Hand-Assisted Laparoscopic Liver Surgery

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Hypothesis: The hand-assisted laparoscopic technique may be applied to the treatment of liver tumors.

Design: A case series with mean follow-up of 13 months.

Setting: University-affiliated tertiary care center.

Patients: A total of 15 patients with hepatic neoplasms underwent screening tests, including appropriate tumor marker analyses, abdominal sonography, and computed tomographic scan and, in most cases, magnetic resonance imaging to determine operability. Contraindications included extrahepatic disease, more than 5 liver lesions, coagulopathy, and ascites.

Intervention: Between March 1, 1998, and April 30, 2001, 15 patients underwent 16 hand-assisted diagnostic laparoscopic operations to rule out extrahepatic disease. Four patients had extrahepatic disease. In the 11 patients without evidence of extrahepatic disease, intraoperative ultrasound was used to establish the number and location of liver lesions. Operative strategies included resection, cryoablation, or both.

Main Outcome Measures: Operative time, conversion to open procedure, length of stay, complications, and recurrence of disease.

Results: Of the 15 patients with liver tumors, 6 patients had more extensive disease than was detected by either preoperative imaging or laparoscopic exploration. They included extrahepatic disease (3), additional liver lesion (2), or both (1). Hand-assisted management included resection only (3), cryoablation only (5), and a combination of the 2 (3). A total of 9 lesions were resected and 10 lesions were cryoablated. The mean operative time was 197 minutes with a mean length of stay of 4.5 days. There were no conversions to open procedures. One patient experienced minor postoperative bleeding but required no treatment. All treated patients are alive, and 5 have had recurrence of disease.

Conclusions: Hand-assisted technique can be applied safely and effectively to laparoscopic liver surgery and may identify presence of otherwise undetectable disease.

Arch Surg. 2002;137:407-412

Improvements in diagnostic imaging and screening techniques have increased the number of hepatic lesions that require surgical evaluation. For those lesions that are amenable to surgery, advancements in minimally invasive techniques have decreased the morbidity associated with laparotomy. We report the application of a new technique, hand-assisted laparoscopy, as a tool that enhances the diagnosis and treatment of liver tumors.

Worldwide, hepatocellular carcinoma (HCC) is the most prevalent malignancy. Each year, up to 1.25 million people die from HCC. Approximately 10% of people living in the Far East are hepatitis B carriers. Of those carrying the virus, 40% develop HCC. Therefore, the prevalence rate is approximately 2% to 8% of the population. In the United States, the annual incidence is approximately 1 to 7 per 100,000 people. Five-year disease-free survival rates of 20% to 39% have been reported following curative resection for patients with HCC. Unfortunately, these lesions are often unresectable, and treatment for them is controversial.

In the United States, most hepatic neoplasms are metastases from bronchogenic carcinoma, prostate cancer, and colorectal carcinoma. Approximately 150,000 new cases of colorectal cancer are reported in the United States each year, and about 75,000 people per year develop metastatic liver disease. Untreated, the 5-year survival rate is about 1%. One-, two-, and three-year survival rates for patients with inoperable liver metastases from colorectal cancer are 32%, 10%, and 3%, respectively. The median survival time ranges from 7 to 11 months. Five-year disease-free survivals are rare.
survival rates of 20% to 25% have been reported following curative resection of hepatic colorectal metastases.7

Benign neoplasms are fairly common and are found more frequently today because of improvements in diagnostic imaging tests (computed tomography, radio nucleotide techniques, arteriography, and magnetic resonance imaging) and increased use of ultrasound for screening patients with abdominal symptoms. For most of these lesions, treatment is unnecessary, but if symptoms develop or a rapid growth occurs, surgery may be indicated.9

Historically, the only curative treatment for hepatic neoplasms has been surgical resection.9-11 Surgery is associated with a perioperative mortality of less than 5% and an acceptable morbidity rate. Unfortunately, only about 25% of patients with hepatic metastases and 35% of patients with HCC have surgically resectable lesions at the time of diagnosis. Other patients have relative or absolute contraindications to resection, including advanced cirrhosis, vena cava or main portal vein invasion, diffuse hepatic involvement, or extrahepatic disease.12 For patients with surgically unresectable lesions, several techniques have been developed for local tumor ablation. Some of these techniques include percutaneous ethanol injection, radiofrequency ablation, interstitial laser photocoagulation, microwave tumor coagulation, and cryoablation.

Cryoablation has been shown to be a safe and effective alternative to resection for patients with unresectable lesions.13 Cryoablation minimizes hepatic parenchymal loss and can be used to treat multiple lesions in both
lobes of the liver at the same time\textsuperscript{14} and for small lesions at greater depths.\textsuperscript{15} In addition, cryoablation has been shown to lengthen survival in nonrandomized trials.\textsuperscript{16-19}

Laparoscopic technique has been successfully applied to hepatic resection as well as ablative modalities. Diagnostic laparoscopy can be used to identify extrahepatic disease prior to therapeutic intervention and has become standard practice at many medical centers. Ultrasound guidance during laparoscopic exploration enables the surgeon to locate more accurately preoperatively diagnosed lesions and to establish the presence of additional lesions. Hand-assisted laparoscopy has been used safely and effectively for a variety of procedures and has several advantages over traditional laparoscopic techniques. During exploration, the assisting hand can provide tactile feedback for identification of otherwise undetectable disease. For hepatic surgery, the assisting hand is useful for gentle retraction, blunt dissection, and more precise placement of stapling devices.\textsuperscript{20} The hand-ultrasound probe allows multiplanar visualization of a greater portion of the liver as well as more accurate placement of cryoprobes. We describe our experience with hand-assisted laparoscopic treatment of hepatic neoplasms from March 1, 1998, to April 30, 2001.

### RESULTS

From March 1, 1998, to April 30, 2001, 15 patients underwent 16 procedures. The average age was 60.4 years old. There were 6 men and 9 women. Initial laparoscopic exploration revealed no evidence of extrahepatic disease; however, when the hand-assist device was placed, 4 patients were found to have extrahepatic disease and received no treatment for the liver lesions. The remaining 11 patients underwent 12 procedures with curative intent (1 patient had a tumor recurrence after laparoscopic management that was again treated laparoscopically). Nine patients had metastatic lesions (8 colorectal cancer, 1 renal cell cancer), while 2 patients had benign symptomatic tumors (enlarging adenoma and enlarging symptomatic cyst). In these 11 patients, preoperative imaging identified a total of 17 lesions. All of these lesions were visualized by intraoperative ultrasound. Two patients had 1 additional lesion identified intraoperatively. In the 4 patients with extrahepatic disease, the intraoperative ultrasound visualized all 4 lesions identified by preoperative imaging and 2 additional treatable liver lesions. A total of 19 lesions were treated laparoscopically; 9 were resected and 10 were cryoablated (Table). Of the 15 patients who underwent hand-assisted exploration, 6 had more extensive disease than could be detected by either preoperative imaging or pure laparoscopic exploration.

For the patients with malignant disease, 7 had undergone adjuvant chemotherapy; 6 showed partial response. The average ± SD interval between treatment for the primary tumor and diagnosis of metastatic disease was 17.2 ± 21.4 months. The average ± SD interval between diagnosis of metastatic disease and treatment was 5 ± 3.6 months.

The average ± SD operative time was 197 ± 62 minutes. The estimated blood loss was 150 mL (range, <50 to 400 mL) and there were no conversions to open procedures. The average length of stay was 4.5 days. There were 2 minor complications. One patient had postoperative bleeding as evidenced by a significant fall in hematocrit level. The bleeding stopped spontaneously and the patient did not require transfusion. One patient had a prolonged ileus that resolved without intervention. Two cryoablation patients had platelet counts less than 150/µL on the first day after surgery. Both were asymptomatic and required no treatment. Platelet counts returned to normal within 1 to 2 days.

The average length of follow-up was 13 months. All patients who were treated are alive. Five patients have had recurrence of disease discovered at an average of 10 months after treatment. As previously stated, 1 patient had cryoablation of the recurrent tumor.

### COMMENT

Traditionally, surgical excision had been the standard of care for liver neoplasms. Benign lesions as well as primary and secondary malignancies can be resected with low operative mortality. Liver resection was the only curative treatment option available for patients with HCC and metastatic colorectal disease to the liver, and is the

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\*Preoperative No. indicates the number of lesions identified by preoperative workup; Postoperative No., number of lesions identified at operation; Size, centimeters of largest diameter; Location, segmental location of lesion based on Couinaud nomenclature; R, resection; and C, cryoablation.
Cryotherapy was first applied to the liver in the early 1960s. In the 1980s, improvements in technology and the addition of intraoperative ultrasound enabled surgeons to monitor tumor and ice ball formation. During this time, cryotherapy was used as palliative treatment for patients with progressive disease of the liver who did not respond well to chemotherapy. Several studies demonstrated that for these patients, cryotherapeutic procedures improved disease-free survival and actual 5-year survival. The first long-term follow-up of cryosurgery for liver metastases showed improved survival of patients undergoing cryosurgery vs traditional therapy of 19% and 8%, respectively, at 10 years, showing that cryotherapeutic methods are effective in the treatment of resectable and unresectable liver cancer.

Hepatic cryosurgery is a procedure that is well suited to laparoscopy for a select group of patients. Patients who are candidates for this procedure include those with unresectable primary or secondary malignancy, comorbid medical conditions that make them poor candidates for liver resection, and those with recurrent metastases. Several studies have demonstrated the safety and efficacy of laparoscopic cryoablation of liver malignancies. Lezoche et al studied a total laparoscopic approach for tumor ablation in 15 patients with metastatic liver tumors — 2 with HCC and 1 with a hepatic adenoma. Of 28 lesions treated, 25 were treated with cryoablation and 3 with laparoscopic wedge resection. Two were converted to open procedures, and there were no major complications or mortality observed. Mean length of stay was 6.4 days, and mean operative time was 131.2 minutes. At mean follow-up of 10.8 months, all patients were alive and 14 were disease free.

Iannitti et al described a series of 9 patients who underwent laparoscopic exploration for metastatic liver lesions. Two patients had extrahepatic disease and the remaining 7 underwent 9 laparoscopic procedures. Cryoablation was performed on a mean of 3 lesions per session. There was 1 serious complication (bile leak treated with stent), and the mean length of hospital stay was 4.5 days. At a mean follow-up of 9 months, 4 of 7 patients were alive without disease, 2 of 7 were alive with disease, and 1 patient died of pancreatic cancer. Heniford et al evaluated 15 patients with hepatic metastases. Three patients were found to have extrahepatic disease. Laparoscopic cryoablation was performed on an average of 2.7 lesions per patient. One patient had significant intraoperative bleeding that required an open segmentectomy. There was 1 serious postoperative complication (bile leak). At a mean follow-up of 11 months, 7 (58%) of 12 patients treated were alive without disease, 3 (25%) were alive with disease, and 2 (17%) had died.

Ultrasound guidance is an important tool in the laparoscopic approach, enabling surgeons to target lesions anywhere within the liver, identify size and shape of the lesions, and monitor cryoprobe placement and freezing. Often, laparoscopy with ultrasound can reveal treatable lesions not identified by preoperative studies. Lezoche et al confirmed the site and number of lesions using intraoperative ultrasound in 13 (72%) of 18 patients, for a true positive rate of 72%. In 3 of 10 patients who had been preoperatively diagnosed as having 10 nodules, only 6 lesions were confirmed by intraoperative ultrasound (4 false positives), and in 2 patients, 7 lesions were identified by intraoperative ultrasound compared with 4 lesions diagnosed preoperatively (3 false negatives). Heniford et al identified additional treatable lesions in 6 (40%) of 15 patients. Bilchik et al found additional intrahepatic lesions with intraoperative ultrasound in 33% of patients undergoing laparoscopic cryoablative procedures.

A more recent advance is hand-assisted laparoscopic surgery. With this technique, a hand may be inserted into the abdomen while pneumoperitoneum is maintained. The hand can be used to assist instruments, palpate, provide safe retraction, and apply immediate hemostasis when needed. Initial reports that describe hand-assisted laparoscopic surgery concluded that it seemed to be useful in several types of minimally invasive surgery, especially those deemed too complex for a traditional laparoscopic approach. Fong et al studied 5 cases of hand-assisted laparoscopic liver resection. Median operative time was 248 minutes (range, 145-348 minutes), and median hospital stay was 5 days. Two patients had complications associated with surgery, and there was no mortality.

We also applied the hand-assisted technique to the treatment of patients with benign and malignant hepatic neoplasms. The selected patients had isolated hepatic disease by preoperative studies. None of the patients had significant cirrhosis or impaired liver function. Closed laparoscopic exploration revealed no extrahepatic disease in any patient.

The assisting hand aided in mobilizing the liver, provided gentle retraction, and allowed tactile feedback while palpating the abdomen for extrahepatic disease. In 4 patients (37%), this enhanced exploration identified extrahepatic disease that had not been detected by
preoperative imaging or standard laparoscopy. This is a higher rate of identification of extrahepatic disease than had been previously reported by standard closed laparoscopy. Lezoche et al\textsuperscript{15} found extrahepatic disease in 12 (18\%) of 68 patients who underwent laparoscopic exploration, while Iannitti et al\textsuperscript{31} identified diffuse extrahepatic disease in 2 of 9 patients.\textsuperscript{15} The hand-assisted approach facilitated rapid and accurate assessment of the liver lesions by intraoperative ultrasound. The 21 preoperatively identified lesions were confirmed, and in 3 (20\%) of 15 patients, additional treatable lesions were discovered (1 patient had extrahepatic disease). In the current study, 6 (40\%) of 15 patients were upstaged as a result of hand-assisted laparoscopic exploration.

Hand-assisted technique enhanced our therapeutic, diagnostic, and staging capabilities by permitting minimally invasive multimodal therapy at a single operation. The assisting hand facilitated the resection of amenable lesions by closely mimicking open finger-fracture technique. When cryotherapy was used, the relative awkwardness of the laparoscopic ultrasound probe was eliminated by using the handheld probe that allowed easy real-time multiplanar monitoring of ice ball progression. Additionally, the handheld probe can more accurately assess the completeness of lesion ablation. We selected cryoablation for the treatment of unresectable disease because of our open experience with this modality. There were no major complications and only 1 minor self-limited hemorrhage. Two patients experienced mild asymptomatic postoperative thrombocytopenia requiring no treatment. Platelet counts returned to normal within 1 to 2 days.

Hand-assisted technique may also be applied to radiofrequency ablation. Radiofrequency has well-documented advantages and disadvantages. Radiofrequency has shorter ablation times and may be performed percutaneously. Radiofrequency may be associated with higher local recurrence rates when used for lesions larger than 3 cm, and percutaneous application may result in higher complication rates.\textsuperscript{35} Percutaneous treatment of malignant lesions, while more minimally invasive, is prone to result in inappropriate or inadequate treatment. Between 18\% and 37\% of patients will have unrecognized extrahepatic disease at the time of operation. These patients would be unnecessarily exposed to the risk of ablation without diagnostic laparoscopy. In addition, 25\% to 40\% of patients will have treatable lesions identifiable by intraoperative ultrasound that are not detected by nonoperative workup and will therefore be left untreated if percutaneous ablation is used.

In summary, the hand-assisted technique can be safely and effectively applied to liver surgery. It improves diagnostic and staging accuracy for malignancies, while facilitating minimally invasive tumor resection and ablation.

This paper was presented at the 82nd Annual Meeting of the New England Surgical Society, Providence, RI, September 22, 2001.

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REFERENCES

DISCUSSION

Roger Jenkins, MD, Burlington, Mass: I cannot speak as an expert on laparoscopic surgery, as my laparoscopic skills have generally been limited to diagnostic laparoscopy for biopsy, ultrasonography, ablative techniques, or the overall assessment of resectability.

Indeed, many hepatobiliary surgeons have viewed the total laparoscopic forays into hepatic resection with skepticism, and the belief that its use will remain confined to a small group of daring and tireless surgeons and their disciples. Although major hepatic resections are now well standardized, variability in disease and anatomy always creates the potential for misadventures more easily handled during open procedures than during total laparoscopic procedures.

The introduction of the hand-assisted laparoscopic technique, however, changes this dynamic by enabling the introduction of a completely new set of skills that add to the safety and the aggressiveness of the laparoscopic approach. I am fond of telling my surgical residents and fellows that as a right-handed surgeon, the use of my left hand to compress, distract, elevate, and approximate during liver resections is the most important factor in reducing blood loss, providing exposure, and obtaining adequate margins. The hand-assisted laparoscopic technique used by the authors allows the left hand to more closely emulate its function in open procedures. Hand-assisted laparoscopic techniques have the advantage as compared with laparoscopic-only techniques of providing the tactile feedback necessary to improve palpation, retraction, and instrument placement.

Traction by the left-hand facilitates more complete mobilization of the left and right lobes of the liver for ultrasonography, ablation, or resection. The introduction of more sophisticated ultrasonic probes through the handport allows more assured scanning of the entire liver than with current laparoscopic probes. The use of the Harmonic scalpel, various coagulating devices, and laparoscopic staplers can be supplemented, if necessary, by the use of finger fracture during parenchymal transection. Although not described in the authors’ article, it can also facilitate the technique of hilar inflow occlusion to reduce blood loss during resection or reduce the local heat-sink effect during thermal ablation.

The authors have prudently confined their resections to subsegmental or segmental regions of the liver often in combination with cryosurgical ablation. Most of the resections appear to be in the anterior location where techniques of visualization and control of parenchymal vessels would be optimal. There was 1 patient, however, who apparently had resection of a lesion in segment 7 of the liver, which 1 should imagine would be quite difficult. What criteria were used to determine whether resection or ablation would be utilized? As a corollary to this question, I am curious about how this technique fits into an institutional approach to hepatic neoplasia? How many patients underwent formal open resection for benign or malignant tumors during the same time period?

Cryosurgical ablation of liver tumors leads to the development of a progressive ice ball that is easily monitored by intraoperative ultrasonography. Radiofrequency ablation is much more difficult to monitor intraoperatively, at least in my hands. However, radiofrequency technology more easily adapts to percutaneous approaches and is cheaper for units initiating ablative programs. I would like to ask if radiofrequency ablation is being introduced into their hand-assisted laparoscopic surgical program and whether they think there are patient groups who are better served by percutaneous techniques than by hand-assisted techniques?

Finally, the authors have reported on the use of this technique predominantly in patients with metastatic disease or the occasional benign lesion. With the epidemic of hepatitis C faced by most transplant centers, we are seeing large numbers of patients with hepatocellular carcinoma in the background of varying degrees of cirrhosis. Patients with more advanced cirrhosis and small lesions are being increasingly treated by liver transplantation, particularly live donor liver transplantation within our own program. Resection or ablation of lesions in patients awaiting transplantation or ineligible for transplant is becoming a significant burden for hepatobiliary centers. Do the authors foresee a role for hand-assisted laparoscopic techniques in this patient population, and, if so, how would you interface with the transplant team?

Dr Antonetti: We have applied this technique to a highly selected group of patients for this pilot program. Patients with significant cirrhosis or ascites were excluded. The criteria used to determine whether ablation or resection would be utilized were similar to those used in standard management, namely size and location of the lesion as well as involvement of vital structures. As Dr Iannitti had previously stated, any lesion that is amenable to resection should be aggressively resected, and we adhered to the same principle. No patient requiring formal right hepatectomy or extended right or left hepatectomy are candidates for hand-assisted management at this point. The most extensive resections performed were 2 left hepatectomies. Patients with unresectable hepatic disease without extrahepatic disease were candidates for hand-assisted ablation.

Dr Iannitti gave an eloquent talk on the merits of radiofrequency ablation and we have been employing this ablative modality via the hand-assisted technique. These data were not presented here. The key lesson learned from this pilot program is that standard preoperative imaging combined with closed laparoscopic exploration will significantly understage patients with hepatic neoplasms. We found patients with extrahepatic disease palpated with the assisting hand that would have been missed by closed laparoscopy. Therefore these patients have been spared a great deal of morbidity by not receiving therapy for that would not alter survival. For most patients, a purely percutaneous approach to management will lead to overtreatment or undertreatment. There is a select group of patients who would be candidates for percutaneous management, including those patients with comorbid conditions that preclude surgery and those with symptomatic disease who undergo ablation or palliation.

We have not yet reported on any patients with hepatocellular carcinoma. We have, since April, treated 2 patients with HCC; 1 patient underwent cryoablation and 1 patient had a resection. It remains to be seen how this technique will be applied to those awaiting transplantation, but we feel that accurate staging of hepatic neoplasms must include at least laparoscopic exploration with intraoperative ultrasound if not a hand-assisted exploration.