ORIGINAL ARTICLE

Liver Resection for Intrahepatic Stones

Moon-Tong Cheung, FRCS, FHKAM; Philip Chong-Hei Kwok, FRCR, FHKAM

Hypothesis: Long-term outcome is good for a selected group of patients with hepatolithiasis treated with liver resection. Liver resection should also be offered to patients with complex hepatolithiasis such as bilateral stones or those with strictures.

Design: Retrospective study.

Setting: Regional hospital.

Patients: A total of 174 patients with hepatolithiasis (201 procedures) treated between January 1, 1989, and September 30, 2003.

Interventions: Liver resection (52 procedures) or removal of stones primarily by percutaneous choledochoscopy (149 procedures).

Main Outcome Measure: Recurrence of cholangitis.

Results: Most patients in the liver resection group had stones localized to the left side. The overall success rate in this group was 98.0% (49 of 50 patients, excluding 2 patients found to have cholangiocarcinoma). The chance of biliary sepsis at 5 years after resection was 13.3%. The overall success rate of stone removal primarily by percutaneous choledochoscopy was 70.5%. The bilaterality of stones, the presence of stricture, and the presence of atrophy were found to be significant risk factors for a poor long-term outcome after stone removal alone. The chance of biliary sepsis at 5 years was 26.4% and 43.2% for those without and with stricture, respectively.

Conclusions: The long-term outcome after liver resection for hepatolithiasis was excellent for a selected group of patients. Poor outcomes were recorded for patients whose intrahepatic stones were removed primarily by percutaneous choledochoscopy, especially those with strictures. The indication for liver resection for hepatolithiasis should be extended to patients with strictures and those with bilateral stones. A combination of different treatment modalities is necessary to improve the outcome of these patients.

Arch Surg. 2005;140:993-997

Author Affiliations:
Departments of Surgery (Dr Cheung) and Radiology and Imaging (Dr Kwok), Queen Elizabeth Hospital, Hong Kong.

PERCUTANEOUS CHOLEDOchoscopy has been widely used for the treatment of complex hepatolithiasis. The rate of recurrence of stones or symptoms remains high, especially for those with intrahepatic strictures.[1-5] In a selected group of patients undergoing liver resection (LR), the result was promising.[6-9] Most surgeons would advocate resection if the diseased liver was localized to the left side, if it was atrophic, or if there was a suspicion of superimposed malignancy. We report herein on a series of patients with hepatolithiasis who were treated with LR. They were compared and contrasted with patients whose intrahepatic stones were treated primarily by stone removal (SR) via percutaneous choledochoscopy. The selection criteria, patient characteristics, treatment results, and especially the long-term outcomes were analyzed. On the basis of these results, the treatment strategy for patients with complex hepatolithiasis can be modified.

METHODS

Between January 1, 1989, and September 30, 2003, in the Department of Surgery, Queen Elizabeth Hospital, Hong Kong, LR was performed on 52 patients who presented with hepatolithiasis related to recurrent pyogenic cholangitis. All patients with a preoperative diagnosis of cholangiocarcinoma associated with intrahepatic stones were excluded from this analysis. The usual indication for LR was atrophy of liver segments or a lobe. The resection was usually performed through a bilateral subcostal incision. Dissection was performed at the liver hilum. The common bile duct was identified. Choledochotomy was usually performed and the bile ducts were explored. The affected atrophic segments were carefully mobilized and then resected, and as much healthy liver tissue as

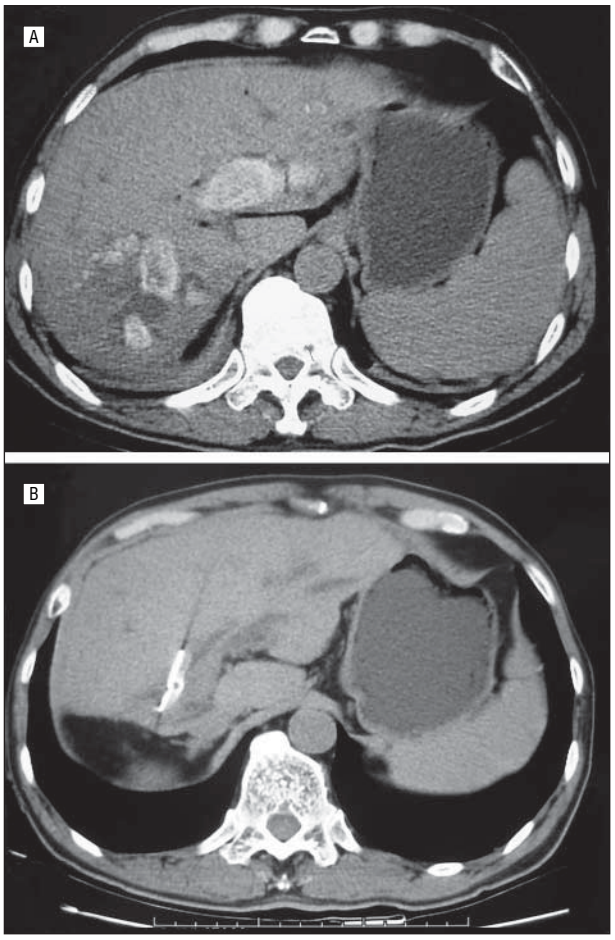

Figure 1. Computed tomography. The computed tomographic scans were taken before (A) and after (B) liver resection and postoperative choledochoscopy.

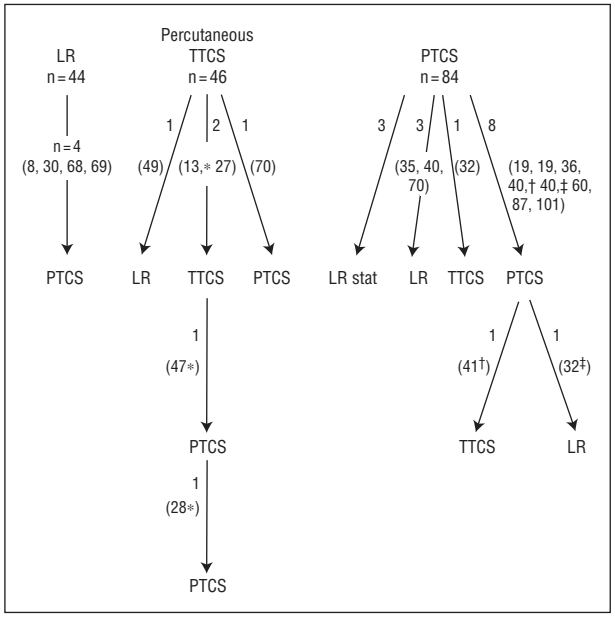

Figure 2. Flow chart showing the number of patients entering the study, some with repeated interventions (asterisks, daggers, and double daggers denote the same patient). The numbers in parentheses indicate the time intervals between 2 procedures, in months. LR indicates liver resection; TTCS, T-tube track choledochoscopy; and PTCS, percutaneous transhepatic choledochoscopy.

possible was left behind. Formal lobectomy was performed only if the whole lobe was atrophic.

Vascular inflow was controlled by Pringle maneuver when necessary. Parenchymal dissection was performed by the clamp crushing method or an ultrasonic dissector. The segmental bile duct at the raw surface was cut and deliberately laid open. After hemostasis had been achieved, flexible choledochoscopy was performed through the transected bile duct opening and via the choledochotomy site to examine whether the ductal stricture had been resected and whether all the stones in the rest of the biliary system had been cleared. The transected duct was then sutured with absorbable material. Other procedures such as hepaticojejunostomy or sphincteroplasty were sometimes also performed at the same time. At the end of the operation, a T tube was inserted into the common bile duct through the choledochotomy site, which was repaired. A postoperative cholangiogram was performed via the T tube about 1 week after the operation. Computed tomography was also performed in some complicated cases (**Figure 1**). If residual stones were suspected, the T-tube track was dilated 4 to 6 weeks after the operation. Flexible choledochoscopy was performed via the T-tube track to remove the remaining intrahepatic stones.

A retrospective study was done to analyze the patients' characteristics, the results and complications of the procedure, and the long-term outcomes for these patients. The group of patients who underwent LR was compared and contrasted with a group of patients with hepatolithiasis who had undergone what was primarily an SR procedure during the same study period. The SR procedures included either an open operative exploration of the common bile duct and postoperative choledochoscopic removal via a T-tube track (TTCS) or percutaneous transhepatic choledochoscopic removal of intrahepatic stones (PTCS). Most of the TTCS procedures were performed in the earlier part of the study period, since PTCS was introduced in our department in 1993. Some patients underwent multiple procedures. A total of 174 patients were entered into our analysis during the study period. The numbers of patients who had multiple procedures and the time intervals between the 2 procedures are shown in **Figure 2**. Altogether, the 174 patients underwent 52 LRs, 99 PTCSs, and 50 TTCSs.

The patients' characteristics were analyzed. The complexity of stones was graded as simple, a category defined as stones affecting a single segmental duct; moderate, when stones affected more than 1 segmental duct; and complex, with multiple ducts affected. A stricture was defined as the presence of an intrahepatic stenotic duct proximal to the stones, usually less than 2 mm in diameter, or one that required dilation during choledochoscopy. The degree of atrophy of liver segments was graded as mild, moderate, or severe. The success of each procedure in removing the stones was categorized into 2 groups. Overall success included both complete and near-complete removal, where tiny stones remained in peripheral or segregated ducts. All others were regarded as failures. These patients were followed up regularly and the symptoms were charted by means of a symptom score (**Table 1**). Cholangitis or other biliary sepsis occurring during the follow-up period was regarded as an unfavorable event. Patients requiring another operation or procedure to remove stones were also regarded as having had an unfavorable outcome. This was analyzed with the Kaplan-Meier method. The test statistics for equality of recurrence distribution were analyzed with the log-rank test. Multivariate analysis was performed by means of multiple logistic regressions to identify independent risk factors that predicted poor outcome in both LR and SR groups. Statistical significance was accepted at $P<.05$. The SPSS version 11.0 software (SPSS Inc, Chicago, Ill) was used to perform the analysis and generate the curves.

Table 1. Symptom Scores for Long-term Outcome in 172 Patients After Treatment

Outcome Score	LR Group (n = 46)	SR Group (n = 126)
0: Asymptomatic	20	51
1: Occasional pain	10	20
2: Frequent pain	5	4
3: Pain requiring hospital attendance or preventing work	1	8
4: First recurrence of cholangitis or biliary sepsis	3	14
5: >1 Recurrence of cholangitis or biliary sepsis	1	2
6: Need for reoperation or other intervention	6	27

Abbreviations: LR, liver resection; SR, stone removal.

RESULTS

The characteristics of patients in the LR and SR groups are shown in **Table 2**. Most of them presented with cholangitis, pancreatitis, or liver abscess. Among the 52 patients who underwent laparotomy for LR, only 19 (36.5%) had not had any previous biliary operations, as compared with 67 (45.0%) of 149 in the SR group. The liver segments resected during the operation were as follows: segment 2, 1 patient; 2 and 3, 33 patients; 2 through 4, 11 patients; 2, 3, and 4a, 3 patients; 5 through 8, 2 patients; 6, 1 patient; and 6 and 7, 1 patient. Two patients were found to have cholangiocarcinoma in the resected specimens. The complications after LR are shown in **Table 3**. The overall complication rate was 44.2%. The in-hospital mortality rate was 3.8% (2 patients). Apart from exploration of the common bile ducts, 2 patients had sphincteroplasty and 3 patients had hepaticojejunostomy performed concomitantly. Postoperative choledochoscopy via T-tube track was performed in 7 patients after LR. These patients were included only in the LR group for the study. The overall success rate (excluding for those with cholangiocarcinoma) of removing the stones was 49 (98%) of 50 in the LR group as compared with 103 (70.5%) of 146 in the SR group (71 [73.2%] of 97 patients for PTCS, 32 [65.3%] of 49 for TTCS).

In the SR group, 3 patients were diagnosed as having cholangiocarcinoma during the choledochoscopic examinations and 4 other patients died in the hospital after the procedure. Two patients in the LR group and 13 patients in the SR group defaulted on their follow-ups within 6 months of their discharge. All of these patients, including the 2 deaths after LR and the 2 patients diagnosed as having cholangiocarcinoma during LR, were excluded from the analysis of the long-term outcome. Three patients had LR done immediately after the failure of PTCS to remove the stones. They were included only in the LR group for long-term outcome analysis. For the remaining 46 patients in the LR group, the length of follow-up ranged from 6 to 170 months (mean [SD] follow-up, 66.4 [48.4] months; median, 58 months). For the remaining 126 patients in the SR group, the length of follow-up ranged from 6 to 152 months (mean [SD] follow-up, 49.9 [34.7] months; median, 42 months). The outcome scores of these 2 groups of patients during follow-up are given in Table 1. The bilaterality of stones, the presence of stricture, and the presence of atrophy were found to be independent significant risk factors for a poor long-term outcome in patients in the SR group. None of these was found to be a significant risk factor in the LR group (**Table 4**).

In a Kaplan-Meier analysis of the occurrence of unfavorable outcome, patients in the LR group were significantly better off than those in the SR group ($P = .008$; $df = 1$). The chance of occurrence of cholangitis or biliary sepsis was 13.3% at 5 years after LR. Patients in the SR group were divided into 2 further sets of subgroups for analysis, specifically, by the degree of success of the procedure and the presence of stricture. The chance of cholangitis or biliary sepsis at 5 years was 29.3% for those after successful removal of stones and 56.1% for those with failure (**Figure 3**). For those without and with stricture, the chance of such an occurrence at 5 years was 26.4% and 43.2%, respectively (**Figure 4**). Five other patients in the SR group subsequently developed cholangiocarcinoma during follow-up. The overall incidence of cholangiocarcinoma in all patients was 10 (5.7%) of 174 patients.

Table 2. Patient Characteristics in the LR and SR Groups

	LR Group (n = 52)	SR Group (n = 149)
Age, mean (range), y	55.7 (31-79)	57.5 (21-95)
Sex, No. M/F	20/32	53/96
Site of stones, No. left/right/bilateral	40/3/9	69/28/52
Complexity of stones, No. simple/moderate/complex	0/43/9	33/81/35
Stricture, No. yes/no	52/0	90/59
Atrophy of liver lobe, No. mild/moderate/severe	8/16/28	94/33/22
Presentation, No.		
Cholangitis	28	116
Pancreatitis	9	9
Liver abscess	6	3
Subphrenic abscess	0	2
Cholecystitis	0	1
Pain	9	16
Asymptomatic	0	2

Abbreviations: LR, liver resection; SR, stone removal.

Table 3. Complications of Liver Resection for Hepatolithiasis

Complication	No. of Events
Wound infection	16
Septicemia	2
Pneumonia	2
Pleural effusion	2
Prolonged gastric stasis	1
Cardiac arrhythmia	1
Clinical leakage at transected site	1
Radiologic leakage at transected site	3
Total No. of Complications	**28**
Total No. of patients with complications	23

Table 4. Risk Factors for Long-term Outcome

Risk Factor	SR Group Odds Ratio	SR Group *P* Value	LR Group Odds Ratio	LR Group *P* Value
Age	1.01	.72	0.97	.48
Sex, M	1.05	.91	1.61	.57
Site				
Right	1.52	.49	NA	NA
Bilateral	3.52	.03*	1.10	.95
Complexity of stone	0.84	.22	1.45	.47
Presence of stricture	2.91	.03*	NA	NA
Presence of atrophy	1.22	.03*	1.12	.54
Failure of procedure	2.37	.06	NA	NA

Abbreviations: LR, liver resection; NA, number too small for analysis; SR, stone removal.
*$P<.05$.

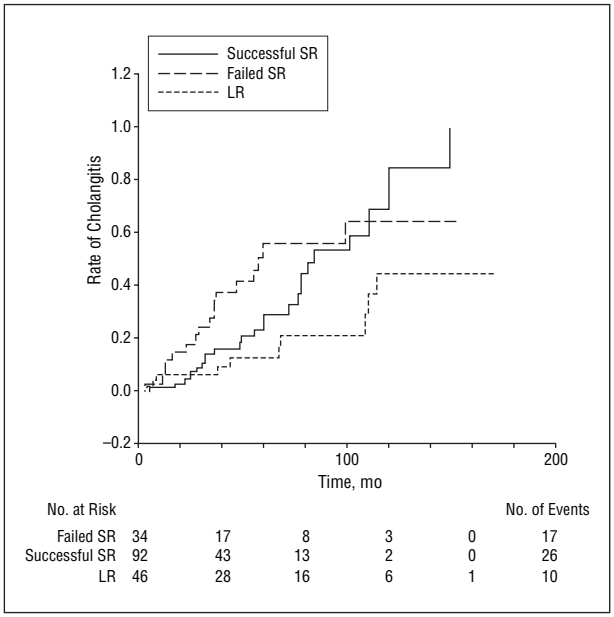

Figure 3. Occurrence of cholangitis after successful and failed stone removal (SR) and liver resection (LR).

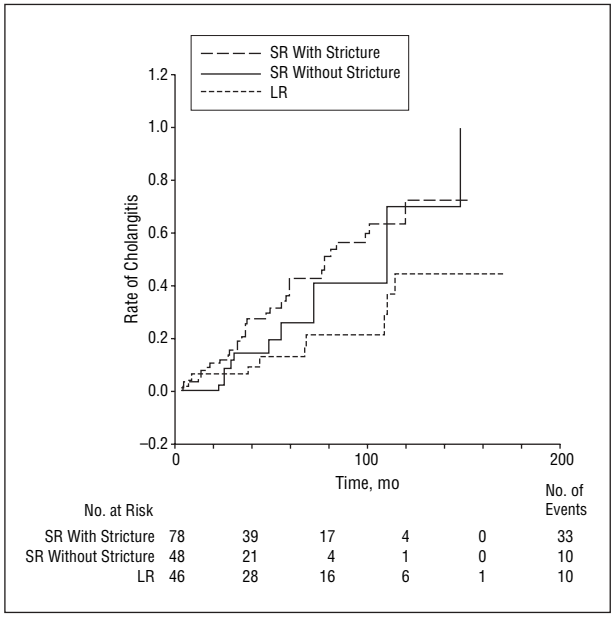

Figure 4. Occurrence of cholangitis after stone removal (SR) with and without stricture and liver resection (LR).

COMMENT

Recurrent pyogenic hepatolithiasis is characterized by its natural course of recurrent cholangitis.[10] Recurrent stone formation and stasis secondary to fibrosis and stricture precipitate biliary sepsis, which presents as conditions such as acute cholangitis, liver abscess, or portal phlebitis. Percutaneous choledochoscopy has become a well-established procedure for the removal of stones and dilation of strictures. A high success rate and good results have been reported.[2-5,11] The patients in the SR group in our series who had a failure of SR are probably representative of the natural course of the disease in which cholangitis recurs within a short time. For patients whose intrahepatic stones were successfully removed, the occurrence of cholangitis was much delayed compared with those with failure of removal. However, the long-term outcome for both groups was disappointing.[1-5]

In a selected group of patients in whom the disease was localized to 1 lobe or a few segments, resection removed not only the stones but also the associated pathologic changes, including ductal stricture, fibrosis, and microabscess. This has been shown to have good results in previous reports.[6-9] Comparing the results of the SR and LR groups in our series may not be appropriate, as they represented different groups of patients. However, in this selected group of patients treated with LR, the long-term outcome was excellent. A large proportion of them remained well even 10 years after their resection. The chance of recurrent cholangitis was significantly less than for those in the group that underwent SR.

It was generally agreed at our institution that LR should be offered to patients with associated atrophy of the involved segments, mostly those in whom the left lobe was involved, because of the reduced operative risk. However, this was only feasible in cases where the segments were localized to 1 lobe or to peripheral segments. Associated hypertrophy of the remaining liver segments was not uncommon. Hypertrophy of the quadrate lobe was commonly found in patients with atrophic left lateral segments or hypertrophy of the right anterior segments with atrophic right posterior segments. Segment-oriented resection targeted at removal of the destroyed lobe and preservation of good liver tissue should be the goal. This was shown in our series to have achieved good results. Resection of atrophic segments was not technically difficult, as most of the tissue had been destroyed. Stone removal could also be facilitated through the transected duct orifices. It seems a safe procedure, with the likelihood of postoperative liver failure being remote. Our series showed that the morbidity of LR was 44.2%, compared with 12% to 38.5% in other series.[6-8] Most of these patients had had previous multiple operations, and there remained a risk of operative mortality of 2% to 4%, as in our series and others.[6-8] The morbidity and mortality might be comparable to that for percutaneous choledo-

choscopic removal of stones.[1,2,11-14] However, the deaths in the latter group of patients were usually related to advanced age or a poor premorbid condition. Right-sided hepatolithiasis was particularly difficult to remove percutaneously, especially when associated with acute ductal angulation.[2,15,16] The indication for resection might need to be extended to those with atrophy of the right lobe. The advantages should be judged and balanced against the increased risk.

Should we resect stone-bearing segments that are not atrophic? Intrahepatic strictures have been reported by a number of investigators to have produced poor outcomes.[1-4] The rate of restenosis was high despite successful dilation of the stricture.[17] In our data, the presence of stricture was shown to be an independent factor that predicted poor outcome in patients with stones that were removed by percutaneous choledochoscopy alone. The recurrence of cholangitis after choledochoscopic removal consistently occurred earlier in those with stricture. This group of patients with stricture would definitely benefit from a more aggressive approach. In patients without stricture yet with numerous stones, resection might be considered. This option should be opened for discussion with the patient. Percutaneous choledochoscopy should be best for patients with intrahepatic stones without stricture or in elderly patients whose life expectancy is short.

The overall incidence of cholangiocarcinoma in association with hepatolithiasis has been reported to be 5% to 16%.[18-20] This occurred in about 6% of our patients. Some patients found to have cholangiocarcinoma may be young. The occurrence of cholangiocarcinoma is unpredictable in these patients, and early diagnosis could be difficult. Some cases may mimic an abscess. Resection offered an advantage in eliminating the risk of occurrence of cholangiocarcinoma.[21] Thus, a more liberal attitude toward LR should be adopted in case of suspicion.

In this series of patients, LR was performed in patients with localized disease. The results were good when contrasted with those of the SR group, some of whom had very complex hepatolithiasis and strictures. The removal of stones primarily by percutaneous choledochoscopy yielded poor long-term outcomes. Bilateral stones were also shown to be a risk factor for poor outcome in our patients who underwent SR. These patients probably would have had better long-term outcome if LR had been done in combination with percutaneous choledochoscopy, which was usually performed via a postoperative T-tube track. Better results have been shown in a series of patients with bilateral hepatolithiasis treated with left-lobe resection than in those without.[21] However, the optimal management of these complex intrahepatic stones remains a very difficult and challenging task.

Accepted for Publication: December 15, 2004.
Correspondence: Moon-Tong Cheung, FRCS, FHKAM, Department of Surgery, Queen Elizabeth Hospital, Gascoigne Road, Kowloon, Hong Kong (qehsurg@ha.org.hk).

REFERENCES

1. Cheung MT. Postoperative choledochoscopic removal of intrahepatic stones via a T tube tract. *Br J Surg*. 1997;84:1224-1228.
2. Cheung MT, Wai SH, Kwok PCH. Percutaneous transhepatic choledochoscopic removal of intrahepatic stones. *Br J Surg*. 2003;90:1409-1415.
3. Jan YY, Chen MF. Percutaneous trans-hepatic cholangioscopic lithotomy for hepatolithiasis: long-term results. *Gastrointest Endosc*. 1995;42:1-5.
4. Lee SK, Seo DW, Myung SJ, et al. Percutaneous transhepatic cholangioscopic treatment for hepatolithiasis: an evaluation of long-term results and risk factors for recurrence. *Gastrointest Endosc*. 2001;53:318-323.
5. Yeh YH, Huang MH, Yang JC, Mo LR, Lin J, Yueh SK. Percutaneous transhepatic cholangioscopy and lithotripsy in the treatment of intrahepatic stones: a study with 5 year follow-up. *Gastrointest Endosc*. 1995;42:13-18.
6. Otani K, Shimizu S, Chijiiwa K, et al. Comparison of treatments for hepatolithiasis: hepatic resection versus cholangioscopic lithotomy. *J Am Coll Surg*. 1999; 189:177-182.
7. Fan ST, Lai ECS, Wong J. Hepatic resection for hepatolithiasis. *Arch Surg*. 1993; 128:1070-1074.
8. Chijiiwa K, Kameoka N, Komura M, Yamasaki T, Noshiro H, Nakano K. Hepatic resection for hepatolithiasis and long-term results. *J Am Coll Surg*. 1995;180: 43-48.
9. Jan YY, Chen MF, Wang CS, Jeng LB, Hwang TL, Chen SC. Surgical treatment of hepatolithiasis: long-term results. *Surgery*. 1996;120:509-514.
10. Ong GB. A study of recurrent pyogenic cholangitis. *Arch Surg*. 1962;84:199-225.
11. Hwang MH, Tsai CC, Mo LR, et al. Percutaneous choledochoscopic biliary tract stone removal: experience in 645 consecutive patients. *Eur J Radiol*. 1993; 17:184-190.
12. Ponchon T, Genin G, Mitchell R, et al. Method, indications, and results of percutaneous choledochoscopy, a series of 161 procedures. *Ann Surg*. 1996; 223:26-36.
13. Jeng KS, Chiang HJ, Shih SC. Limitations of percutaneous transhepatic cholangioscopy in the removal of complicated biliary calculi. *World J Surg*. 1989; 13:603-610.
14. Bonnel DH, Liguory CE, Cornud FE, Lefebvre JF. Common bile duct and intrahepatic stones: results of transhepatic electrohydraulic lithotripsy in 50 patients. *Radiology*. 1991;180:345-348.
15. Jeng KS, Ohta I, Yang FS, et al. Coexisting sharp ductal angulation with intrahepatic biliary strictures in right hepatolithiasis. *Arch Surg*. 1994;129:1097-1102.
16. Cheng YF, Lee TY, Sheen-Chen SM, Huang TL, Chen TY. Treatment of complicated hepatolithiasis with intrahepatic biliary stricture by ductal dilatation and stenting: long-term results. *World J Surg*. 2000;24:712-716.
17. Jan YY, Chen MF, Hung CF. Balloon dilatation of intrahepatic duct and biliary-enteric anatomosis strictures—long-term results. *Int Surg*. 1994;79:103-105.
18. Chen MF, Jan YY, Wang CS, et al. A reappraisal of cholangiocarcinoma in patients with hepatolithiasis. *Cancer*. 1993;71:2461-2465.
19. Liu CL, Fan ST, Wong J. Primary biliary stones: diagnosis and management. *World J Surg*. 1998;22:1162-1166.
20. Chijiiwa K, Ichimiya H, Kuroki S, Koga A, Nakayama F. Late development of cholangiocarcinoma after the treatment of hepatolithiasis. *Surg Gynecol Obstet*. 1993; 177:279-282.
21. Jeng KS, Ohat I, Yang FS. Reappraisal of the systematic management of complicated hepatolithiasis with bilateral intrahepatic biliary strictures. *Arch Surg*. 1996;131:141-147.