Laparoscopic and open cholecystectomy in New York State: Mortality, complications, and choice of procedure

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Background. *With the advent of laparoscopic cholecystectomy patient outcomes and choice of procedure (laparoscopic vs open) are of vital interest. The purpose of this study was to examine the mortality and complication rates for patients undergoing laparoscopic and open cholecystectomy in New York State and to test for differences among hospital peer groups and regions of the state in the tendency to use the laparoscopic approach.*

Methods. *A population-based, retrospective cohort study of laparoscopic and open cholecystectomy was conducted in which data were analyzed on all 30,968 patients who underwent cholecystectomy as a principal procedure in New York State in 1996.*

Results. *A total of 78.7% of the 30,968 patients who underwent cholecystectomy as a principal procedure in New York State in 1996 underwent laparoscopic cholecystectomy. The mortality rate was lower for laparoscopic cholecystectomy than for the open procedure (0.23% vs 1.90%, P < .0001) and remained significantly lower after patient characteristics related to patient survival (odds ratio 0.34, P < .0001) were controlled for. The prevalence rate of the 8 most common complications among cholecystectomy patients was also much lower among patients undergoing laparoscopic cholecystectomy. Patients undergoing cholecystectomy in public hospitals, Bronx County, and Kings County were found to be significantly less likely to have laparoscopic procedures, and patients undergoing cholecystectomy on Long Island were found to be significantly more likely to have laparoscopic procedures than were other patients in the state.*

Conclusions. *There are reasonably large differences among hospitals, hospital groups, and regions of the state in the type of cholecystectomy used, even after adjustment for differences in patient comorbidities and indications for type of procedure. (Surgery 1999;125:223-31.)*

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LAPAROSCOPIC CHOLECYSTECTOMY WAS DEVELOPED in France and the United States in the late 1980s.[1] By early 1992 more than 80% of the general surgeons in the United States had adopted the procedure,[1] and in 1996 in New York State 78.7% of all cholecystectomies performed as principal procedures were laparoscopic.

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Laparoscopic cholecystectomy has been especially popular because it is less invasive and has shorter hospital stays and a shorter timeframe until return to normal activities than is associated with open cholecystectomy.[2-7] On the other hand, there have been reports of higher rates of common bile duct injury and stone retention associated with laparoscopic cholecystectomy.[8-12]

The results of small randomized clinical trials (which are based on a total of about 400 patients) demonstrate that the mortality rate for laparoscopic cholecystectomy is lower than that for open cholecystectomy and that the recovery time is faster and patient satisfaction higher.[13-15] It is unlikely that larger trials will be undertaken given the current widespread acceptance of laparoscopic cholecystectomy.

This study examined (1) differences in length of stay, complications, and in-hospital mortality rates (adjusted and unadjusted) among patients undergoing laparoscopic and open cholecystectomy, (2) patient characteristics (diagnoses, demographics, admission status) that are associated with laparoscopic cholecystectomy, and (3) differences among regions of the state, hospital peer groups, and individual hospitals in the tendency for patients undergoing cholecystectomy to have laparoscopic procedures after adjustment for patient characteristics associated with the choice.

METHODS

The New York State Department of Health's (NYSDOH) Statewide Planning and Research Cooperative System (SPARCS) was used to identify all cholecystectomies performed in New York State hospitals in 1996 as principal procedures that were reported to the NYSDOH as of September 1, 1997. These procedures include 24,186 laparoscopic cholecystectomies (International Classification of Diseases, Clinical Modification [ICD-9-CM] procedure code 51.23) and 5,536 open cholecystectomies (ICD-9-CM procedure code 51.22).

First, the in-hospital mortality rate and postprocedural length of stay were calculated for each procedure type (laparoscopic, open) and tested for significant differences by type of procedure with use of a chi-square test for mortality rates and a *t* test for lengths of stay. Because length of stay was not normally distributed, *t* tests were also used to test for differences in the log lengths of stay and a chi-square test was used to test for differences, after the lengths of stay for the 2 procedures were subdivided into intervals.

Differences in prevalence rates and in mortality rates for the 8 most common complications that occurred among cholecystectomy patients were compared by type of procedure. These complications were all in the ICD-9-CM range 996-999 (Complications of Medical and Surgical Care). Chi-square tests were used to test for differences by procedure type.

Next, a stepwise logistic regression model was used to determine the significant independent predictors of mortality for cholecystectomy patients. The dependent variable was in-hospital mortality. Candidates for independent variables in the model were demographics (age, sex, race), admission status (elective, urgent, emergency, with "elective" used as the reference variable), common duct exploration during the same admission, and a variety of diagnoses or comorbidities that were demonstrated to have a significant bivariate relationship to mortality and were judged by clinical experts not to be complications of hospital care. Type of cholecystectomy (laparoscopic or open) was also included in the model to determine whether there were mortality differences between the 2 types while controlling for patients' preoperative risks of mortality.

Then a stepwise logistic regression model was used to predict choice of procedure type, which was the dependent variable in the model. Candidates for independent variables were patient age, sex, race, admission status, common duct exploration during the same admission, and a variety of diagnoses or comorbidities. The candidate diagnoses were chosen on the basis of significant bivariate relationships with choice of procedure. Again, care was taken to eliminate from consideration any diagnoses that could have been complications of care provided in the hospital rather than conditions that were present at admission.

The product of this model was a formula that predicts the probability that a patient requiring gallbladder removal will undergo a laparoscopic cholecystectomy rather than an open cholecystectomy with use of the significant variables from the logistic regression model. These predicted probabilities were then summed to obtain the predicted percentages of cholecystectomy patients undergoing laparoscopic cholecystectomy for hospital peer groups (teaching hospitals, nonteaching hospitals, and major public hospitals) and region of the state and for individual hospitals. Observed percentages of cholecystectomy patients undergoing laparoscopic cholecystectomy were also obtained for peer groups, regions, and hospitals. The risk-adjusted proportion of cholecystectomy patients undergoing laparoscopic cholecystectomy for each of the groups just mentioned was calculated by dividing its observed proportion of cholecystectomy patients undergoing laparoscopic cholecystectomy by the predicted proportion and then multiplying this quotient by the statewide proportion of cholecystectomy patients undergoing laparoscopic cholecystectomy.

Differences in the risk-adjusted proportion of cholecystectomy patients undergoing laparoscopic cholecystectomy were then tested for significance among peer groups, regions, and individual hospitals. Also, individual hospitals were subdivided into those with "low percentages of laparoscopic procedures" and "other hospitals." Then the 2 groups were compared with respect to the percentages of patients undergoing laparoscopic cholecystectomy among subgroups of patients who should have been more likely to undergo laparoscopic procedures on the basis of their lack of contraindications or absence of acute cholecystitis.

RESULTS

Volume, mortality rate, and length of stay by type of cholecystectomy. As indicated in Table I,

Table I. Relative frequency and in-hospital mortality for laparoscopic and open cholecystectomy in New York State, 1996

Type of cholecystectomy	*No. (%)*	*Deaths (in-hospital mortality rate)**	*Mean postoperative length of stay (SD)**
Open	6,583 (21.3)	125 (1.90%)	7.04 (8.04)
Laparoscopic	24,385 (78.7)	56 (0.23%)	2.06 (3.74)
Total	30,968 (100.0)	181 (0.58%)	3.12 (5.20)

*Difference between 2 procedures significant for $P < .0001$.

Table II. Relative frequency and mortality rate of major complications associated with cholecystectomy by type (laparoscopic vs open)

		Laparoscopic cholecystectomy		*Open cholecystectomy*	
Type of complication	*ICD-9-CM code*	*Relative frequency (%)*	*Mortality rate (%)*	*Relative frequency (%)*	*Mortality rate (%)*
Cardiac	997.1	0.58	5.67	1.78	9.40
Respiratory	997.3	0.94	3.49	3.65	6.25
Gastrointestinal	997.4	1.07	1.15	3.10	3.43
Urinary	997.5	1.00	2.45	2.02	3.01
Hemorrhage or hematoma	998.1	0.59	1.41	1.37	3.28
Accidental puncture or laceration	998.2	0.35	1.16	1.41	4.30
Postoperative infection	998.5	0.23	1.79	2.16	5.97
Emphysema resulting from procedure	998.89	0.82	0.00	1.72	0.88
One or more of the above	—	5.02	1.88	14.70	4.34

Note: prevalence rates (relative frequencies) for all complications in above table are significantly different ($P < .001$) by type of procedure. Also, mortality rates are significantly different for gastrointestinal complications and postoperative infections (each for $P < .10$) and for “one or more complications” ($P < .001$) by type of procedure.

the number of cholecystectomies performed as a principal procedure in New York in 1996 was 30,968. The number of laparoscopic cholecystectomies was 24,385 (78.7% of the total). A total of 6,523 patients underwent open cholecystectomy in 1996, representing 21.3% of all cholecystectomy patients in New York in that year.

Of the patients undergoing laparoscopic cholecystectomy, 56 (0.23%) died in the hospital before discharge. By contrast, 125 (1.90%) of the open cholecystectomy patients had in-hospital mortality. These 2 mortality rates are statistically different ($P < .0001$).

The mean postoperative length of stay was 7.04 days for patients with open cholecystectomy and 2.06 days for patients with laparoscopic cholecystectomy. These values and their logarithms were significantly different ($P < .0001$). When postoperative length of stay was subdivided into intervals (0, 1, 2 to 5, 6 to 8, 9 to 12, 13 or more days), the difference was also significant.

Complications of cholecystectomy. Table II presents the prevalence rates and mortality rates for the 8 most common types of complications in cholecystectomy patients. Please note that emphysema resulting from a procedure should have occurred only as a result of pneumoperitoneum resulting from laparoscopic cholecystectomy. Consequently, although 113 patients undergoing open cholecystectomy had been coded as having this complication, we concluded that these patients must have had the complication during laparoscopic cholecystectomy before it was converted to an open procedure, and the complication was attributed to the laparoscopic procedure. It should also be noted that some of the accidental puncture or laceration complications attributed to the open procedure may have occurred during laparoscopy before conversion to an open procedure.

Table II demonstrates that the prevalence rates for these complications among laparoscopic cholecystectomy patients varied from 0.23% for postoperative infections to 1.07% for gastrointestinal complications. The complication with the lowest prevalence rate for patients undergoing open cholecystectomies was hemorrhage or hematoma (1.37%), and the one with the highest prevalence rate was respiratory complications (3.65%).

For every complication in Table II except emphysema the prevalence rate was at least twice as high among open cholecystectomy patients as it was among laparoscopic cholecystectomy patients. Also, for one complication, postoperative infec-

Table III. Significant independent predictors of mortality among cholecystectomy patients in New York, 1996

Predictor	*Cholecystectomy patients with predictor (%)*	*Patients with predictor with in-hospital mortality (%)*	*Odds of in-hospital mortality compared with patients without predictor*	*Statistical significance*
Age	—	—	1.06	
Emergency admission	43.8	1.07	4.64	$P < .0001$
Urgent admission	8.7	0.78	3.65	$P = .0002$
Congestive heart failure	2.8	8.23	4.29	$P < .0001$
Cirrhosis	0.9	4.92	6.17	$P < .0001$
Atrial fibrillation	2.9	5.97	2.33	$P < .0001$
Laparoscopic cholecystectomy	78.7	0.23	0.34	$P < .0001$

Note: mortality rate for all cholecystectomy patients was 0.58%. C statistic = 0.922.

tions, the complication rate for open cholecystectomies was more than 9 times higher than the rate for laparoscopic procedures (2.16% vs 0.23%). For each complication the prevalence rate was significantly different by type of procedure performed (all for $P < .001$).

Among the laparoscopic cholecystectomy patients with these complications, the in-hospital mortality rate ranged from 0.00% for emphysema resulting from a procedure to 5.67% for cardiac complications. These 2 types of complications were also associated with the lowest and highest mortality rates for open cholecystectomy patients: 0.88% for emphysema resulting from a procedure and 9.40% for cardiac complications. The mortality rates for gastrointestinal complications and for postoperative infection were each different by type of procedure performed (each for $P < .10$), and the mortality rate for 1 or more complications was significantly different according to the type of procedure performed ($P < .001$). Mortality rate differences among other complications did not yield statistically significant differences by type of procedure.

Multivariate analysis of factors related to in-hospital mortality for cholecystectomy patients. Table III presents the results of a stepwise regression model with a binary independent variable of in-hospital mortality (1 = yes, 0 = no). As indicated, nonoperative factors that proved to be significantly related to higher in-hospital mortality rates among cholecystectomy patients were increasing age, emergency admission (requiring immediate medical intervention as a result of severe, life-threatening, or potentially disabling conditions), urgent admission (requiring immediate attention, generally admitted to the first available and suitable accommodation), congestive heart failure, cirrhosis, and atrial fibrillation. With regard to age, a patient's odds of dying in the hospital were found to be 1.06 times the odds of a patient whose other risk factors were identical but who was 1 year younger.

Emergency admissions, urgent admissions, and patients with congestive heart failure, cirrhosis, and atrial fibrillation were all significantly more likely to die in the hospital during or after undergoing a cholecystectomy. The odds ratios for these groups of patients ranged from 2.33 for patients with atrial fibrillation to 6.17 for patients with cirrhosis. Thus, for example, a patient with cirrhosis had odds of dying in the hospital during or after cholecystectomy that were 6.17 times the odds of a patient without cirrhosis whose other significant risk factors in Table III were identical to those of the first patient.

The odds ratio for laparoscopic cholecystectomy is 0.34, meaning that the odds of these patients dying in the hospital during or after the procedure is only 0.34 times the odds of open cholecystectomy patients dying in the hospital during or after the procedure, controlling for differences in other risk factors among the patients. This odds ratio was highly significant ($P < .0001$).

Multivariate analysis of factors related to choice of procedure for cholecystectomy patients. Table IV presents the factors significantly related to the choice of type (laparoscopic vs open). As indicated, female patients, patients with calculus of the gallbladder without acute cholecystitis (either without cholecystitis or with nonacute cholecystitis), patients with no calculus of the gallbladder and nonacute cholecystitis, and patients with cholesterosis all were significantly more likely to undergo laparoscopic cholecystectomy than other patients were. Black patients, emergency admissions, urgent admissions, patients with common duct explorations during the same admission, and older patients were significantly less likely to undergo laparoscopic cholecystectomies. Also, patients with diabetes, cirrhosis, chronic airway obstruction, peritoneal adhesions, fistula of the gallbladder, peritonitis, ischemic heart disease, and cholangitis or other diseases of the biliary tract were more likely to

Table IV. Significant independent predictors of laparoscopic versus open cholecystectomies among cholecystectomy patients in New York, 1996

Predictor	*Cholecystectomy patients with predictor undergoing laparoscopic cholecystectomy (%)*	*Multivariate odds of undergoing laparoscopic cholecystectomy*	*Statistical significance*
Female gender	82.5	1.70	$P < .0001$
Black race	76.5	0.67	$P < .0001$
Emergency admission	71.4	0.57	$P < .0001$
Urgent admission	71.5	0.53	$P < .0001$
Diabetes	67.2	0.80	$P = .0003$
Cirrhosis	61.0	0.56	$P < .0001$
Calculus of gallbladder, no acute cholecystitis	84.4	1.97	$P < .0001$
Nonacute cholecystitis, no calculus mentioned	83.7	1.73	$P < .0001$
Chronic airway obstruction	60.6	0.80	$P = .0049$
Peritoneal adhesions	63.7	0.49	$P < .0001$
Fistula of gallbladder	4.9	0.02	$P < .0001$
Peritonitis (unspecified)	25.9	0.20	$P = .0005$
Ischemic heart disease	46.4	0.48	$P < .0001$
Cholangitis or other diseases of biliary tract	45.2	0.64	$P < .0001$
Cholesterosis of gallbladder	88.5	1.60	$P = .0178$
Age	—	0.98	$P < .0001$
Common duct exploration	14.5	0.05	$P < .0001$

Note: 78.7% of all cholecystectomy patients underwent laparoscopic cholecystectomy. C statistic = 0.763.

undergo open cholecystectomies (less likely to undergo laparoscopic cholecystectomies).

Adjusted percentages of cholecystectomy patients undergoing laparoscopic cholecystectomy by hospital peer group and region. Table V examines differences by hospital peer group (teaching hospitals, nonteaching hospitals, major public hospitals) in the tendency to use laparoscopic versus open cholecystectomy. The second column of Table V presents the percentage of patients in each peer group undergoing laparoscopic cholecystectomy in 1996 (recall that the average for the entire state was 78.7%). For teaching and nonteaching hospitals, both the observed and adjusted percentages of cholecystectomy patients undergoing laparoscopic cholecystectomy were very close to the statewide average of 78.7%. However, major public hospitals had significantly fewer cholecystectomy patients undergoing laparoscopic cholecystectomy than expected. The percentage of cholecystectomy patients in major public hospitals undergoing laparoscopic cholecystectomy was 72.0%, and this decreased to 71.0% after adjustment for patient characteristics and conditions that were found to be related to the choice of procedure.

Table VI examines the percentage and adjusted percentage of cholecystectomy patients undergoing laparoscopic cholecystectomy by region of the state, where the regions include the counties in New York City and the planning regions of the state outside New York City. The table indicates that the observed percentage of cholecystectomy patients who underwent laparoscopic cholecystectomy ranged from 69.5% in Kings County (Brooklyn) to 83.4% on Long Island. After adjustment for the variables in Table IV, the percentages ranged from 71.7% in Bronx and Kings Counties to 83.4% in Richmond (Staten Island) and 83.0% on Long Island. Bronx and Kings Counties had a significantly lower percentage of patients undergoing laparoscopic cholecystectomy than expected ($P < .05$), and Long Island had a significantly higher percentage of patients undergoing laparoscopic cholecystectomy than expected ($P < .05$). These significant differences remained after controlling for hospital type (public, nonpublic) in addition to controlling for the other variables in Table IV.

Eight of 230 individual hospitals had adjusted percentages of patients undergoing laparoscopic cholecystectomy that were significantly higher ($P < .05$) than the statewide percentage of 78.7%, and 17 hospitals had percentages that were significantly lower. Among hospitals with at least 50 cholecystectomies in 1996, the adjusted percentages ranged from 14.6% to 97.4%.

Table VII compares 2 groups of hospitals with respect to the tendency for cholecystectomy patients to have undergone a laparoscopic cholecystectomy. The first group, named "low-laparoscopy hospitals," are all hospitals that had a risk-adjusted percentage of laparoscopic cholecystectomies below 68% with

Table V. Number, percent, and adjusted percent of cholecystectomy patients undergoing laparoscopic cholecystectomy by teaching status, New York State, 1996

Teaching status	*No. of laparoscopic cholecystectomy patients*	*Percent of all cholecystectomy patients*	*Adjusted percent of all cholecystectomy patients*
Teaching hospitals	13,338	79.8	79.1
Nonteaching hospitals	9,852	78.3	79.3
Major public hospitals	1,186	72.0	71.0*
Total	24,376	78.7	78.7

*Significantly lower than expected for $P < .05$.

Table VI. Number, percent, and adjusted percent of cholecystectomy patients undergoing laparoscopic cholecystectomy by region, New York State, 1996

Region	*No. of laparoscopic cholecystectomy patients*	*Percent of all cholecystectomy patients with laparoscopic cholecystectomy*	*Adjusted percent of all cholecystectomy patients with laparoscopic cholecystectomy*
Western New York	2,899	82.1	79.8
Finger Lakes	1,766	77.4	77.5
Central New York	2,626	78.4	78.5
Northeastern New York	1,763	74.1	76.9
Hudson Valley	2,719	80.9	81.6
Bronx	1,269	73.7	71.7*
Kings	1,812	69.5	71.7*
Manhattan	2,918	79.3	78.5
Queens	1,981	80.0	79.6
Richmond	403	78.4	83.4
Long Island	4,229	83.4	83.0†
Total	24,385	78.7	78.7

*Significantly lower than expected for $P < .05$.
†Significantly higher than expected for $P < .05$.

use of the model in Table IV. This group consists of 48 hospitals; the reason 68% was chosen as a cutoff value was that all the hospitals with significantly fewer laparoscopic cholecystectomies than expected on the basis of the model in Table IV had a risk-adjusted percentage below 68%. The remaining 172 hospitals were considered to be "other hospitals." As indicated in Table VII, the "low-laparoscopy" hospitals performed 14% of all cholecystectomies in 1996, but the percentage of patients in these hospitals undergoing laparoscopic procedures (57%) was significantly lower ($P < .001$) than the percentage undergoing the procedure in other hospitals (82%).

Cholecystectomy patients in the 2 groups of hospitals were then restricted in 2 ways in an attempt to ensure that they were more likely to be candidates for laparoscopic cholecystectomy. First, patients were restricted to those who did not have any serious comorbidities (ischemic heart disease, diabetes, or cirrhosis) and those who did not have problematic local conditions (peritonitis, fistula of gallbladder, cholangitis, or other specified diseases of the biliary tract). This reduced the original group of cholecystectomy patients by 9% to 28,185. However, the gap between the 2 groups of hospitals in the percentage of laparoscopic procedures remained about the same (63% for "low-laparoscopy" hospitals vs 87% for others) and was still significant ($P < .001$).

The second restriction of cholecystectomy patients consisted of considering only patients without acute cholecystitis. The total number of patients was reduced by 34% to 20,573, but again the gap between "low-laparoscopy" hospitals and other hospitals in the percentage of patients undergoing laparoscopic cholecystectomy remained about the same (63% for "low-laparoscopy" hospitals and 88% for others), and the difference was still significant ($P < .001$). Various other attempts to identify patients with a higher likelihood of undergoing laparoscopic cholecystectomy resulted in similar differences in the percentage of patients undergoing the procedure between the 2 groups of hospitals.

Table VII. Comparison of "low-laparoscopy" hospitals and other hospitals with respect to tendency to perform laparoscopic procedures as function of typical and contraindicated cases

	*"Low-laparoscopy" hospitals**	*Other hospitals*	*Total*
(1) Total patients (%)	4,362 (14)	26,606 (86)	30,968 (100)
(2) No. in (1) undergoing laparoscopic cholecystectomy (%)	2,466 (57)†	21,919 (82)†	24,385
(3) Patients not contraindicated for laparoscopic cholecystectomy (% of total)‡	2,852 (65)	19,396 (73)	28,185
(4) No. in (3) undergoing laparoscopic cholecystectomy (%)	1,804 (63)†	16,970 (87)†	22,702
(5) Patients without acute cholecystitis (% of total)§	2,624 (60)	17,949 (67)	20,573
(6) No. in (5) undergoing laparoscopic cholecystectomy (%)	1,661 (63)†	15,707 (88)†	17,368 (84)

*Hospitals with risk-adjusted laparoscopic cholecystectomy percentages of <68%.

†$P < .001$.

‡Defined as patients without ischemic heart disease (ICD-9-CM 4.14), diabetes (250.00), peritonitis (567.9), cirrhosis (571.5), fistula of gallbladder (575.5), cholangitis and other specified diseases of the biliary tract (576.1, 576.8).

§Defined as patients with calculus of gallbladder, no acute cholecystitis (ICD-9-CM 574.10 or 574.20), nonacute cholecystitis, no calculus mentioned (575.1, 575.10, 575.11), cholesterosis of gallbladder (575.6).

DISCUSSION

A total of 30,968 cholecystectomies were performed as principal procedures in New York State in 1996, with an in-hospital mortality rate of 0.58%, which is similar to the mortality rates reported in other settings.[3,4,9,13-17] Laparoscopic cholecystectomy is now very popular in New York, comprising 24,385 (78.7%) of the cholecystectomies performed as a principal procedure in 1996. Despite this fact, the total number of cholecystectomies performed as principal procedures in New York per 1,000 residents in 1996 was 1.71, and the number performed as either principal or secondary procedures per 1,000 residents was 1.90. This is lower than that reported in Maryland in 1992 (2.17) and more similar to the Maryland rate in 1987 to 1989 (1.69).[4]

There was a 0.23% in-hospital mortality rate for laparoscopic cholecystectomy, in comparison with a 1.90% mortality rate for the open procedure. Clearly, these rates are not directly comparable because of the tendency for emergency patients and patients with acute cholecystitis (ie, patients at higher risk of mortality) to undergo open procedures more frequently. However, even after adjustment for admission status and several important comorbidities that are significantly associated with patient mortality, patients undergoing laparoscopic cholecystectomy were found to have odds of dying in the hospital that were only one third the odds of patients undergoing open cholecystectomy. These findings, however, must be viewed in light of the fact that hospital length of stay for laparoscopic cholecystectomy is shorter than for the open procedure.

There was considerable cause for concern about complications of laparoscopic cholecystectomy in the initial years that the procedure was performed, seemingly because of the inexperience of many surgeons in performing the procedure.[8,18-20] However, the complication rates now appear to be lower than those for open cholecystectomy. For example, 5.02% of the patients undergoing laparoscopic cholecystectomy in New York in 1996 had 1 or more of the 8 most common complications of the procedure, and 1.88% of these patients died in the hospital during or after the procedure. In comparison, 14.70% of the patients undergoing open cholecystectomy in New York in 1996 had 1 or more of the complications, and 4.34% of those patients died in the hospital during or after the procedure.

Perhaps the most important finding of the study was that there were significant differences in the tendency to use laparoscopic cholecystectomy among hospital teaching groups, different regions of the state, and individual hospitals. This was true even after adjustment for numerous factors related to the use of laparoscopic cholecystectomy such as age, admission status, severity of the underlying disease, and a variety of comorbidities. In particular, major public hospitals seemed to use laparoscopic procedures significantly less than the rest of the state (relative to open cholecystectomies). Although the hospital categories that were compared with major public hospitals in Table V were teaching hospitals and nonteaching hospitals, other analyses that included teaching status crossed with region (upstate vs downstate) and with bed size also led to the conclusion that only major public hospitals had significantly different utilization of laparoscopic procedures.

With respect to more finely defined regions (the counties in New York City and the planning regions of the state outside New York City), Bronx and Kings Counties used laparoscopic procedures significantly less than the rest of the state, and Long Island used them significantly more than the rest of the state. Bronx and Kings Counties are 2 of the lowest income areas in the state, and Long Island is one of the more affluent regions.

Among individual hospitals, there was a huge range in the choice of laparoscopic versus open procedures. Eight of the 230 hospitals in which cholecystectomies were performed had percentages of laparoscopic procedures that were significantly higher than the statewide rate and 17 hospitals had percentages that were significantly lower than the statewide rate. Thirteen of the 17 had adjusted percentages of less than 60%, and 4 had percentages less than 25%. When hospitals were grouped into those with low percentages and other hospitals, the "low-laparoscopy" hospitals had significantly lower percentages of laparoscopic cholecystectomies even when patients were restricted to those who appeared to have no contraindications for the procedure and those who had nonacute cholecystitis.

Thus there appear to be large practice-pattern variations in the choice of procedure for patients requiring cholecystectomy. Hospitals with the fewest resources (public hospitals) and urban regions with the lowest per capita incomes are associated with lower percentages of laparoscopic cholecystectomy among cholecystectomy patients. There are several possible explanations for these findings. Surgeons at these hospitals may not have acquired laparoscopic skills because of resource constraints. In addition, the hospitals themselves may lack adequate laparoscopic equipment. For the several hospitals with extremely low percentages of cholecystectomy patients undergoing laparoscopic procedures, an additional reason may be that affiliated surgeons have had little incentive to acquire laparoscopic skills. In view of the findings of this study, we recommend that efforts be undertaken to carefully examine the choice of procedure for patients requiring cholecystectomy and to be sure that each hospital in which the procedure is performed has access to a sufficient number of surgeons trained to perform the procedure laparoscopically.

A limitation of the study is that the available database, New York's SPARCS system, did not enable us to determine which patients required a conversion from a laparoscopic cholecystectomy to an open procedure. These patients were treated as open cholecystectomy patients in our study because there is no indication in the database that they underwent a failed laparoscopic procedure. It should be noted that the literature indicates that most conversions follow operative discoveries such as dense adhesions and are not the result of an injury incurred during the performance of the laparoscopic procedure.[1] Still, the question arises as to whether converting from laparoscopic to open cholecystectomy in effect shifts complications associated with the former to the latter. Such a shift could conceivably occur because procedures coded as open in this study were not further characterized as having been originally open or as conversions from laparoscopic to open. However, published series in the literature report that conversion rates are very modest, averaging less than 5%. Some series report conversion rates as low as 1% and 2%.[18,21,22] Even if complications originally associated with laparoscopic cholecystectomy were shifted to complications of the open procedure because of conversion, the augmentation in open complication rates would be insignificant. Thus the inability to capture conversions does not appear to significantly bias the findings in favor of the laparoscopic procedure. In the fourth quarter of 1997, a new ICD-9-CM code, V64.4, was added to capture conversions to open cholecystectomies, and this should enable future analyses of conversions.

Another limitation is that, because SPARCS was created primarily for reimbursement and planning purposes, there is the possibility that not all secondary diagnoses (and therefore complications of care) may have been coded for each patient. Consequently, the complications listed in Table II may be underreported, and if the underreporting is more prevalent among patients with laparoscopic cholecystectomies, then the results are biased in their favor. Moreover, even if coding were not a problem, the complication definitions are too vague to be able to detect the severity of the complication. Thus the data in Table II should be treated with extreme caution.

Underreporting of secondary diagnoses that are comorbidities rather than complications of care is also known to occur in administrative databases, and this could have biased the mortality regression model in favor of laparoscopic procedures if the comorbidities were omitted more frequently for patients with open cholecystectomies. Also, it is possible that our inability to adjust fully for differences in patient severity because of clinical data that are not available in SPARCS may have led to an underestimation of the additional risk incurred by patients undergoing open cholecystectomies.

Furthermore, if the regions of the state (Bronx, Kings), types of hospitals (public), or individual hospitals that were identified as having significantly fewer laparoscopic procedures than expected were less likely to code important comorbidities or contraindications to laparoscopic cholecystectomies, they would have been (unfairly) more likely to have been identified as outliers.

Despite the limitations of the study, we conclude that the findings regarding differences among regions, types of hospitals, and individual hospitals in the choice of laparoscopic versus open cholecystectomy are compelling. We recommend that efforts be undertaken to carefully examine the choice of procedure for patients requiring cholecystectomies and to be sure that patients entering each hospital in which the procedure is performed have access to a sufficient number of surgeons trained to perform the procedure laparoscopically. We also look forward to similar studies of this nature in other regions of the country.

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