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Multivariate Comparison of Complications After Laparoscopic Cholecystectomy and Open Cholecystectomy

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Objective

To answer the question whether laparoscopic cholecystectomy (LC) or open cholecystectomy (OC) is safer in terms of complications, the authors evaluated complications relating to 1440 cholecystectomies performed by the same surgeons in a retrospective study.

Summary Background Data

A definite pronouncement on whether LC truly is superior to OC is not possible because prospective trials are burdened with problems of recruitment.

Methods

After the introduction of LC at the authors' institution in April 1991 and until October 1993, 94.6% (700/740) of all patients admitted for operation because of symptomatic gallstone disease could be treated laparoscopically. The clinical records of the last 700 patients who underwent OC before the introduction of LC were re-evaluated with regard to both overall complications and the grade of complication (severity grade 1–4). A comparison of the incidence of complications relating to the two surgical methods, age, sex, common bile duct stones, acute cholecystitis, concomitant illness, Apache score, and length of operation was calculated by multivariate analysis using the logistic regression model.

Results

The total rate of complications in the OC group was 7.7%, with five postoperative deaths, compared with 1.9% and one postoperative death in the LC group. Multivariate analysis for OC revealed that both old age ($p = 0.014$) and the existence of common bile duct stones ($p = 0.02$) had independent prognostic influences in increasing the overall complication rate, whereas only old age ($p = 0.019$) influenced the overall complication rate after LC. Multivariate analysis of all cholecystectomies ($n = 1440$) showed that the overall complication rate was influenced independently by OC as a detrimental factor.

Conclusions

As this analysis emphasizes, LC can be performed safely with an overall complication rate that is distinctly lower than that of OC. For elective surgery, LC is undoubtedly superior to OC and can probably be seen as a new "gold standard" for cholecystectomies.

Table 1. CLASSIFICATION AND DEFINITION OF COMPLICATIONS[10]

Grade 1 complications	Deviations from the ideal postoperative course, non-life-threatening with no lasting disability. Require only bedside procedures, do not significantly extend the hospital stay.
Grade 2a complications	Potentially life-threatening but without residual disability. Invasive procedures are not required.
Grade 2b complications	Potentially life-threatening but without residual disability. Surgery is necessary to restore health.
Grade 3 complications	Complications with residual disability, including organ resection or persistence of life-threatening conditions.
Grade 4 complication	Death due to complications.

Because laparoscopic cholecystectomy (LC) has become the standard therapy for symptomatic gallstone disease, particularly in an elective setting,[1,2] it is essential to determine the extent of the difference in morbidity when compared with open cholecystectomy (OC). Only now are surgeons beginning to recognize the results of LC and the full spectrum of complications associated with this technique.[2-5] In its early days, complications after LC—including major bile duct injuries—were reported to be three to five times higher than that those relating to OC.[6,7] It seems that both the complication rate and resulting morbidity for the consecutive series of 700 LCs performed since we introduced the method in April 1991 were low and satisfactory. In the past, there have been very few prospective trials,[8,9] mostly burdened with problems of recruitment. This means that it is difficult to state whether LC is truly superior to standard cholecystectomy, particularly in terms of safety. Indeed this is only possible within the framework of a multivariate comparison of defined complications relating to an equal number of OCs performed during the prelaparoscopic era by the same surgeons. Results were evaluated by classifying surgical complications on a severity scale graded from one to four[10,11] (Table 1). Risk factors for developing these complications were compared using multivariate analyses.

PATIENTS AND METHODS

The first 700 patients who underwent laparoscopic operations for symptomatic gallstone disease were taken as a basis for our retrospective study (dating back to April 1991, when LC was introduced to our department). Laparoscopic cholecystectomy was performed by six surgeons associated with our department. One of them had more than 20 years of experience in hepatobiliary surgery, one had 10 years of experience, and another had 7 years of experience. Two were familiar with hepatobiliary surgery, and another surgeon was introduced to LC right from the start, with an experienced surgeon present in all cases. All patients referred for operation because of symptomatic gallstone disease after April 1991 were evaluated by one of the three more experienced hepatobiliary surgeons to see whether a cholecystectomy was necessary and whether LC was possible. The first 50 LCs were restricted to patients requiring elective procedures for chronic cholecystitis and cholelithiasis. After this initial learning process, when the first 100 patients were operated on by only one surgeon, the others gradually were familiarized with LC. In addition, indications were expanded to include acute cholecystitis (defined as emergency admission with right upper-quadrant pain, fever, elevated white blood count, and gallstones with increased wall thickness of the gall bladder on ultrasonography), as well as patients who had previously undergone operations in the upper abdomen. Patients with additional symptoms of bile duct stones or with biliary pancreatitis were selected for LC if it was possible to successfully perform a preoperative endoscopic retrograde cholangiopancreatography (ERCP) and papillotomy (EPT) with gallstone removal. All patients underwent preoperative routine laboratory tests, including a complete blood count, electrolyte levels, liver enzyme levels, and abdominal ultrasonography.

Preoperative intravenous cholangiography was routinely performed before LC, except in cases with obvious bile duct stones. In these cases, patients were referred for preoperative ERCP and EPT. The technique used for LC did not differ from the usual procedure repeatedly reported in the literature.[12-14] Intraoperative cholangiography was mandatory for OC and only was performed during LC in cases in which dilated common bile ducts were not recognized preoperatively. A single-shot broad spectrum antibiotic prophylaxis was administered for both procedures. From April 1991 until the 700th LC in October 1993, only 40 patients with gallstone disease were preoperatively excluded from the LC procedure because they either had acute cholecystitis (n = 13), common bile duct stones (CBDS; n = 14), severe cardiac or pulmonary disease (n = 11), or previously had undergone upper abdominal operations (n = 2). Only in those cases in which it was necessary to switch from LC to OC were patients excluded from the analysis. To create a necessary basis for comparison, the clinical records of the last 700 patients with gallstone disease admitted to our department

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Table 2. COMPARISON OF CLINICAL DATA OF PATIENTS OPERATED IN THE PRELAPAROSCOPIC AND LAPAROSCOPIC ERA

	Prelaparoscopic Era August 1986–April 1991 (N = 700)	Laparoscopic Era April 1991–October 1993 (N = 740)	p Value
Sex			
Female	485 (69.3%)	531 (71.8%)	NS
Male	215 (30.7%)	209 (28.2%)	NS
Age (mean)			
Female	53 (SEM 0.76)	54 (SEM 0.71)	NS
Male	56 (SEM 0.96)	56 (SEM 1.07)	NS
Acute cholecystitis	132 (18.9%)	102 (13.9%)	<0.01
Common bile duct stones	103 (14.7%)	43 (5.8%)	<0.01

for operations before LC was introduced were re-evaluated with respect to age, concomitant disease, percentage of additional common bile duct exploration, duration of operation, and grade of complications. Thus, it was possible to analyze a total of 1440 cholecystectomies, 740 OCs, and 700 LCs in the same manner. Distribution of age and sex was similar in both groups; the incidence of acute cholecystitis and common bile duct exploration was statistically significantly higher in the group treated before April 1991 than in the later group (Table 2). For this reason, complications were analyzed for all patients (n = 1440) and also for those who underwent operations in an elective setting (excluding acute cholecystitis and CBDS; n = 1060).

Common bile duct stones in patients in the laparoscopic group were removed only by endoscopic papillotomy, either preoperatively or shortly after operation. Concomitant diseases were assessed further in terms of the operative and postoperative risk for OC and LC, using a modified Apache score,[10,11] as illustrated in Table 3. The simplified Apache II score was determined retrospectively, based on only two sets of objective criteria: age (<45 years, 0 points; 45–54 years, 2 points; >74 years, 6 points) and concomitant disorders (5 points for the presence of one or more severe organ system insufficiencies), as initially proposed by Knaus et al.,[15] for a maximum score of 11. Three patient groups were examined for prediction of risk, i.e., low risk, <5 points; intermediate risk, 6 to 9 points; and high risk, ≥10 points.

The degree of complication was represented by a score that differentiates between four groups of complications, ranging from minor deviations from an ideal postoperative course to death due to complications.[10,11] Classification and definition of complications are shown in Table 1.

The EGRET software package (Statistics and Epidemiology Research Corporation; Seattle, WA) was used for statistical analyses. A comparison of the incidence of complications relating to the two surgical methods was calculated with multivariate analysis using the logistic regression model.[16] For other comparisons, the chi square and Student's t test were used.

RESULTS

Seven hundred forty patients underwent OC, and 700 patients underwent LC. In 14 cases (2.0%), it was necessary to change to OC after the operations had been started laparoscopically. The reasons for this were acute inflammation of the gall bladder and Challot's triangle in six cases, the presence of adhesions relating to previous surgery in one case, an unclear anatomic situation in two cases, intraoperative bleeding in two cases (once from the injured right hepatic artery, once from the gallbladder bed), one bile duct injury, one pre-existent biliodigestive fistula, and in one case, an extremely dilated common bile duct caused by gallstones and discovered during cholangiography. The postoperative course after change of technique was inconspicuous in all cases. Ten patients who previously had undergone operations in the upper abdomen could be treated successfully with LC. No complications were observed after preoperative intravenous cholangiography. Forty-three patients were referred for ERCP preoperatively, and in 26 of these cases, EPT and stone removal were done before LC was performed. Intraoperative cholangiography in the LC group was performed in 20 cases; in one case, conversion to OC was necessary. Five patients were referred for ERCP postoperatively, and three patients had postoperative EPT and stone removal. No complications were observed after EPT and stone removal. Eight patients undergoing LC had to undergo re-operation in the earlier or later post-

Table 3. DISTRIBUTION OF THE MODIFIED APACHE SCORE IN THE OC AND LC GROUPS

	OC Group (n = 740)	LC Group (n = 700)	p Value
Concomitant disease	202 (27.3%)	174 (24.9%)	NS
Apache I 0–5	516 (69.7%)	517 (73.9%)	NS
Apache II 6–9	115 (15.5%)	90 (12.9%)	NS
Apache III ≥10	109 (14.7%)	93 (13.3%)	NS

OC = open cholecystectomy; LC = laparoscopic cholecystectomy.

Table 4. OVERALL COMPLICATION RATES IN THE OC AND LC GROUPS RELATED TO GRADE OF COMPLICATIONS FOR ALL PATIENTS AND FOR PATIENTS OPERATED IN AN ELECTIVE SETTING (ACUTE CHOLECYSTITIS AND COMMON BILE DUCT STONES EXCLUDED)

	Open Cholecystectomy		Laparoscopic Cholecystectomy	
	Over (n = 740)	Elective (n = 469)	Overall (n = 700)	Elective (n = 591)
Total	57 (7.7%)	39 (8.3%)	13 (1.9%)	9 (1.5%)
Grade 1	38 (5.1%)	32 (6.8%)	2 (0.3%)	2 (0.3%)
Grade 2a	8 (1.1%)	4 (0.9%)	4 (0.6%)	2 (0.3%)
Grade 2b	6 (0.8%)	3 (0.6%)	8 (1.1%)	4 (0.7%)
Grade 3	0	0	0	0
Grade 4	5 (0.7%)	0	1 (0.1%)	1 (0.2%)

operative course. Three of these patients could be treated laparoscopically; two had a postoperative hemorrhage and one had a bile leakage from the liver bed. For the other five patients, re-laparotomy became necessary because of hemorrhage (n = 3) and bile leakage (n = 2). Altogether, 94.6% (700/740) of patients admitted for operation because of a symptomatic gallstone disease in the laparoscopic era could be treated with LC. The mean duration of operations (common bile duct exploration or biliodigestive anastomoses included) was 60.6 (30–170) minutes for OC and 51.8 (15–240) minutes for LC. The total rate of complications in the OC group was 7.7% (57/740), including five postoperative deaths, and 1.9% (13/700) in the LC group, with one postoperative death due to a myocardial infarction ($p < 0.01$). The mean hospital stay was significantly shorter ($p < 0.01$) in the LC group (7.6 days) than in the OC group (15.0 days), although the relationship is distorted by the Austrian hospital finance system, which pays per day rather than for the operation itself. Overall complications for both groups related to the scale of severity are displayed in Table 4.

Multivariate analyses for OC revealed that old age ($p = 0.014$) and the existence of CBDS ($p = 0.02$) had independent prognostic influence, increasing the overall complication rate, whereas acute cholecystitis ($p = 0.019$) and duration of operation ($p = 0.048$) were factors with independent influence increasing grade 2b complications or higher (Table 5). After LC, only old age influenced overall complication rate ($p = 0.019$) and also grade 2a ($p = 0.038$) and 2b ($p = 0.026$) complications independently (Table 5).

For all cholecystectomies performed conventionally or laparoscopically, the overall complication rate ($p < 0.001$) and grade 1 complications ($p < 0.001$) were influenced independently by OC as a detrimental factor. The existence of acute cholecystitis was recognized as an independent factor for grade 2a ($p < 0.001$) and grade 2b ($p = 0.006$) complications, whereas old age ($p < 0.001$) and length of operation ($p = 0.018$) were factors influencing grade 2b complications (Table 6). For an elective setting, OC also was a detrimental factor for overall ($p < 0.001$) and grade 1 complications ($p < 0.001$), whereas old age independently influenced grade 2a ($p = 0.009$) and 2b complication rates ($p = 0.008$) (Table 6).

DISCUSSION

Until quite recently, standard OC still was considered the treatment of choice for symptomatic gallstone disease. Mortality rates have declined to between 0% and 1% in most recent reports, and in an elective setting, the rate of major complications is approximately 4.5%.[17–19,11] Despite these favorable data for OC, LC has become a popular and common method for removing the gallbladder in all western countries. A shorter stay in hospital, faster recovery, less postoperative pain, and smaller scars are the main advantages of this method.[20] The rapid spread of LC from its inception has to be seen because most hepatobiliary surgeons who have adopted this new method have done so under the pressure of patient demand rather than by the strength of their convictions. Although LC clearly has been associated with life-threatening complications, particularly major bile duct injuries,[6,7] this method was able to replace traditional cholecystectomy as the standard procedure for cholelithiasis within a very few years. Although prospective trials comparing OC and LC have been performed[8,9] they only involve a small number of patients. Therefore, further critical assessment of complications and resulting morbidity is necessary. A comparison of the two surgical methods may not be appropriate because one of them can cope with the broad spectrum of difficulties connected with hepatobiliary surgery, whereas the other cannot. Nevertheless, we still have attempted to compare our results from 700 LCs performed since April 1991 with an historic group of the previous 700 OCs, mostly performed by the same surgeons in terms of the overall complications and their grade of severity, using multivariate analysis, in this retrospective study.

Age, sex, and the modified Apache score were similar in both groups, but there was a distinct difference between the percentage of CBDS and acute cholecystitis in the groups before and after April 1991 (Table 2). Only 29 cases CBDS could be treated with endoscopic papillotomy and stone removal before or after LC. The low incidence of CBDS and acute cholecystitis in the laparoscopic era probably is related to the selection of lower-

Table 5. MULTIVARIATE ANALYSIS OF PROGNOSTIC FACTORS FOR DEVELOPING COMPLICATIONS AFTER OC AND LC

	Overall Complications p Value		Grade 1 p Value		Grade 2a or Higher p Value		Grade 2b or Higher p Value	
Factors	OC	LC	OC	LC	OC	LC	OC	LC
Old age	0.014	0.019	NS	NS	0.015	0.038	NS	0.026
Common bile duct stones	0.020	NS	NS	NS	NS	NS	NS	NS
Acute cholecystitis	NS	NS	NS	NS	0.003	NS	0.019	NS
Concomitant illness	NS	NS	NS	NS	0.007	NS	NS	NS
High Apache score	NS	NS	NS	NS	0.027	NS	NS	NS
Length of operation	NS	NS	NS	NS	NS	NS	0.048	NS

risk patients for this new procedure, as illustrated by the increased number of patients admitted for operation after April 1991. Whereas 700 patients were underwent OC between August 1986 and April 1991, 740 patients with gallstone disease were admitted for operation in the space of $2\frac{1}{2}$ years in the LC era. In a common setting of patients with symptomatic gallstones, one would expect an average percentage of CBDS of 8% to 16%, as reported in the literature.[21-23] This percentage corresponds exactly with our figures of 14.7% in the prelaparoscopic era. The low incidence of 5.8% for the laparoscopic era is, therefore, an effect of selection. The figures of undiscovered CBDS in the LC group at 0.42% (3/700) seems acceptable, although the follow-up period is short.

An important issue is the appropriate procedure for concomitant CBDS when removing the gallbladder laparoscopically.[23] Because the laparoscopic procedure does not reliably and constantly allow exploration of and stone removal from the common duct, the surgeon must decide whether to change to an open procedure or to perform ERCP and EPT stone removal as a matter of principle. An important factor for this decision is the availability of ERCP and EPT round the clock, not guaranteed in our department, as indicated by the fact that only 29 of 43 common duct stones were removed endoscopically. But on the whole, our experience with LC showed that this procedure can be performed safely, when using an "almost all-comers' policy," [24] presupposed, appropriate patient selection and attention to meticulous technique. If there is any confusion regarding anatomy, surgeons should switch to the conventional method without delay. Overall complication rate for OC was 7.7% in comparison with only 1.9% in the laparoscopic group, and this difference was equally notable for an elective setting, where complications occurred in 8.3% of cases with OC *versus* 1.5% for LC. Grade 1 complications were significantly higher for OC, both for the overall and elective group, whereas the difference in complication groups 2 and 4 was not significantly different. It would appear that OC is connected with a higher rate of minor complications, such as wound healing disturbances, in the early postoperative period related to the

Table 6. MULTIVARIATE ANALYSIS OF PROGNOSTIC FACTORS FOR DEVELOPING COMPLICATIONS AFTER CHOLECYSTECTOMY (OC + LC, n = 1440) AND FOR AN ELECTIVE SETTING (n = 1060)

	Overall Complications p Value		Grade 1 p Value		Grade 2a or Higher p Value		Grade 2b or Higher p Value	
Factors	All Patients	Elective	All Patients	Elective	All Patients	Elective	All Patients	Elective
Old age	0.003	NS	NS	NS	0.006	0.009	0.003	0.008
Open cholecystectomy	<0.001	<0.001	<0.001	<0.001	NS	NS	NS	NS
Common bile duct stones	NS	NS	NS	NS	NS	NS	NS	NS
Acute cholecystitis	NS	NS	NS	NS	<0.001	NS	0.006	NS
Concomitant illness	NS	NS	NS	NS	NS	NS	NS	NS
High Apache score	NS	NS	NS	NS	NS	NS	NS	NS
Length of operation	NS	NS	NS	NS	NS	NS	0.018	NS

more invasive surgical method. The major complications rate of 1.3% (9/700) for LC and also the "swap-over" rate of 2% (14/714) seems proportionally low in comparison with published reports.[1,4,5,24] In multivariate analysis for LC, only old age had an unfavorable independent significant influence on overall, grade 2a, grade 2b, and higher grade complications. In contrast, multivariate analysis revealed that old age and OC are the main detrimental factors relating to overall complications for the total collection of clinical cases—i.e, OC for grade 1 complications, old age and acute cholecystitis for grade 2a complications, and old age, acute cholecystitis, and length of operation for grade 2b complications and higher. For OC, old age, CBDS, acute cholecystitis, concomitant illness, a high Apache score, and the duration of operation were found to be detrimental factors influencing complications relating to the operation.

In the light of published reports and as confirmed by our own results, LC can be considered a very safe method with a low overall complication rate and a frequency of re-laparotomy similar to that of OC.[1-5] Prerequisites for the use of LC are experience and familiarity with the whole spectrum of hepatobiliary surgery, recognition and mastery of arising complications, and knowledge of correct indications. In these circumstances, LC is a fascinating new operative method, particularly for elective surgery to remove gallstones.

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