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Laparoscopic cholecystectomy combined with endoscopic sphincterotomy and stone extraction or laparoscopic choledochoscopy and electrohydraulic lithotripsy for management of cholelithiasis with choledocholithiasis

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Summary. Six hundred twenty-two laparoscopic cholecystectomies were performed at St. Vincent Hospital over a 14-month period. We reviewed the records of 366 of these patients who were referred to the authors. Thirty-six patients had suspected choledocholithiasis. The primary author (M.E.A.) performed 38 endoscopic retrograde cholangiopancreatography (ERCPs) on these patients for diagnosis and management. Seventeen of the 36 patients had common bile duct stones; 19 patients had negative studies. Of the 17 patients with choledocholithiasis, 15 had successful cannulation of the common bile duct, and, of these, 10 underwent laparoscopic cholecystectomy plus endoscopic sphincterotomy and extraction of the common duct stone(s). In one high-risk elderly patient, we extracted the stone from the common duct and left the gallbladder in situ. Two patients failed endoscopic cannulation and underwent open cholecystectomy with common bile duct exploration. Four additional patients, cannulated successfully, had unsuccessful endoscopic stone removal because the stones were too large or were impacted. Two of these patients underwent open cholecystectomy and common duct exploration. The two other patients underwent laparoscopic cholecystectomy and choledochoscopy through the cystic duct with the flexible choledochoscope. An electrohydraulic lithotripsy probe was then inserted through the choledochoscope to fragment the stones, and stone fragments were allowed to pass through the previously created sphincterotomy. We believe our data, supported by data in the literature, show that these alternative methods for treating choledocholithiasis are safe and effective and should be considered primary modalities for treating this condition now that laparoscopic cholecystectomy is the treatment of choice for cholelithiasis.

Key words: Laparoscopic cholecystectomy – Laparoscopic choledochoscopy – Endoscopic sphincterotomy – Electrohydraulic lithotripsy – Choledocholithiasis – ERCP

The rapid acceptance of laparoscopic cholecystectomy has made it desirable to explore methods other than open operative common bile duct exploration for the management of choledocholithiasis. Pre- or postoperative endoscopic retrograde cholangiopancreatography (ERCP) with sphincterotomy and stone extraction is one of these alternatives. Several authors report good results using this procedure prior to open or laparoscopic cholecystectomy [8, 13, 26, 28, 30, 33, 37, 40, 41]. Others describe laparoscopic choledochoscopy and stone extraction [16, 27, 32, 33, 37]. For large or impacted common duct stones, laparoscopic choledochoscopy with stone fragmentation using the Candela laser is another method of treatment [31]. A number of investigators have demonstrated the safety and efficacy of electrohydraulic lithotripsy in biliary lithiasis [3, 4, 12, 17, 19, 21, 22, 25, 29, 31, 33, 36, 38, 39, 42–44]. Although some would question these approaches to common duct stones [2], they promise to become the primary means of treatment for choledocholithiasis. The purpose of our paper is to present our experience with laparoscopic cholecystectomy combined with endoscopic sphincterotomy and common duct stone extraction or laparoscopic choledochoscopy with electrohydraulic lithotripsy and to review the literature to support our findings.

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Materials and methods

From December 1989 to February 1991 (14 months) nine surgeons at St. Vincent Hospital in Indianapolis, Indiana, performed 622 laparoscopic cholecystectomies. Of these, 366 patients were referred to the authors who share the same management philosophy. (The complete series of 622 patients will be presented in an upcoming report.) Patients with known or suspected choledocholithiasis or other common bile duct pathology underwent pre- or postoperative ERCP by one surgeon (M.E.A.). The criteria for performing ERCP were (1) dilated common bile duct or choledocholithiasis on ultrasound, (2) jaundice, (3) gallstone pancreatitis, and (4) stones seen on intraoperative cholangiogram during laparoscopic cholecystectomy. Ideally, an attempt was made to remove the common duct stones preoperatively by performing an endoscopic sphincterotomy and stone extraction. If this was successful the patient underwent laparoscopic cholecystectomy. If not, we performed an open cholecystectomy with common bile duct exploration (early in the series) or laparoscopic cholecystectomy and laparoscopic choledochoscopy with electrohydraulic lithotripsy (later in the series). We explored the common bile duct by inserting a 5-mm flexible choledochoscope (Olympus Corp.) through a dilated cystic duct. We then introduced a 5-Fr electrohydraulic lithotripsy probe (Wolfe) through the biopsy port of the choledochoscope and carefully fragmented the stones under direct visualization, thus avoiding injury to the common bile duct. The stone fragments were pushed or allowed to pass through the previously created sphincterotomy.

Intraoperative cholangiography was performed by inserting a metal cholangiocatheter (Ranfac) through the abdominal wall via a 14-gauge intravenous catheter. The tip of the catheter was introduced into the cystic duct and secured with a 0-chromic gut suture. We then injected 50% Hypaque into the duct under fluoroscopy or took a single flat plate.

Postoperatively, patients were admitted for a short stay. Outcomes were recorded.

Results

Thirty-six patients met the criteria for performance of an ERCP. Thirty-eight ERCPs were performed on 36 patients with 36 successful cannulations. Twenty-nine patients had pre-op ERCPs and nine had post-op studies. Choledocholithiasis was discovered in 17 patients (Table 1). The most accurate predictor of common bile duct stones was ultrasonography, which visualized stones in the common bile duct with 100% accuracy. This was followed by intraoperative cholangiography (80%), jaundice (61%), dilated common bile duct on ultrasound (47%), and pancreatitis (8%) (Table 2). Five patients with positive intraoperative cholangiograms (without preoperative ERCP) had postoperative ERCPs. Four of the five patients underwent endoscopic extraction of stones. The one patient with a negative ERCP was thought to have passed a stone after the cholangiogram but before the ERCP or to have had a false-positive intraoperative cholangiogram possibly due to an air bubble.

Of the 17 patients with choledocholithiasis, 15 had successful cannulation of the common bile duct, and, of these, 10 underwent laparoscopic cholecystectomy plus endoscopic sphincterotomy and extraction of the common duct stone(s). In one high-risk elderly patient, we extracted the common duct stone with ERCP and sphincterotomy and left the gallbladder in situ. Prior to our ability to perform laparoscopic choledochoscopy, the two patients who failed cannulation and two with successful cannulations but stones too large for extraction underwent open cholecystectomy with common bile duct exploration. Two additional patients, cannulated successfully, had incomplete endoscopic stone removal due to impaction of the stones in the distal common duct. These two patients underwent laparoscopic cholecystectomy and choledochoscopy through the cystic duct with the flexible choledochoscope. An electrohydraulic lithotripsy probe was then inserted through the choledochoscope to fragment the stones, and stone fragments were allowed to pass through the previously created sphincterotomy. In all, an open cholecystectomy was avoided in 13 of the 17 patients with choledocholithiasis (Table 3).

Two patients required a preoperative and postoperative ERCP. One was one of the patients who underwent intraoperative electrohydraulic lithotripsy. She had ascending cholangitis and had a preoperative ERCP with stent placement for biliary decompression. She required a postoperative ERCP for removal of the stent and remaining stone fragments. The other patient needed a repeat ERCP postoperatively with stone extraction using a mechanical lithotripser inserted through the endoscope. Of note, eight patients had gallstone pancreatitis documented by symptoms and elevated serum amylase. All eight underwent preoperative ERCP without incident. None of them had exacerbation of their pancreatitis. Only one was found to have choledocholithiasis (Table 2).

There were three patients with complications related to ERCP for a complication rate of 7.9% (three of 38 ERCPs performed). One patient developed pancreatitis, one acute cholecystitis, and one a post-ERCP fever (probably representing mild early ascending cholangitis). All of these patients had preoperative

Table 1. ERCP with laparoscopic cholecystectomy (366 patients)

No. of patients for ERCP[a]	36 (9.8%)
No. of ERCPs	38
Pre-op	29
Post-op	9
Successful cannulations	36 (95%)
No. patients with CBD stones	17 (4.6%)

[a] Endoscopic retrograde cholangiopancreatography

Table 2. Criteria for ERCP

Criteria[a]	No. patients	Positive for stones	Accuracy (%)
CBDS on ultrasound	12	12	100
Dilated CBD on ultrasound	23	11	47
Jaundice	18	11	61
Pancreatitis	8	1	8
Stones on IOCG	5	4	80

[a] CBDS, common bile duct stones; CBD, common bile duct; IOCG, intraoperative cholangiogram

Table 3. Management of common duct stones with ERCP and laparoscopy (17 patients)

Open cholecystectomy avoided		13
ERCP and lap. chole.[a]	10	
ERCP alone	1	
ERCP, lap. chole., choledochoscopy, EHL[b]	2	
Open surgery required		4
Failed cannulation	2	
Large stones	2	

[a] Lap. chole., laparoscopic cholecystectomy
[b] EHL, electrohydraulic lithotripsy

ERCPs and each complications resolved without sequelae. There was one complication related to laparoscopic cholecystectomy: a patient who developed postoperative atelectasis and fever. There were no complications related to the two laparoscopic choledochoscopies and electrohydraulic lithotripsies, nor related to the four open cholecystectomies with common bile duct exploration. The average length of stay for 10 of the 13 patients managed successfully with endoscopic and laparoscopic technique was 4.5 days (range 1 to 10 days). Three patients were excluded from these calculations: one patient was left with his gallbladder in situ (5 days), another was hospitalized for a total of 33 days because of a mitral valve replacement, and a third, hospitalized with pneumonia, subsequently developed acute cholecystitis (Table 4).

Discussion

Common bile duct stones can exist in conjunction with gallstones or in the form of retained or recurrent stones after cholecystectomy. There are many techniques for dealing with these stones but much attention has been paid in recent years to managing them endoscopically. The endoscopic approach has become particularly pertinent now that laparoscopic cholecystectomy is enjoying such success and acceptance. Reddick and others have embraced ERCP as the procedure of choice for managing choledocholithiasis [8, 28, 33, 37, 41]. On the other hand, Petelin and others have championed laparoscopic common duct exploration and stone extraction [16, 27, 32]. Berci argues with these approaches, preferring open common duct exploration for most patients [2].

His reasoning is that in the hands of most surgeons, open common duct exploration has a very low morbidity and mortality. We have been impressed with the low morbidity of the above "minimally invasive" procedures in our practice and the early return to work and normal activity they afford. Consequently, we now use both ERCP and laparoscopic common duct exploration in managing common duct stones. However, early in our experience, ERCP seemed the most logical procedure to use since one of us (M.E.A.) was already proficient at it and there were good data to support endoscopic sphincterotomy and stone extraction. As our experience with laparoscopic common duct exploration grows we suspect it will become our primary treatment for choledocholithiasis. Certainly, for stones which are impacted or are too large and cannot be removed endoscopically, laparoscopic choledochoscopy with electrohydraulic lithotripsy can be safe and effective.

Table 4. Length of hospital stay: ERCP with laparoscopic cholecystectomy

No. of patients considered		10
Ave. length of stay (days)	4.5	
Range (days)	1–10	
Patients excluded		3
Mitral valve replacement	33 days	
Primary hospitalization for pneumonia	10 days	
Gallbladder left in situ	5 days	
Total no. of patients		13

McCune (a general surgeon) performed the first successful ERCP in 1968 [23]. Endoscopic sphincterotomy was reported initially by Kawai in 1974 then by Classen in 1975 [6, 18]. Since then, numerous investigators have reported on the endoscopic removal of common bile duct stones in a variety of situations. Cotton reported on stone extraction in 721 patients who had undergone prior cholecystectomy with success rate of 87% and 1.2% mortality and 11% morbidity rates [7]. Siegel had a 96.6% success rate in 267 patients with 5% morbidity and 0.77% mortality rates [35]. Danilewitz has demonstrated the safety of early postoperative ERCP for retained common duct stones [9].

Some investigators have extracted stones endoscopically in high-risk patients leaving the gallbladder in situ. In Rosseland's series of 75 patients, a 5- to 8-year follow-up showed that 13 patients (17.3%) subsequently underwent cholecystectomy: one for acute cholecystitis immediately following ERCP, seven for acute cholecystitis at a much later date, three for recurrent attacks of biliary colic, and two electively [34]. Davidson reported an 11.3% cholecystectomy rate in 106 patients with their gallbladders left in situ [10]. Miller reported that 21% of patients so treated ultimately required surgery for complications [24]. In some centers this method of treatment has become not only accepted but preferred for high-risk elderly patients.

The use of endoscopic stone extraction preceding open cholecystectomy, instead of open cholecystectomy with common bile duct exploration, has been controversial. In a study by Heinerman comparing the two procedures, there were reduced morbidity (2.1% vs 21.8%) and mortality (1% vs 3.8%) rates and a lower stone retention rate (0.5% vs 2.2%) using endoscopic stone removal prior to open cholecystectomy [13]. Neoptolemos prospectively compared the two procedures. The complication rate for ERCP followed by cholecystectomy was 32.7% vs 22.8% for cholecystectomy and common duct exploration. The mortality rates were 3.6% and 1.7% respectively. Even though the morbidity and mortality rates were higher for the ERCP approach, the difference was not statistically

Table 5. Endoscopic stone removal followed by open cholecystectomy

	Complications (%)	Mortality (%)	Stone retention (%)	Advantages
Neoptolemos (1987)				
ERCP + surg.	32.7	3.6	–	Reduced hosp.
Surg. CBDE[a]	22.8	1.7	–	
Heinerman (1989)				
ERCP + surg.	2.1	1	0.5	Lower morb./mort.
Surg. CBDE[a]	21.8	3.8	2.2	
Ponchon (1989)				
ERCP + surg.	7.2	1.4	0	Reduced hosp.
Van Stiegmann (1989)				Lower hosp. cost

[a] Choledochoscopic guidance

significant; the reduction in hospitalization was [26]. Ponchon reported 7.2% morbidity, 1.4% mortality, and a reduction in hospitalization with this approach [30]. Van Stiegmann postulated a significant reduction in hospitalization charges [40]. Our low morbidity (7.9%) and zero mortality compare favorably with these studies (Table 5).

The issue of the long-term effects of sphincterotomy remain to be resolved. There is a small sphincter stenosis rate: 4% in Cotton's series and 0.7% at 3.5 years in Siegel's study [7, 35]. To date, no other long-term untoward effects have been reported. Cotton reports an increased incidence of bactibilia and a two-thirds incidence of air or free reflux of barium into the biliary tree, but the significance of this is unknown [7]. Interestingly, Heinerman has performed intraoperative manometric studies of the sphincter of Oddi after endoscopic sphincterotomy for stone extraction and demonstrated a protective gradient in his patients [14]. This gradient may reflect a short sphincterotomy with incomplete ablation of the sphincter muscle since the sphincterotomy is made just large enough for stone extraction. In contrast, patients with sphincter of Oddi dyskinesia or stenosis undergo a more extensive sphincterotomy. The issue of these long-term effects remains to be resolved. However, the obvious benefits of endoscopic sphincterotomy and stone extraction are shorter hospitalization, reduced pain, and quicker recovery. Follow-up is too early in our series to be meaningful, but we have had no patients with sphincter of Oddi stenosis to date.

In patients in whom endoscopic stone removal is not successful, some authors have demonstrated the feasibility, safety, and efficacy of laparoscopic choledochoscopy and common bile duct exploration [33, 37]. Deyo, Petelin, Quattlebaum, and Jacobs describe laparoscopic common bile duct exploration, stone extraction, and T-tube placement [11, 16, 27, 32]. Reddick has managed impacted and large stones with the Candela laser [33]. Successful common bile duct stone fragmentation using the Candela laser via ERCP has also been reported [20]. Electrohydraulic lithotripsy has been used successfully and safely for fragmenting large stones in the common and hepatic ducts by using the percutaneous transhepatic approach, via a T-tube tract with fluoroscopic or choledochoscopic guidance, by using an endoscopic approach, or performed intraoperatively by using choldochoscopy during open cholecystectomy [3, 4, 12, 17, 19, 21, 22, 25, 29, 31, 36, 38, 39, 42–44]. We believe, however, we are the first to report using this technique laparoscopically. Combining the previously reported series with our own, a total of 146 patients have undergone common duct electrohydraulic lithotripsy with 136 successful stone clearances. There have been seven transient bleeding episodes, one case of bleeding requiring transfusion (most likely related to the dilation of the percutaneous tract to 24 French at the initial session) [31], and one mucosal tear. Although perforations have been demonstrated in animal studies, none has occurred in any human studies [21, 38] (Table 6). The advantage of the electrohydraulic lithotripser over the Candela laser is cost ($10,000 vs $235,000).

Two additional points deserve attention: the issue of the safety of ERCP and endoscopic sphincterotomy in patients with acute pancreatitis and the predictability of tests for choledocholithiasis. Carr-Locke's data illustrate the safety of endoscopic sphincterotomy in patients with acute pancreatitis. Furthermore, he showed reduced morbidity and hospitalization time in patients at high risk for severe pancreatitis (Glasgow criteria) by performing early sphincterotomy and stone extraction [5]. Our eight patients with gallstone pancreatitis experienced no complications following ERCP, thus supporting Carr-Locke's findings.

Regarding the tests for choledocholithiasis, we were interested to find that the accuracy of the predictors of common duct stones in our series is comparable to that in other series [1, 15]. A history of jaundice, abnormal liver function tests, gallstone pancreatitis, and a dilated common bile duct on ultrasound all have low accuracy rates. If choledocholithiasis could be found preoperatively on ultrasound, the predictability was 100% in our series. However, not all common duct stones will be detected by it: 12 of our 17 patients with choledocholithiasis had a positive preoperative ultrasound (70%). On the other hand, operative cholangiography has a relatively high accuracy rate in good

Table 6. The use of electrohydraulic lithotripsy in biliary lithiasis: human clinical experience[a]

	T-tube	Percut.	ERCP	Open CBDE	Lap. CBDE	Success	Failure	Complication
Burhenne(1975)[b]	1					1		
Koch(1980)[c]			14			12	2	None
Lear(1984)[b]		1				1		None
Tanaka(1985)[c]		2	1			3		None
Matsumoto(1987)[d]		2				2		None
Ponchon(1987)[d]		1				1		Bleed[e]
Mo(1988)[d]		10				10		1 bleed
Yip(1988)[d]				11		11		Tear Mucosa
Fan(1989)[d]	3	3		4		10		1 bleed
Yasuda(1989)[d]		26	11			35	2	None
Picus(1990)[d]	4	7				11		None
Wakayama(1990)[d]	4	5				7	2	4 bleeds
Callans(1990)[b]	1					1		None
Josephs(1990)[b]	12					11	1	None
Siegel(1990)[b]			21			18	3	
Arregui(1991—this study)[d]					2	2		None
Total	25	57	47	15	2	136	10	7 bleeds 1 tear

[a] Percut., percutaneous; Lap. CBDE, laparoscopic common bile duct exploration; [b] flouroscopic guidance; [c] basket entrapment; [d] choledochoscopic guidance; [e] immediate dilation of percutaneous tract to 24-Fr probably caused bleeding which required transfusion: all other bleeds were mild, not requiring treatment

hands and is easily performed. The predictive value of operative cholangiography in our hands (80%) was not dissimilar to the results of others, but it is difficult to draw any conclusions from our data since the numbers involved are small. In Abdul Ghani's study, 18 of 20 patients with positive intraoperative cholangiograms had positive common duct explorations for an accuracy rate of 90% [1]. Ijzermans et al. had 46 positive explorations out of 61 patients with positive cholangiograms for a predictability value of 75.4% [15].

Our data and the data from other studies show that laparoscopic cholecystectomy combined with endoscopic sphincterotomy is a safe and effective treatment for cholelithiasis with choledocholithiasis and has few short-term side effects. Although our follow-up time is short, we believe the long-term side effects (specifically, the sphincter stenosis rate) will be comparable to those in other studies—that is, minimal. As experience with laparoscopic cholecystectomy grows, it seems that laparoscopic operative cholangiography, choledochoscopy, and extraction of common duct stones will become the primary treatment for choledocholithiasis. The main advantage of this approach is that it avoids an extra procedure (a preoperative ERCP) and its attendant discomfort, morbidity, and cost. This is especially relevant in light of the low accuracy of most preoperative tests for choledocholithiasis. However, until surgeons learn laparoscopic common duct exploration, endoscopic sphincterotomy and stone extraction seems the most logical treatment of choledocholithiasis because of its easy availability and proven safety. It certainly deserves a prominent place among the options for treating this condition.

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