of 57 (standard deviation, 13; range, 29-81) years. All but one underwent a successful laparoscopic operation. Pathology included hepatocellular carcinoma (n=17), recurrent pyogenic cholangitis (n=14), colorectal liver metastasis (n=4), benign liver tumour (n=4), and intrahepatic cholangiocarcinoma (n=1). All except four were hand-assisted laparoscopic liver resections. The mean operating time was 169 (range, 60-290) minutes and mean blood loss amounted to 270 mL (range, 0-1000 mL). Complications occurred in eight (20%) patients, which included six wound infections, one postoperative bile leak, and two incisional hernias. There was no operative or hospital mortality. For hepatocellular carcinoma, clear resection (>10 mm) was achieved in all except five patients, and the 1-year and 2-year survival rates were 86% and 59% respectively. Favourable results were also obtained for resections in patients with recurrent pyogenic cholangitis; after a mean (standard deviation) follow-up of 29 (23) months, only one was readmitted (for cholangitis).
Conclusion. In appropriately selected patients, laparoscopic liver resection is feasible and safe, and achieves acceptable survival among individuals with hepatic malignancy and very favourable long-term outcomes in those with recurrent pyogenic cholangitis undergoing hand-assisted laparoscopic segmentectomy.

目的：檢討腹腔鏡肝臟切除手術的效果，特別對肝臟惡性腫瘤和復發性化膿膽管炎的病人。
設計：回顧分析。
安排：香港一所微創外科訓練中心。
患者：在1998至2005年期間，因「前、下、側部分」(肝臟分區〔Couinaud segment〕2、3、4b、5及6區）出現病變而須進行腹腔鏡肝臟切除手術的病人。病變出現在中間間隔或上、後部位（肝臟分區4a、7及8區）、腫瘤較大（直徑超過5 cm）和腫瘤接近主要血管和肝臟腫臍的病人則不在研究之列。
結果：在研究期間，不計算成袋術和治療簡單肝囊腫所作的切除術，我們進行了40次腹腔鏡肝臟切除手術。病人為20男20女，平均年齡57歲（標準差13歲；介乎29-81歲）。只有一名病人的腹腔鏡肝臟切除手術不成功。病人的病變包括肝細胞癌（17人）、復發性化膿膽管炎（14人）、結腸癌肝臟轉移（4人）、良性肝臟腫瘤（4人）和肝內膽管癌（1人）。除了4名病人，其他病人都是進行人手輔助的腹腔鏡肝臟切除手術。手術所須時間平均為169分鐘（介乎60-290分鐘），平均失血量為270毫升（介乎0-1000毫升）。8名病人（20%）出現併發症，包括6人傷口感染、1人術後膽汁漏出和2人手術切口破裂。沒有病人在手術或住院期間死

Key words:
Carcinoma, hepatocellular;
Cholangitis;
Hepatectomy;
Laparoscopy;
Liver diseases

關鍵詞：
癌，肝細胞的；
膽管炎；
肝切除術；
腹腔鏡手術；
肝病

Hong Kong Med J 2006;12:419-25

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亡。對肝細胞癌病人，除 5 人外其餘病人的癌瘤都全部切除（超過 10 mm），而一年及兩年的存活率分別為 86% 及 59% 。腹腔鏡肝臟切除手術對復發性化膿膽管炎病人亦有良好效果，在平均 29 個月的跟進期（標準差 23 個月）後，只有一名病人因膽管炎而須再次入院。

結論：腹腔鏡肝臟切除手術不單可行及安全，對肝細胞癌患者更帶來良好的存活率，而人手輔助的腹腔鏡切片對復發性化膿膽管炎病人亦有良好的長遠結果。

Introduction

The challenge of laparoscopic liver resection is to accurately locate and resect the pathology via a keyhole incision, and at the same time achieve satisfactory haemostasis along the transection plane. As a result of skill maturation and availability of specially designed advanced instruments in the past decade, the majority of liver resections are now feasible laparoscopically. Thus, several series of laparoscopic liver resections have now been reported for primary and secondary tumours, in both cirrhotic and non-cirrhotic livers.[1-11]

In 1992, Gagner et al[1] performed the first successful laparoscopic partial hepatectomy for a patient with focal nodular hyperplasia and 4 years later the first anatomical laparoscopic left lateral segmentectomy was reported by Azagra et al.[2] To minimise the risks of massive bleeding and gas embolism, and based on 10 patients with primary and metastatic tumours, Kaneko et al[3] advocated using a microwave tissue coagulator with an abdominal wall-lift method to carry out a laparoscopic partial hepatectomy. In the series of 38 cases by Huscher et al,[4] it was again demonstrated that the laparoscopic approach was as feasible and safe as conventional surgery, in dealing with different liver pathologies, including benign and malignant cases. In 1999, Katkhouda et al[5] reported 34 such operations for both solid and cystic liver pathologies. This landmark paper emphasised the importance of appropriate case selection and described the standardised '4-handed technique', which means the surgeon and chief assistant use both hands together during mobilisation and parenchymal transaction. After the turn of millennium, more and more such resections were reported by different centres all over the world.[6-9]

Laparoscopic liver resection can either be totally laparoscopic or hand-assisted. The drawbacks and difficulties encountered with the former are (1) possible massive bleeding and air embolism via injured hepatic veins, (2) loss of tactile palpation, and (3) difficulty in extracting intact malignant specimens through the trocar incision. It therefore seems quite reasonable to modify it to hand-assisted laparoscopic surgery (HALS), so as to overcome some of these problems. The notable advantages of HALS over the total laparoscopic approach are: better exposure of the anatomy and the possibility of blunt dissection with the assistance of the surgeon's left hand (for the right-handed surgeon). In addition, the 'laparoscopic hand' can also provide immediate haemostasis and prevent air embolism even if branches of the hepatic vein are severed. Last but not least, if extension of the incision is required for retrieval of intact specimens, it is advantageous for it to have been prepared earlier, so as to facilitate the dissection.[10-14]

Early postoperative recovery, less analgesic consumption and operative blood loss, shorter hospital stay, and less fluid sequestration are notable important advantages of minimal access surgery (MAS) over open surgery. However, of equal importance are long-term outcomes like (1) survival and elimination of recurrence (particularly for tumour resection) and (2) prevention of further recurrent pyogenic cholangitis (RPC) attacks.

Methods

Absence of significant coagulopathy, satisfactory liver reserve, and a clear idea of the location and extent of the pathology provided by preoperative imaging via trans-abdominal ultrasound, computed tomography (CT), and sometimes hepatic arteriogram are important prerequisites. Not uncommonly, small peritoneal and intrahepatic metastases cannot be completely excluded by preoperative imaging; their presence contradicts any major resection. Therefore, routine laparoscopic staging is recommended and a history of previous abdominal surgery is not considered an absolute contra-indication for laparoscopic liver resection.

We only recruited patients with pathologies located at anterio-inferio-lateral segments (Couinaud segments 2, 3, 4b, 5, 6) for laparoscopic resection. These segments are also named as 'laparoscopic segments' as they are accessible by laparoscopy. On the contrary, central lesions and those situated at the superior and posterior segments (4a, 7, 8) are normally excluded despite the technical feasibility of thoracoscopic transdiaphragmatic resections for tumours. Moreover, patients with large tumours (>5 cm in diameter) and those close to major vasculature or the liver hilum were also excluded.

Operative procedure

The patient was placed in Llyod-Davis position. The chief surgeon operated between patient's legs with assistants on each side. Following a subumbilical cut down and creation of a pneumoperitoneum, the insufflation pressure was usually kept around 10 mm Hg. The trocar site and the position of handport were not fixed, but varied according to the site of the pathology. As a general rule, the trocars were arranged so that two operating surgeons could work together. The use of a 30° laparoscope was recommended as it can provide a wider range of view and its magnification can

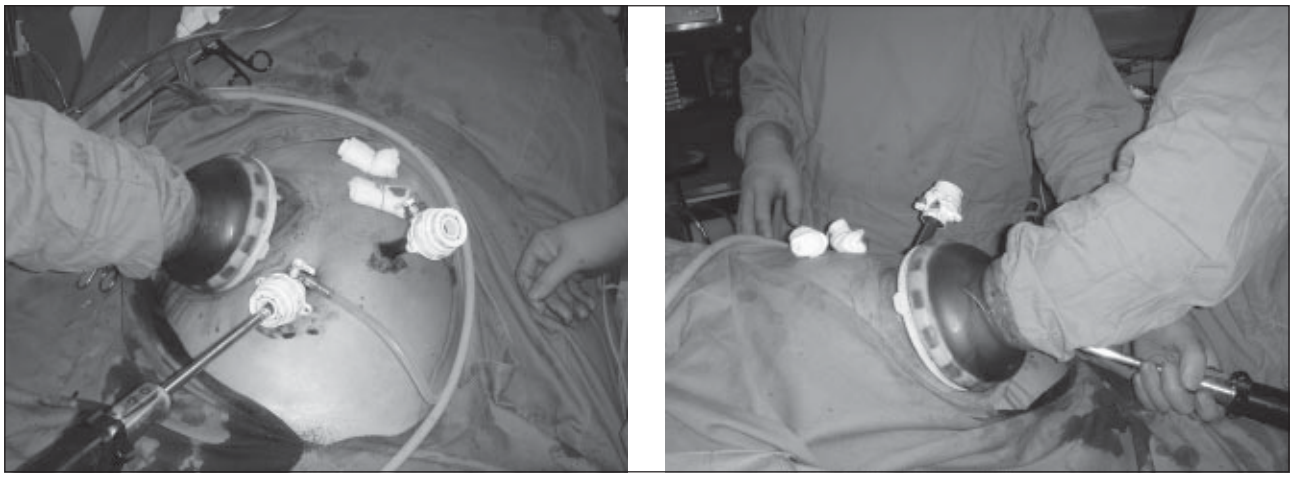


Fig 1. The layout of various trocar ports and Gelport in laparoscopic liver resection

easily reveal even very tiny peritoneal deposits. Laparoscopic ultrasound can also compensate for the drawbacks of laparoscopic surgery, replacing tactile palpation. It also helps to define the relationship between the tumour and adjacent vascular structures. The 7.5-MHz laparoscopic ultrasound (UST -5536-7.5 MHz, linear array probe; Aloka, Tokyo, Japan) can usually provide satisfactory depth of image and high resolution for most hepatic pathologies. The subsequent plane of transaction can then be easily determined. The sensitivity is guaranteed by its high frequency and absence of 'abdominal wall effect', and its deflectable tip can be adjusted according to the liver contour. As for RPC, the segmental distribution of stones and any residual common bile duct fragment can also be determined satisfactorily by laparoscopic ultrasound. The planned transection plane can then be marked by diathermy as for tumour surgery.

For hepatectomy without gross impairment of liver reserve (eg due to cirrhosis), the Pringle manoeuvre is recommended, which can significantly cut down the operative blood loss by decreasing vascular inflow via the portal vein and the hepatic artery. To accomplish this, the avascular lesser omentum is divided and a vascular sling is passed around the hepatoduodenal ligament. If portal control is required, the tension can be tightened and retained as needed by an artery forceps.

In our experience, total laparoscopic liver resection was only adopted for small lesions (<2 cm in diameter) situated at the edge, since the chance of major bleeding and air embolism was minimal. More important there was no need to make a large incision to retrieve the specimen. Our approach of choice for both RPC and most sizeable liver tumours is HALS. The 'laparoscopic hand' is usually the non-dominant hand of the chief surgeon, which facilitates better overall exposure, finger dissection, tactile palpation, immediate haemostasis, and specimen retrieval via the handport incision.

The position of Gelport (Applied Gelport XE; Applied Medical Resources Corp, California, US) is governed by the position of patient and the type of liver resection. It is our practice to have a 7-cm long transverse incision (based on the palm size of the operating surgeon) at the right side of abdomen, slightly above the level of the umbilicus (Fig 1). The incision should not be directly over the pathology or too close to the laparoscope, otherwise the view as well as the range of movement would be very limited. The surgeon's hand can then be inserted through the self-sealing gel without loss of pneumoperitoneum. Air leak is unusual and the cuff can also protect the wound against tumour implantation. Items like gauze rolls and artery clamps can be inserted through this port.

The ligaments attaching the liver are all divided, eg left triangular ligament for left lateral segmentectomy and right triangular ligament for right lobe pathology. The falciform ligament is routinely transected with the aid of LigaSure (Valleylab, Tyco, Gosport, UK) and the stump can be grasped for retraction. After these preliminary steps and provided the central venous pressure is optimal (below 5 cm H_2O), parenchymal resection was carried out using a Harmonic Scalpel (Ultracision; Ethicon, Cincinnati, OH, US) and ultrasonic surgical aspirator (Sonopet UST2000; M&M Co Ltd, Tokyo, Japan). The laparoscopic ultrasonic surgical aspirator can effectively break down the liver parenchyma whilst preserving vessels and bile ducts. This can facilitate identification of structures for subsequent clipping and division and used as in open surgery but with a long laparoscopic hand-piece.

In fact, lowering the central venous pressure to lower than 5 cm H_2O has been shown to be a simple and effective means of reducing blood loss during hepatectomy.[15] Application of either a titanium clip or endostapler (2.5/60, Autosuture; United States Surgical Corp, Norwalk, CT, US) is used for the main vascular branches and bile ducts. Injury to the main branches of the hepatic vein

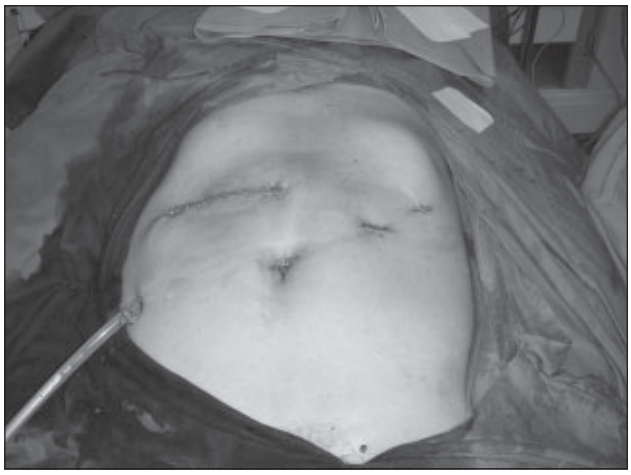


Fig 2. Wounds visible after completion of laparoscopic liver resection

can lead to fatal air embolism and must be cautiously avoided. In our series the only conversion to laparotomy was secondary to bleeding from the left hepatic vein with evidence of air embolism; the 'laparoscopic hand' provided immediate haemostasis before proceeding further. Another measure to minimise air embolism is to maintain insufflation pressure as low as possible (preferably <10 mm Hg) or to apply the abdominal-lift method as in gasless laparoscopy. Throughout the operation, the patient's vital parameters and end tidal CO_2 level should be closely monitored.

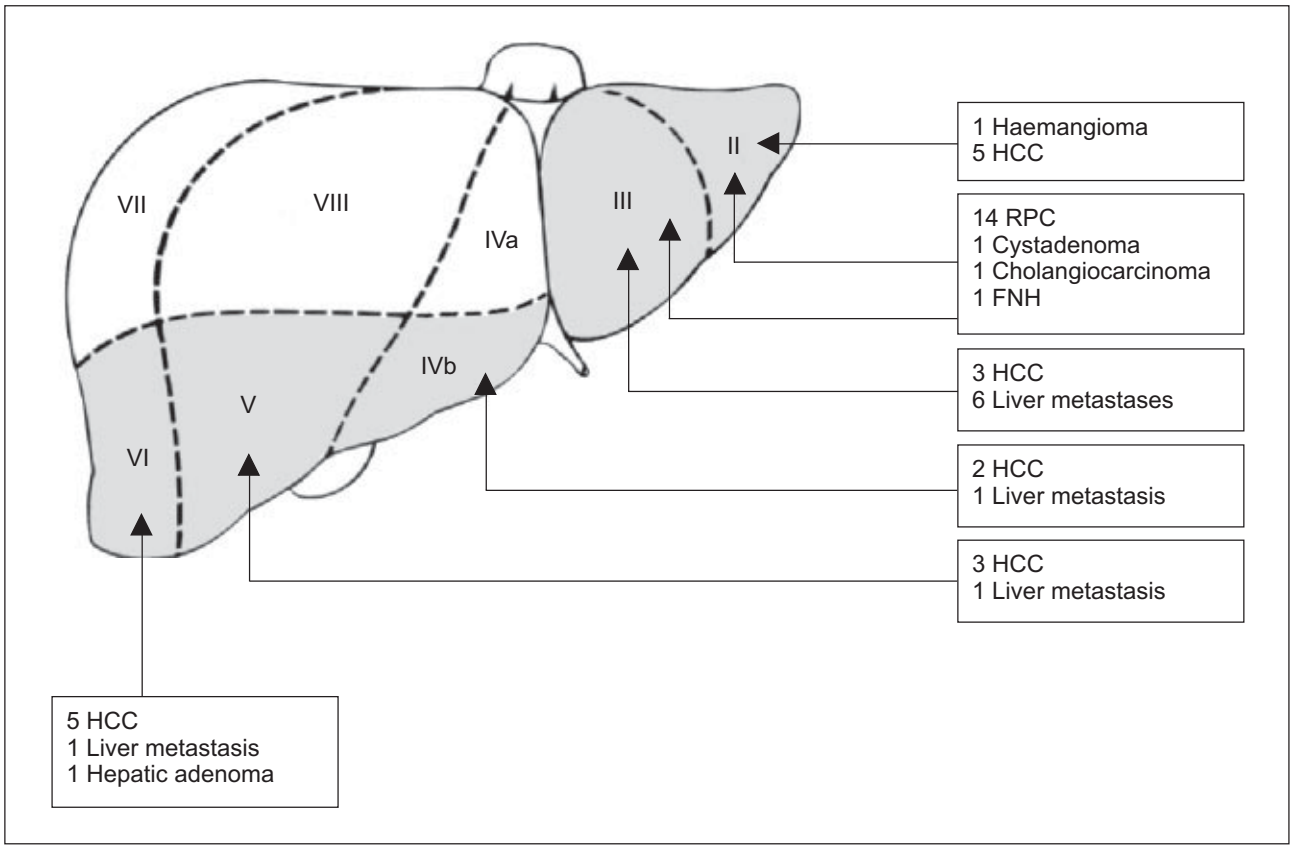
At the completion of the parenchymal transection, the raw surface is inspected for any bile leak or major oozing and such areas are plicated with 2/0 prolene using the 'laparoscopic hand' to tie any knots. An argon beam laser can then be used to achieve more complete haemostasis from any raw and oozing surface, whilst avoiding any sudden increase in intra-abdominal pressure, which could be fatal. It is therefore recommended that this instrument be used with at least one air vent open and close monitoring to exclude intra-abdominal over-pressurisation. The spraying of tissue glue (Tisseel Kit; Tisseel, Immuno AG, Vienna, Austria) over the raw resection surface may further improve haemostasis and prevent bile leak.

All specimens and swabs are placed inside a protective bag and delivered via the Gelport incision followed by the release of the pneumoperitoneum. The incision can then be retracted so that the remaining irrigation fluid can be satisfactorily sucked out. A silicone drain with multiple side holes was routinely inserted via one of the 5-mm trocar ports to prevent fluid collection (particularly in patients with RPC). All wounds more than 10 mm long were closed with 1/0 PDS to approximate to the fascial layer and the skin edge was stapled with clips (Fig 2).

Results

During the period 1998 to 2005, we performed 168 liver resections for patients with various pathologies. They included: 86 with hepatocellular carcinoma (HCC), 35 with colorectal liver metastasis, 26 with RPC, 6 with intrahepatic cholangiocarcinoma, 5 with carcinoma of gallbladder, and 10 with other miscellaneous disorders. Laparoscopic liver resection was attempted in 40 (24%) of these patients; 20 were female and 20 male and their mean age was 57 (standard deviation [SD], 13; range, 29-81) years. Respective pathological diagnoses included: HCC (n=17), RPC (n=14), colorectal liver metastasis (n=4), benign liver tumour (n=4), and cholangiocarcinoma (n=1). All the lesions were localised to their respective laparoscopic segments and the distribution of lesions is shown in Fig 3.

Among the 17 patients with HCC, 16 had macronodular cirrhosis, 14 were hepatitis B carriers, and 1 was a hepatitic C carrier. About half of the operations were non-anatomical resections (n=19) and there were 21 formal left lateral segmentectomies mainly for RPC. Almost all non-anatomical resections involved less than one Couinaud segment except for a few lesions located between different segments. The mean (SD) size of different pathologies were 31 (30) cm^3 (HCC), 5 (4) cm^3 (colorectal liver metastasis), and 138 (239) cm^3 (other miscellaneous neoplasm). The mean (SD) size of liver resections for different pathologies were 259 (166) cm^3 (HCC), 143 (127) cm^3 (RPC), 171 (132) cm^3 (colorectal liver metastasis), and 230 (207) cm^3 (other miscellaneous neoplasm). All except four resections were by HALS, and were successful, except in one patient. The only conversion was due to injury to the left hepatic vein, which resulted in moderate bleeding and air embolism; the patient underwent immediate open laparotomy and haemostasis. The mean (SD) blood loss was 270 (205) mL (range, 0-1000 mL) and mean (SD) operating time was 169 (56) minutes (range, 60-290 minutes). No patient received a peri-operative blood transfusion. The mean (SD) hospital stay was 9 (9) days (range, 4-60 days); all except two patients were discharged within 2 weeks after surgery. The patient enduring the longest hospital stay (60 days) was for a postoperative bile leak and wound complication, treated by combined biliary drainage and regular dressings. Another patient stayed more than 2 weeks, which was related to her poor premorbid condition as well as social problems. Complication occurred in eight (20%) patients, which included the previously mentioned postoperative bile leak with residual stones, six wound infections, and two incisional hernias. Bile leak associated with residual stones manifested as pleural collections and were confirmed by ultrasound and CT. The patient was managed using combined percutaneous and endoscopic biliary drainage and finally settled without recourse to laparotomy. Stone clearance was otherwise achieved in the rest of our patients with RPC. Wound infection of the Gelport incision occurred in six patients, two of whom subsequently developed incisional hernias that were surgically repaired. The unusually high



* HCC denotes hepatocellular carcinoma, RPC recurrent pyogenic cholangitis, and FNH focal nodular hyperplasia

Fig 3. Distribution of hepatic lesions undergoing laparoscopic liver resections (ie some patients had multiple lesions)*

incidence of wound infection was possibly related to the practice of re-using the Gelport after sterilisation, for which reason the reutilisation policy was abandoned in latter half of the study period and a corresponding reduction in the wound infection rate was noted. There was no operative or hospital mortality in our series. As for patients with HCC, clear resection (>10 mm) was achieved in all except five. Regarding the latter, one had tumour in the margin and all were subjected to postoperative transarterial chemoembolisation. After a mean (SD) follow-up of 26 (23) months, nine (53%) of the 17 patients with HCC developed recurrence and 1-year and 2-year survival rates were 86% and 59% respectively. Regarding patients with colorectal liver metastases, the 1-year and 2-year survival rates were 100% and 75% respectively. The only cholangiocarcinoma in our series was identified incidentally after resection of chronic liver abscess developed after percutaneous drainage of an infected liver cyst. The resection margin was clear, but the patient died 7 months after the operation, because of chest infection and acute-on-chronic renal failure. The long-term results of resections for RPC were also promising, only one (7.1%) of whom was readmitted for cholangitis after a mean (SD) follow-up of 29 (23) months. However, the latter results must be interpreted cautiously, because of the small number of cases in our series.

Discussion

The two components of operative trauma relate to access and operative ablation. The role of MAS seems to be more obvious in functional repair operations like antireflux surgery. For surgery of deep-seated pathology (eg that might require adrenalectomy), the contribution of access trauma is proportionally large. The role of MAS in major liver resection remains controversial, though the contribution of access trauma to the overall trauma is comparatively less. Although it has been more than a decade since the first report of laparoscopic partial hepatectomy, skepticism persists despite many reports on its feasibility and safety at dealing with various liver pathologies. Careful patient selection as well as proper evaluation of long-term outcomes is clearly important.

As compared to open surgery, the laparoscopic approach undoubtedly has limitations. Though most problems have been successfully overcome with improvements in technique and refinement of instruments, bleeding and air embolism deserve special consideration. The incidence of air embolism is probably underreported and most patients with early manifestations are quickly recognised by anaesthetists and treated accordingly. In both animal and human settings, pneumoperitoneum has the potential to cause air embolism, particularly during total laparoscopic

liver resection.[16,17] In view of this potentially fatal complication, a gasless approach using an abdominal lifting device has been previously recommended by Kaneko et al[3] to minimise this risk. However, the resulting exposure is far from satisfactory in most gasless laparoscopy. The introduction of the 'laparoscopic hand', which can achieve immediate haemostasis by direct compression and thus minimise or even prevent air embolism without major injury to the hepatic vein offers a notable advantage. This potential advantage has also been supported by Schmandra et al's animal study,[18] which assessed the risk of air embolism by comparing hand-assisted versus total laparoscopic liver resection. It is also important to keep the insufflation pressure at around 10 mm Hg and if major venous injury is suspected, the patient should be placed in the Trendelenburg's position, whilst anaesthetic colleagues closely monitor vital parameters including end tidal CO_2 concentration. Increased risks of gas embolism are also encountered when the argon plasma coagulator is in use, as it often leads to over-pressurisation. Thermo-ablation devices like radiofrequency ablation have been frequently employed to deal with unresectable hepatic malignancies in open surgery. Their use is particularly promising in patients with limited liver reserve or bilobe involvement, as they are reported to coagulate the plane of transection in laparoscopic liver resection so as to minimise intra-operative bleeding.[19,20]

In their case-control study, Rau et al[21] compared 17 laparoscopic liver resection patients with 17 closely matched patients having open resections. They reported longer operating times but shorter hospital stays in the laparoscopic group. Similar results were reproduced by Mala et al[22] in their comparative review of liver resections mainly for colorectal liver metastases; an additional benefit was less opioid consumption in the laparoscopic group. It is also very important to evaluate the effect of the surgical approach in patients with chronic liver disease, as hepatic dysfunction and fluid sequestration ensue quite commonly. Laurent et al[8] showed that the laparoscopic approach was associated with slightly less postoperative liver failure and ascites. Another case-control study comparing laparoscopic versus open left lateral segmentectomy by Lesurtel et al[23] also showed decreased blood loss, but at the cost of longer portal clamping and operating times. In 2002, Tang and Li[12,13] first described their hand-assisted laparoscopic technique in resecting the atrophic left lateral segments in patients with RPC. The same centre also carried out a retrospective analysis comparing their results to historical open surgery controls. They encountered less postoperative pain and shorter hospital stays with the former technique that were statistically significant, and surmised that decreased access trauma was the reason.[24] They also demonstrated quite promising results by combining hand-assisted laparoscopic segmentectomy with laparoscopic choledochoduodenostomy. Adding laparoscopic choledochoduodenostomy to the procedure was based on the status of the common bile duct (presence of multiple impacted stones noted in the cholangiogram).[25]

It is not enough to achieve improved short-term results for a new surgical approach; the long-term outcomes are equally important, particularly for tumour resection and prevention of further attacks of RPC. As for patients with HCC, clear resection (>10 mm) was achieved in all except five, and the 1-year and 2-year survival were 86% and 59% respectively, which was similar to open resections for small HCCs with underlying liver cirrhosis without decompensation.[26] The long-term results of resections for RPC were also promising; only one (7%) of the patients was readmitted for cholangitis after a median follow-up of about 54 months.

Conclusion

As the feasibility, safety, and adequacy of resection are guaranteed, and the long-term outcomes appear similar to those of the open surgery, laparoscopic liver resection can be attempted whenever the necessary expertise is available. However careful case selection is nevertheless very important.

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