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Minimally invasive approaches to extrapancreatic cholangiocarcinoma

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Abstract
Background Due to the perceived difficulty in dissecting gallbladder cancers and extrapancreatic cholangiocarcinomas off of the portal structures and in performing complex biliary reconstructions, very few centers have used minimally invasive techniques to remove these tumors. Furthermore, due to the relative rarity of these tumors when compared to hepatocellular carcinoma, only a few reports have focused on short- and long-term results.
Methods We performed a review by combining the experience of three international centers with expertise in complex minimally invasive hepatobiliary surgery. Patients were entered into a database prospectively. All patients with gallbladder cancer and cholangiocarcinoma were analyzed; patients with distal cholangiocarcinomas who underwent laparoscopic pancreatoduodenectomies were excluded. Patients were divided according to if they had gallbladder cancer, hilar cholangiocarcinoma, or intrahepatic cholangiocarcinoma.
Results A total of 15 patients underwent laparoscopic resection for gallbladder cancer and 10 for preoperatively suspected gallbladder cancer, and 5 underwent laparoscopic completion procedures. An average of four lymph nodes (range = 1–11) were retrieved and all patients had an R0 resection. One patient (7 %) required conversion to an open procedure. No patients developed a biliary fistula, required percutaneous drainage, or had endoscopic stent placement. One patient had a recurrence at 3 months despite a negative final pathological margin, and a second patient had a distant recurrence at 20 months with a mean follow-up of 23 months. Nine patients underwent laparoscopic hepatectomy for intrahepatic cholangiocarcinoma. All anastomoses were completed laparoscopically. Biliary fistula was seen in two patients, one of which died after a transhepatic percutaneous biliary drain resulted in uncontrollable intra-abdominal hemorrhage despite reoperation. A third patient developed a pulmonary embolism. Thus, the morbidity and mortality rates were 33 and 11 %, respectively. One patient was converted to open and six patients (66 %) are alive with a median follow-up of 22 months. Five patients underwent minimally invasive resection for hilar cholangiocarcinoma; of these, two also required laparoscopic major hepatectomy. The mean estimated blood loss (EBL) was 240 mL (range = 0–400 mL) and the median length of stay (LOS) was 15 days (range = 11–21 days). All patients are alive with a median follow-up of 11 months (range = 3–18 months). None of the 29 patients developed port site recurrences.
Conclusion Minimally invasive approaches to gallbladder cancer and intrahepatic and extrahepatic cholangiocarcinoma seem feasible and safe in the short term. Larger series with longer follow-up are needed to see if there are any long-term disadvantages or advantages to laparoscopic resection of extrapancreatic cholangiocarcinoma.

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Although complex minimally invasive hepatic and pancreatic procedures such as the laparoscopic Whipple procedure and laparoscopic major hepatectomies have been performed since the 1990s, few centers have begun minimally invasive approaches to cholangiocarcinomas and gallbladder cancer [1–8]. This is due to many factors, including concerns that these tumors cannot be adequately dissected off of the vascular structures within the portal triad, the relative rarity of these tumors, and the reality that minimally invasive surgery and surgical oncology have developed as two separate fields. Because of this, few hepatic, pancreatic, and biliary (HPB) surgeons have developed minimally invasive skills, and even fewer training programs specializing in surgical oncology and transplant surgery have adequate training in minimally invasive techniques. Concomitantly, because these are rare tumors and are often referred to HPB centers, surgeons with laparoscopic skills rarely get a chance to tackle these challenging cases.

Despite these limitations, several centers in Europe, North America, and South America have begun approaching gallbladder cancer and intrahepatic and extrahepatic cholangiocarcinomas with laparoscopic techniques [9–11]. Because of the rarity of these tumors, a multi-institution retrospective review was performed to see if any insight could be gained as to the potential advantages and/or risks to approaching these tumors without the benefit of an open approach.

Prior to embarking on laparoscopic approaches to intrahepatic and extrahepatic cholangiocarcinomas, gallbladder cancer was approached first. This was because common bile duct excision would be rarely indicated and that tumors, when resectable, would often be further away from the portal vein, and complex biliary and vascular anastomoses would theoretically be less likely [9–11]. In addition, since adequate oncological staging for gallbladder cancer mandates a hepatoduodenal lymphadenectomy, it was felt that proficiency and comfort in laparoscopic dissection of the tumors from the portal triad structures could be obtained [12].

Methods

Patients were entered into a database prospectively and longitudinally. All patients who underwent attempted minimally invasive resection for either gallbladder cancer or extrapancreatic cholangiocarcinoma, specifically intrahepatic cholangiocarcinoma and extrahepatic cholangiocarcinoma, were analyzed. Results of cholangiocarcinomas in the distal common bile duct (CBD) that have been removed laparoscopically via a Whipple procedure were excluded from this study and have been presented elsewhere [1, 13]. The experience at three international centers of surgeons with expertise in advanced laparoscopic hepatobiliary techniques was then reviewed retrospectively to see if the minimally invasive approach is feasible and safe for these tumors.

Preoperative studies

As with patients approached via laparotomies, all patients undergo preoperative serum testing for CEA and Ca19-9 so that if elevated, they can be used to perform surveillance for recurrence. Most patients are diagnosed after ERCP and/or endoscopic ultrasound. All patients undergo preoperative magnetic resonance cholangiopancreatography (MRCP) to help plan the extent of the resection. Although some authors believe that only color Doppler ultrasound is necessary to determine resectability during open resection for cholangiocarcinomas, we obtain an abdominal CT scan with triphasic IV contrast enhancement to assess vessel involvement [14]. Due to the lack of tactile sensation during laparoscopy, maximization of preoperative imaging and, when needed, three-dimensional reconstructions can help identify vascular anomalies and assist in the planning and performance of the minimally invasive approach [15, 16]. Resectability for hilar cholangiocarcinomas was determined using the Blumgart preoperative staging system, and only tumors deemed to be T1 or T2 were approached laparoscopically [17]. Chest and pelvic CT scans are also performed to rule out the presence of metastatic disease. If questions remain or the patient is high-risk, we add a preoperative PET-CT to confirm the absence of metastases [18, 19].

Operating room setup

Patients are placed on a bean-bag before being placed supine on the operating table. Lower-extremity sequential compression devices are applied. The patient is placed in the low-lithotomy or “French” position after the induction of general endotracheal anesthesia, a safety strap is placed over the pelvis, and all bony prominences are given extra padding. The abdomen is then prepped and draped. After a preoperative pause, when it is confirmed that preoperative antibiotics have been administered, pneumoperitoneum is obtained. An optic trocar is placed one hand breadth below the right subcostal margin along the midclavicular line (Fig. 1). A diagnostic laparoscopy is performed to rule out the presence of peritoneal carcinomatosis. A peritoneal lavage can be performed and send STAT to cytology to rule out the presence of malignant ascites [9–11]. The

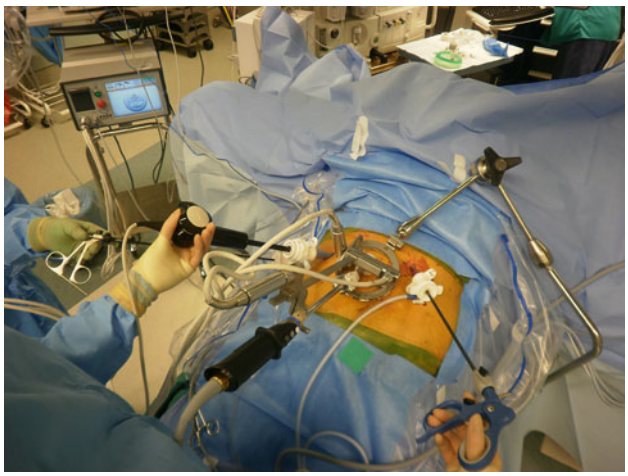

Fig. 1 Operating room setup. The patient is placed in the low-lithotomy or "French" position, with the operating surgeon standing between the patient's legs. Trocars are placed one hand breadth below the right subcostal margin in a semicircular fashion. A robotically controlled laparoscope holder can be used (ViKY, Endocontrol, Grenoble, France)

patient is then placed in the reverse Trendelenburg position with the left side of the table down.

A robot-controlled camera holder is secured to the operating table along the right side of the patient at the level of the midchest (Video-endosKopY [ViKY], Endocontrol, Grenoble, France) [20]. Working trocars are placed to the left and the right of the optic trocar, a right-sided trocar is placed at the level of the inferior border of the liver along the anterior axillary line for autostatic liver retraction, and a final trocar can be placed in the subxiphoid region for the assistant if necessary.

Gallbladder cancer

A staging hepatic laparoscopic ultrasound is performed to confirm resectability (Fig. 2). Gallbladder polyps larger than 1 cm or smaller than 1 cm with the presence of vascular flow on Doppler studies are removed with a primary laparoscopic radical cholecystectomy. To perform this, the gallbladder is grasped as in a standard laparoscopic cholecystectomy to expose the structures of the triangle of Calot. Care is taken to not rupture the gallbladder wall and cause spillage of bile. If the gallbladder cannot be retracted without drainage of its contents, the procedure is converted to open. The cystic duct is clipped at its confluence with the common bile duct (CBD) and transected as low as possible so that a positive cystic duct margin results in a CBD excision [9].

The parenchymal transection is begun along the anterior surface of hepatic segment 4B. The goal is to resect at least a 1-cm margin of benign hepatic tissue, but as a rule we try to obtain a 1–3-cm margin. Glisson's capsule is incised

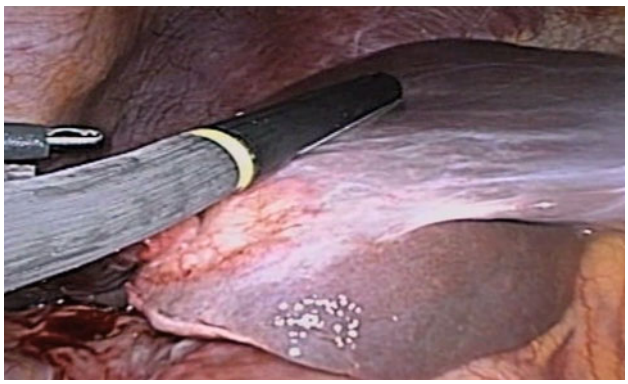

Fig. 2 A full-staging intraoperative laparoscopic hepatic ultrasound is performed for all cases of suspected gallbladder cancer or intrahepatic cholangiocarcinoma. A T3 gallbladder cancer can be seen just below the laparoscopic ultrasound probe

with either the Bovie electrocautery or the active blade of the ultrasonic shears. Larger vessels are clipped prior to their transection. Prior to transection of the middle hepatic vein, the dissection along hepatic segment 5 is begun. The middle hepatic vein is then clipped and transected with the laparoscopic ultrasonic shears. The laparoscopic bipolar device may be particularly useful during the hepatic parenchymal transection to enhance hemostasis along the raw hepatic surface.

It is believed that the pneumoperitoneum helps minimize blood loss during these procedures. In addition, because CO_2 is used for the pneumoperitoneum, it is also believed that the risk of a clinically significant gas embolism may be decreased compared to that in the open approach because CO_2 is dissolved more rapidly than air [21]. This is highlighted by the fact that interventional radiologists routinely use CO_2 intravascularly as contrast.

The en bloc gallbladder and wedge resections of hepatic segments 4B and 5 are then sent to pathology for frozen section analysis of the cystic duct and gross examination of the liver margin while the laparoscopic hepatoduodenal lymph node dissection is carried out. If a major or extended major hepatectomy is required for a negative hepatic margin, this can be performed laparoscopically [11].

To perform the laparoscopic hepatoduodenal lymphadenectomy, we begin by entering the lesser sac and identifying the common hepatic artery (CHA). The lymph node is taken, and the triangle created by the CHA, the gastroduodenal artery, and the superior border of the pancreas is identified so that the suprapancreatic portal vein (PV) is identified (Fig. 3). The CHA is then followed to the bifurcation into the right and left hepatic arteries. The CBD, hepatic arteries, and PV are skeletonized and the hepatoduodenal fat pad and lymph nodes are placed in a specimen retrieval bag and sent for permanent section

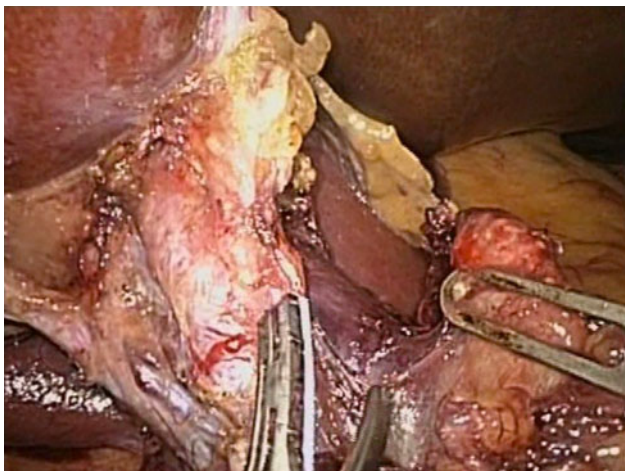

Fig. 3 Laparoscopic hepatoduodenal lymphadenectomy. Enlarged common hepatic artery lymph node is grasped by laparoscopic bipolar forceps

[9–11]. If identified preoperatively, or if an adequate lymph node retrieval is not obtained, a laparoscopic Kocher maneuver can be performed and the paracaval and para-aortic lymph nodes can be taken. A minimum of three lymph nodes should be retrieved to adequately stage gallbladder cancer [9, 10].

Laparoscopic completion radical cholecystectomies can be performed even after previous laparoscopic cholecystectomy [10]. Absence of histopathological examination of the cystic duct is not a contraindication to the laparoscopic approach. In addition, CBD excision and Roux-en-Y hepaticojejunostomy have also been performed using minimally invasive techniques [9, 10] (Fig. 4A, B).

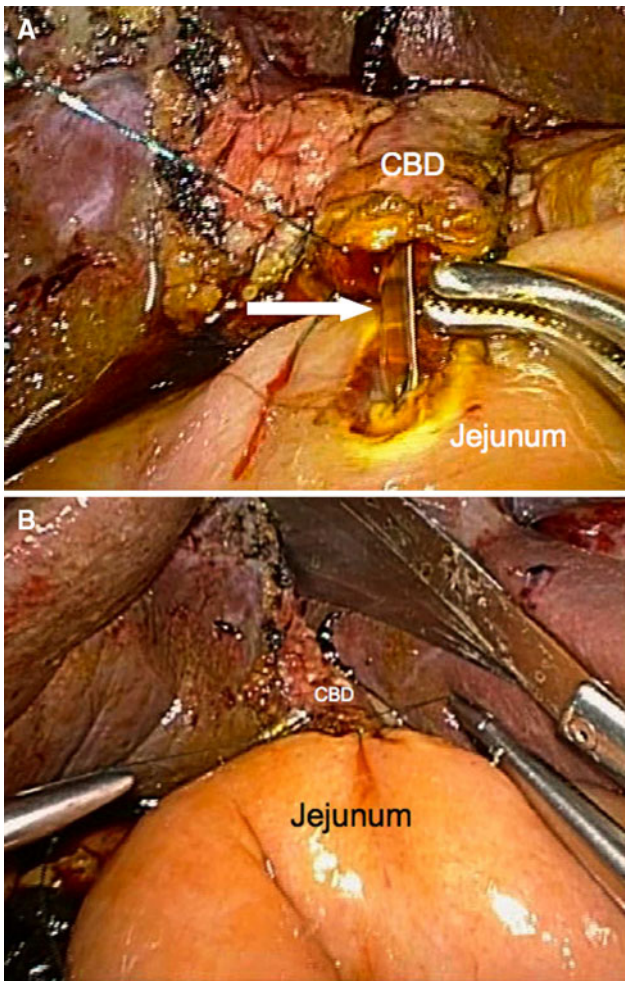

Fig. 4 Laparoscopic Roux-en-Y choledochojejunostomy. **A** Creation of posterior layer of choledochojejunostomy and pediatric 5-Fr feeding tube is used as an internal stent. **B** Completion of laparoscopic choledochojejunostomy

Extrapancreatic cholangiocarcinomas

Intrahepatic tumors

Techniques for laparoscopic major, extended major, and minor hepatectomy have been extensively described [3, 4, 7, 11, 21–23] (Fig. 5). As opposed to open hepatectomy, where patients are placed in the Trendelenburg position in an effort to minimize the risk of air embolism, the patient is placed in reverse Trendelenburg during laparoscopic hepatectomy. As in open surgery the central venous pressure (CVP) must be kept low; however, due to the pneumoperitoneum, CVP readings become useless during laparoscopy. As a result, the inferior vena cava must be inspected early in the case, and only when it is found to be flaccid and to move freely with movements of the heart and lung is the CVP low and parenchymal transection can begin. It is paramount that patients' intravenous fluids be minimized prior to and during the hepatic transection to minimize blood loss.

Hilar tumors

After performing the laparoscopic hepatoduodenal lymphadenectomy (Fig. 6A, B), the CBD is transected distally at its junction with the superior border of the head of the pancreas with a laparoscopic vascular load gastrointestinal anastomosis (GIA) stapler device. The CBD is then retracted superiorly and anteriorly. The proximal CBD is transected either with the laparoscopic ultrasonic shears on the fast setting or sharply with laparoscopic shears. If a unilateral hepatic duct is involved, the right or left hepatectomy is performed as previously described and published (see above) [3, 4, 7, 11, 21–23]. If an extended major hepatectomy is needed, we usually perform a preoperative right portal vein embolization for laparoscopic major right hepatectomies [11]. Postoperative hepatic reserve is calculated with three-dimensional hepatic volumetric studies to ensure at least 300 cm^3 of normal hepatic parenchyma or

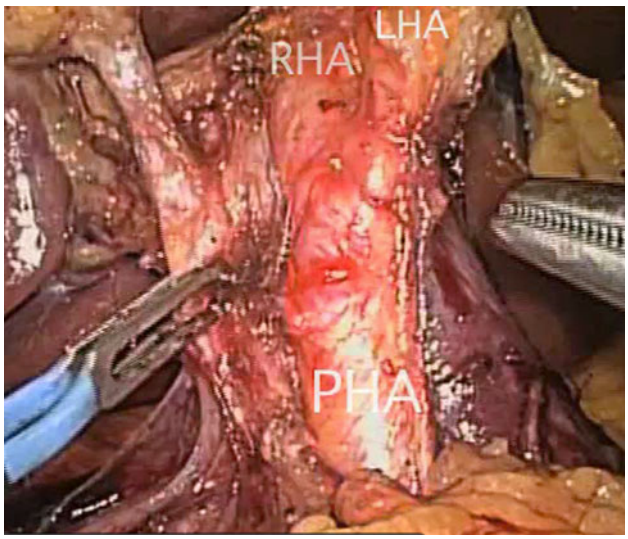

Fig. 5 Completed laparoscopic hepatoduodenal lymphadenectomy with proper (PHA), *right* (RHA), and *left* hepatic arteries (LHA) skeletonized (shown in *red*) (Color figure online)

400 cm^3 in patients with an element of hepatic insufficiency. Patients with primary sclerosing cholangitis who are deemed to not have enough functional hepatic reserve to undergo resection are referred to a regional liver transplant center.

The biliary system is then reconstructed using a Roux-en-Y hepatico- or choledochojejunostomy. To do this, the ligament of Treitz is identified and approximately 30 cm distal to it the proximal jejunum is transected with a laparoscopic GIA stapler device. Additionally, the surgeon may need to stand on the right side of the patient. The Roux limb is brought up in either a retrocolic or antecolic fashion depending on the patient's anatomy and the surgeon's preference, an additional 5-mm trocar in the right lower quadrant may facilitate this part of the procedure. The laparoscopic biliary anastomoses are then performed in a single layer with suture depending on the size of the biliary duct to be anastomosed and the surgeon's preference (Fig. 4B). For bile ducts smaller than 1 cm in diameter, a 5-Fr pediatric feeding tube is used as an internal stent to prevent closure of the biliary system by catching the back wall during closure of the anterior layer and acts as an internal stent in cases of biliary fistula (Fig. 4A). This stent usually is passed on its own or it can be retrieved endoscopically if desired. The jejunojejunostomy is then fashioned laparoscopically with a single firing of the laparoscopic GIA stapler device and the enterotomy is closed with intracorporeal sutures. When a hepatectomy is required, the umbilical region can be used as an extraction site and the jejunojejunostomy is created through the extraction site. If desired, a hand port can be placed at the beginning of the case early in one's experience or when desired.

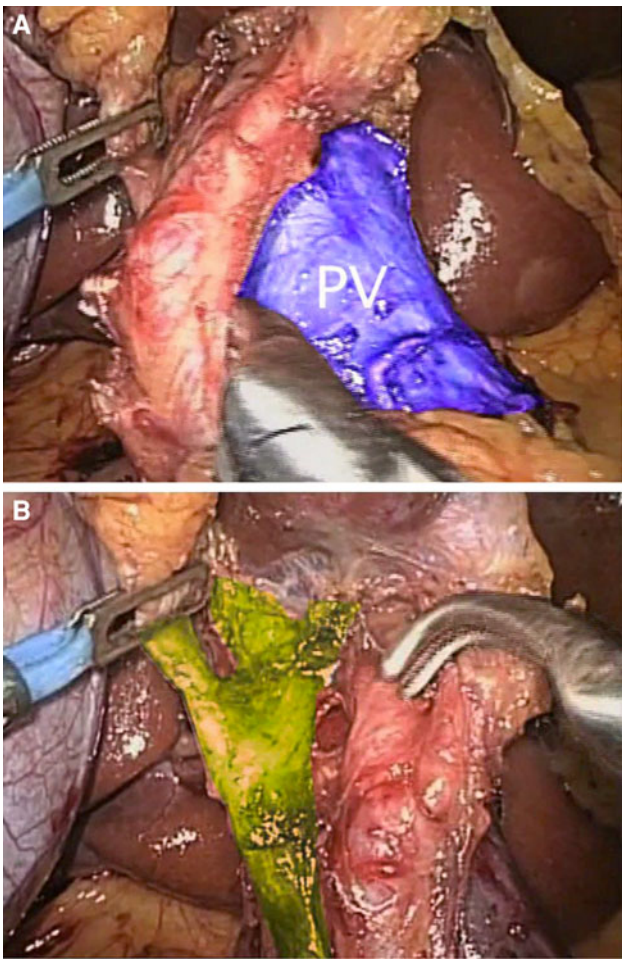

Fig. 6 Laparoscopic dissection of common bile duct (shown in *green*). **A** Dissection off of portal vein (PV) (shown in *blue*). **B** Liberated common and cystic bile ducts prior to transection (Color figure online)

Results

Gallbladder cancer

From December 2005–April 2011, a total of 15 patients underwent attempted minimally invasive surgery for both pre- and postoperatively diagnosed gallbladder cancer. The female-to-male ratio was 2:1, the mean age was 61 years (range = 35–79 years), the mean estimated blood loss (EBL) was 160 mL (range = 0–400 mL), the mean operating room time was 220 min (range = 120–480 min), and mean length of stay was 4 days (range = 2–8 days). A mean of four lymph nodes (range = 1–11) were retrieved and all patients had an R0 resection. Ten patients underwent initial laparoscopic radical cholecystectomy and five patients underwent laparoscopic completion radical cholecystectomy after routine laparoscopic cholecystectomy. One patient who had undergone an open cholecystectomy required conversion to an open procedure

during an attempted laparoscopic completion radical cholecystectomy for a conversion rate of 7 %. This patient required a CBD excision because the cystic duct was not analyzed on the initial specimen and because no cystic duct stump could be found on reoperation, laparoscopically or during the open part of the procedure.

Four patients were found to have stage I disease, all after primary laparoscopic radical cholecystectomy for T1b lesions, eight patients were found to have stage II, and three had stage IIIB disease. One patient found to have stage IIIB disease also underwent a CBD excision with a laparoscopic Roux-en-Y choledochojejunostomy. Two patients underwent preoperative portal vein embolization followed by laparoscopic extended right hepatectomy for T2 lesions diagnosed after routine laparoscopic cholecystectomy. No patients developed a bile leak, required percutaneous drainage, or needed a reoperation at 30 or 90 months, and the mortality rate was 0 % at 30 and 90 days. Despite a negative margin, one patient with stage IIIB disease presented with a local recurrence at 3 months and a second patient with stage IIIB disease had a distant hepatic recurrence at 20 months. Follow-up averaged 23 months (range = 9–38 months).

Cholangiocarcinoma

From December 2002 to June 2011, a total of 14 patients were resected laparoscopically for intrahepatic and extrahepatic cholangiocarcinoma.

Intrahepatic lesions

Nine patients had an intrahepatic lesion. Their mean age was 69 years (range = 48–86 years). Three patients (75 %) required an extended major hepatectomy, four had a major hepatectomy, and two underwent a minor hepatectomy. Eight patients with intrahepatic disease were stage I and one had stage II disease. This last patient had three lesions in segment 4B and had an R2 resection. Of the remaining patients, seven had R0 resections and one was found to have R1 disease on final pathology. The mean resection margin was 11 mm (range = 0–30 mm), the median size of the lesions resected was 67 mm (range = 30–70 mm), the mean EBL was 233 mL (range = 100–400 mL), and the median LOS was 11 days (range = 6–21 days). Two patients developed bile leaks, and one patient underwent reoperation for hemorrhaging after an attempted percutaneous transhepatic biliary drain placement and died on postoperative day 6. A final patient developed a pulmonary embolism that was treated with IVC filter placement and anticoagulation. Thus, the overall morbidity rate and the 30- and 90-day mortality rates were 33 and 11 %, respectively. The overall conversion rate was 11 %. Six of nine patients are currently alive with a median follow-up of 22 months (range = 3–48 months).

Extrahepatic lesions

Five patients had a extrahepatic lesion. Their mean age was 73 years (range = 66–79 years). Three patients had Blumgart T1 lesions and two had T2 lesions and required a concomitant laparoscopic right and left hepatectomy, respectively. On postoperative histopathologic analysis, these patients had AJCC stage IIA (2 patients), IIIA, IIIB, and IV, respectively [24]. One of these patients (20 %) was converted to an open procedure due to concerns for portal vein involvement. The patient with stage IV disease had an R1 resection on final pathology; all other patients had R0 resections. The mean EBL was 240 mL (range = 0–400 mL) and the median LOS was 15 days (range = 11–21 days). All patients are currently alive with a median follow-up of 11 months (range = 3–18 months). None of the five patients developed a port site recurrence.

Discussion

The incidence of cholangiocarcinoma is approximately 1–2 per 100,000 in the US and for gallbladder cancer alone it is 1.2 per 100,000. There is a wider range of incidence of gallbladder cancer worldwide, with incidence rates up to 15.5 per 100,000 in South America, specifically Chile and Bolivia [25–27]. Biliary duct cancers or cholangiocarcinomas are usually divided into gallbladder cancers, intrahepatic cholangiocarcinomas, and extrahepatic cholangiocarcinomas. Interestingly, despite their rarity, the incidence of intrahepatic cholangiocarcinoma seems to be rising [28]. Extrahepatic cholangiocarcinomas are classically divided into thirds: the upper-third cholangiocarcinomas are known as Klatskin or hilar cholangiocarcinomas, the middle-third cholangiocarcinomas involve the extrahepatic and extrapancreatic common bile duct, and the lower-third cholangiocarcinomas are intrapancreatic cholangiocarcinomas. These divisions have been created due to the radically different procedures usually required to remove them, ranging from cholecystectomy, minor hepatectomy, major hepatectomy, extended major hepatectomy, pancreatoduodenectomy, and sometimes a combination of the above. Because of the wide range of procedures and rarity of these tumors, we have combined our laparoscopic experience of resecting extrapancreatic cholangiocarcinomas, specifically, gallbladder cancers, intrahepatic cholangiocarcinomas, and extrahepatic cholangiocarcinomas, and excluded laparoscopic pancreatoduodenectomies because it was felt that a discussion of minimally invasive pancreatic resections would confuse any comments as to our short-term findings on a relatively small sample size of 29 patients.

Although laparoscopic cholecystectomy was one of the first minimally invasive procedures and is certainly one of

the most common, gallbladder cancer and other cholangiocarcinomas ironically have been some of the last intra-abdominal tumors to be approached laparoscopically. This is because minimally invasive surgery and surgical oncology have developed as two separate fields over the last two decades. Because of the frequency of other intra-abdominal malignancies such as colon cancer and prostate cancer, minimally invasive surgeons have been able to enter and, in the case of prostate cancer, dominate the field. This has been less possible with cholangiocarcinomas mainly because they are rare and classically trained HPB surgeons are reluctant to embrace laparoscopy. Nonetheless, with the advances in and the increased performance of laparoscopic major hepatectomy and even laparoscopic Whipple procedures, attitudes have begun to change. A newer generation of surgeons has also been trained in minimally invasive techniques and in some cases grown more comfortable with the laparoscopic approach as opposed to the open approach.

Gallbladder cancer

Laparoscopic resection can be considered for patients with preoperatively and postoperatively diagnosed gallbladder cancer [9, 10]. In addition to preoperative determination of resectability, intraoperative diagnostic laparoscopy and ultrasound should be performed to confirm resectability. Laparoscopic management of resectable gallbladder cancer seems feasible and safe as initial therapy and as a second procedure in the postoperative setting. Although the extent of hepatic resection is still being debated, both major hepatectomy and simple wedge resection of the gallbladder hepatic bed have been done with minimally invasive techniques [9–11].

A minimum of three lymph nodes should be retrieved for adequate staging, but up to six lymph nodes may improve risk stratification [29]. CBD excision is not done routinely at our respective institutions; however, when necessary it can be done laparoscopically [9]. During laparoscopic completion radical cholecystectomy, if the gallbladder was placed in a specimen retrieval bag, we do not excise the extraction site; if a bag or wound protector was not used, we locally excise the extraction site [10]. To date, no patients who have undergone laparoscopic resection for gallbladder cancer ($n = 15$) have developed a port site recurrence.

Extrahepatic cholangiocarcinoma

Despite improvements in cross-sectional imaging, many patients with extrahepatic and intrahepatic cholangiocarcinomas felt to be resectable are found to be unresectable upon laparotomy [30]. Some pioneering HPB surgeons began using diagnostic laparoscopy and intraoperative laparoscopic ultrasound to see if they could confirm unresectability in any additional patients [31]. In a study of 84 patients, the addition of these modalities spared an additional 42.2 % from unnecessary laparotomy [30]. As with open surgery, laparoscopic Doppler ultrasound can be performed and the tumor's relationship to the main portal vein can be assessed intraoperatively [32]. Early in one's minimally invasive experience, aside from performing diagnostic laparoscopy in these patients, laparoscopy for palliation may help one gain confidence in dealing with these lesions with minimally invasive techniques [33].

We still obtain intraoperative frozen sections of the bile duct margins for tumors involving the extrahepatic ducts, despite recent questions as to its utility in hilar cholangiocarcinomas [34]. A recent report of 14 hilar cholangiocarcinomas removed laparoscopically, six patients also required concomitant hepatectomy [35]. Four patients (29 %) developed a bile leak compared to none in our group (0 %). In addition, Yu et al. [35] noted two port site metastases (14 %) compared to none in our group (0 %). Their patients enjoyed an 85.7 % survival rate with a mean follow-up of 20 months [35], and our survival rate was 100 % but our follow-up was almost half theirs at 11 months.

Intrahepatic cholangiocarcinoma

As for intrahepatic cholangiocarcinomas, several series have published data on short-term results after laparoscopic resection [6, 16, 36–38]. Nonetheless, numbers still range from one to three in these series. None of these series reported port site recurrences after laparoscopic hepatectomy for intrahepatic cholangiocarcinoma, indicating that currently the minimally invasive approach seems feasible and safe for these tumors [6, 16, 36–38]. When resecting intrahepatic cholangiocarcinomas, it appears that the laparoscopic approach may have an added benefit in that an anterior or "no-touch" approach is used [39]. When removing these specimens, it is paramount that a specimen retrieval bag or wound protector is used and that the pneumoperitoneum is evacuated while the trocars are still in place to minimize the risk of port site recurrence [6, 15, 21].

Mortality

The 30- and 90-day mortality rates of 0 % for the laparoscopically resected gallbladder cancers and extrahepatic cholangiocarcinomas are clearly comparable to open historical controls, but any discussion of them is severely limited by our small series. Nonetheless, the mortality rate of 11 % for laparoscopically resected intrahepatic

cholangiocarcinomas is notable because it is higher than the rate of approximately 6 % noted in the open literature [40]. This may be due to the large hepatic resections that are often necessary to remove these tumors, supporting the argument that these tumors should possibly be approached via open techniques. However, when mortality rates for hilar cholangiocarcinomas are reviewed, mortality was found to range from 4 to 17 % in the 1990s in series ranging from 65 to 151 patients. This then tended to decrease, with one center even reporting a mortality rate of 0 % in 2009 [41–50]. However, mortality rates still were as high as 17 % as recently as 2000 [44]. It is possible that our elevated mortality rate was due to the learning curve and that as with the experience with open surgery for hilar cholangiocarcinomas, mortality rates for laparoscopically resected intrahepatic cholangiocarcinomas will drop as minimally invasive surgeons gain more expertise and experience in performing these complex hepatic resections. Interestingly, our success with laparoscopically resected hilar cholangiocarcinomas and complex laparoscopic biliary reconstructions show that complex biliary reconstructions are not a contraindication to the minimally invasive approach and may even be beneficial. This may be due to the enhanced visualization of the biliary system, which may lead to decreased missed ducts, superior biliary-enteric anastomoses, and, therefore, fewer bile leaks.

Potential advantages

Another potential advantage specific to laparoscopic hepatobiliary surgery may be a decreased risk of air embolism because the pneumoperitoneum is created with carbon dioxide rather than air. Carbon dioxide is a highly soluble gas that is used routinely for contrast injections during intravascular interventional radiology procedures [15, 21]. Because laparoscopic HPB surgery can be done only in a relatively dry field, estimated blood loss may be decreased during these procedures. This is possibly enhanced by the 10–15 Torr of pneumoperitoneum used during laparoscopy which can tamponade venous bleeding from the raw parenchymal surface [15, 21]. Furthermore, when hepatic resection is not required for resection of an extrahepatic cholangiocarcinoma, the tumor itself can often be removed through a trocar site. This reduces postoperative pain and the incidence of postoperative hernia even more than after laparoscopic hepatic resections that often require sizable incisions for specimen extraction, especially after laparoscopic major hepatectomy.

Conclusions

Surgical teams should have expertise in both open and minimally invasive hepatobiliary surgery before embarking on the techniques discussed here. Although pioneers in the field of minimally invasive hepatobiliary and pancreatobiliary (HPB) surgery had to teach themselves the techniques, younger generations exposed to minimally invasive techniques during their training are inherently more comfortable with laparoscopic surgery and can seek high-volume centers for short-term training and even fellowships [8]. For centers that do not have surgeons with advanced training in minimally invasive HPB surgery, minimally invasive surgeons can pair up with more experienced open hepatobiliary surgeons in an effort to develop these techniques. During this learning curve, a hand-assisted approach may be particularly helpful in an effort to minimize patient morbidity and mortality. As with all new techniques, surgeons should tackle benign pathologies and not attempt resections that have a high probability of requiring complex vascular or biliary reconstructions early in their experience. Because of the paucity of major intraparenchymal vessels, early-stage gallbladder cancers should probably be the malignancy approached first because bleeding during laparoscopic hepatic parenchymal transection can be particularly difficult to control early in one's experience.

Minimally invasive approaches to gallbladder cancer and both intrahepatic and extrahepatic cholangiocarcinomas appear feasible and safe. There is no increased rate of port site recurrence when cholangiocarcinomas or gallbladder cancers are removed laparoscopically. Although short-term results seem similar to those published for the open experience, longer-term follow-up is needed to see how disease-free and overall survivals are affected. Larger trials are needed to see if there are any advantages or disadvantages to either the open or the minimally invasive approach. Advantages to minimally invasive surgery include shorter hospital stay, decreased narcotic usage, and earlier return to work.

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