Has laparoscopic cholecystectomy changed patterns of practice and patient outcome in Ontario?

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Abstract • Résumé

Objective: To examine the effect of the introduction of laparoscopic cholecystectomy (LC) on patterns of practice (number of cholecystectomy procedures, case-mix and length of hospital stay) and patient outcomes in Ontario.

Design: Cross-sectional population-based time trends using hospital discharge data.

Setting: All acute care hospitals in Ontario where cholecystectomy was provided.

Patients: All 119 821 Ontario residents who underwent cholecystectomy between 1989–90 and 1993–94. After exclusions (initial bile duct exploration, cancer, incidental cholecystectomy, or missing codes for age, sex or residence) 108 442 patients remained.

Outcome measures: Number of cholecystectomy procedures, proportion of patients with acute or chronic gallstone disease, length of hospital stay, and rates of death, readmission, and bile duct injury and other in-hospital complications after cholecystectomy by year.

Results: The number of cholecystectomy procedures increased by 30.4% between 1989–90 and 1993–94. The number of patients with chronic gallstone disease increased by 33.6%, and the number who underwent elective surgery increased by 48.3%. The proportion of procedures performed as LC increased from 1.0% in 1990–91 to 85.6% in 1993–94. Patients who received LC tended to be younger female patients with chronic gallstone disease with no coexisting conditions undergoing elective operations. The mean length of stay, adjusted for case-mix differences, was significantly lower in 1993–94 than in 1989–90 (2.6 days v. 7.5 days) ($p < 0.05$); the values for LC and open cholecystectomy in 1993–94 were 1.8 days and 7.3 days respectively. The decrease in the crude death rate over the study period (0.3% to 0.2%) was not significant (relative odds 1.10, 95% confidence interval [CI] 0.72 to 1.69). In 1993–94 the adjusted risk of readmission to hospital within 30 days was 1.38 (95% CI 1.19 to 1.58) as compared with 1989–90. Over the 5 years the rate of bile duct injuries tripled (0.3% in 1989–90 v. 0.9% in 1993–94). The adjusted risk of having at least one complication after cholecystectomy in 1993–94 was 1.90 (95% CI 1.75 to 2.07) as compared with 1989–90.

Conclusions: LC has had a substantial effect on the number of cholecystectomy procedures performed, the type of patient having the gallbladder removed and the length of hospital stay. Death rates are unchanged, but the odds of readmission and in-hospital complications are both increased. Future research should be directed toward determining the reasons for the overall increase in rates, developing methods to reduce bile duct injuries and identifying other relevant outcomes, such as patient satisfaction with the procedure.

Objectif : Examiner l'effet de la mise en oeuvre de la cholécystectomie par laparoscopie (CL) sur les tendances de la pratique (nombre de cholécystectomies, composition de la clientèle et durée de l'hospitalisation) et sur les résultats chez des patients de l'Ontario.

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← For prescribing information see page 584

Conception : Tendances temporelles stratifiées représentatives transversales fondées sur des données relatives aux sorties des hôpitaux.

Contexte : Tous les hôpitaux de soins actifs de l'Ontario où l'on a pratiqué des cholécystectomies.

Patients : Les 119 821 résidents de l'Ontario qui ont subi une cholécystectomie entre 1989–1990 et 1993–1994. Après les exclusions (exploration initiale des canaux biliaires, cancer, cholécystectomie accessoire ou codes d'âge, du sexe ou de la résidence manquants), il est resté 108 442 patients.

Mesures des résultats : Nombre de cholécystectomies effectuées, proportion des patients souffrant de problèmes aigus ou chroniques de calculs biliaires, durée de l'hospitalisation, taux de décès, de réhospitalisation et d'atteinte des canaux biliaires, ainsi que d'autres complications au cours de l'hospitalisation après la cholécystectomie, par année.

Résultats : Le nombre de cholécystectomies a augmenté de 30,4 % entre 1989–1990 et 1993–1994. Le nombre de patients atteints de problèmes chroniques de calculs biliaires a augmenté de 33,6 % et celui des patients qui ont subi une intervention chirurgicale élective a augmenté de 48,3 %. La proportion des CL est passée de 1,0 % en 1990–1991 à 85,6 % en 1993–1994. Les patients qui ont subi une CL avaient tendance à être de jeunes femmes souffrant de problèmes chroniques de calculs biliaires sans affection concomitante, qui ont subi des interventions électives. La durée moyenne du séjour, corrigée des différences selon la composition de la clientèle, était beaucoup plus courte en 1993–1994 qu'en 1989–1990 (2,6 jours c. 7,5 jours) ($p < 0,05$); les valeurs relatives à la CL et à la cholécystectomie ouverte, en 1993–1994, étaient de 1,8 jours et de 7,3 jours, respectivement. La diminution du taux brut de décès au cours de la période d'étude (0,3 % à 0,2 %) n'était pas significative (ratio des probabilités relatives, 1,10, intervalle de confiance [IC] à 95 %, 0,72 à 1,69). En 1993–1994, le risque corrigé de réhospitalisation dans les 30 jours s'établissait à 1,38 [IC à 95 %, 1,19 à 1,58) comparativement à 1989–1990. Au cours de la période de 5 ans, le taux d'atteinte des canaux biliaires a triplé (0,3 % en 1989–1990 c. 0,9 % en 1993–1994). Le risque corrigé d'avoir au moins une complication après une cholécystectomie en 1993–1994 s'établissait à 1,90 (IC à 95 %, 1,75 à 2,07) comparativement à 1989–1990.

Conclusions : La CL a eu un effet important sur le nombre de cholécystectomies effectuées, le type de patients subissant une ablation de la vésicule biliaire et la durée de l'hospitalisation. Les taux de décès n'ont pas changé, mais les taux de réhospitalisation et de complications à l'hôpital ont tous deux augmenté. Les recherches futures devraient viser à déterminer les raisons de l'augmentation globale des taux, à mettre au point des méthodes afin de réduire les atteintes des canaux biliaires et à définir d'autres résultats pertinents, comme la satisfaction des patients face à l'intervention.

The use of cholecystectomy, a frequently performed surgical procedure, has important implications for resource allocation in the provincial health care system.[1] In Ontario laparoscopic cholecystectomy (LC), first introduced in 1990, has now essentially replaced the open approach to become the preferred surgical technique for removing the gallbladder.[2] Benefits to patients are claimed to be lower cost per case, less postoperative pain and need for analgesia, shorter hospital stays and earlier return to work.[3–8]

On the negative side, US studies have shown increases of 21% to 60% in the rate of cholecystectomy after LC was introduced.[3,9–11] The reasons for the increases are speculative but may be related to a pent-up demand among symptomatic patients previously refused or refusing major surgery.[12] Alternatively, the increase may reflect a broadening of accepted indications for the procedure. Patients previously thought to have questionable indications attributable to gallstones may now be offered the new technique because of the presumed lower risk of complications.[11–14] One recent US study, in fact, suggests that the threshold for cholecystectomy has been lowered: the proportion of patients with uncomplicated gallstone disease undergoing elective surgery in Pennsylvania increased by 52% after the introduction of LC.[11] We do not know whether such changes have also occurred in Canada.

Outcomes after open cholecystectomy (OC) were well documented in the past, with a decline in death rates seen before the introduction of LC.[15–17] None the less, given the wide acceptance of LC, it would be important to determine whether there has been an effect on rates of death or other complications after cholecystectomy. Early reports have shown an increase in bile duct injuries after LC, attributed by some authors to a learning curve.[18–20] Based on data from hospital series, the rate of bile duct injuries following OC was reported to range from 0.1% to 0.3%,[21,22] whereas that after LC was found to be 3 to 10 times higher.[23,24] These rates reflect results from tertiary care hospitals; the rate of such injuries among the general surgical population is not known.

We used population-based data to look at the effect of LC in Ontario. We examined whether LC has affected the patterns of practice of cholecystectomy in terms of the overall number of procedures performed, the types of patient undergoing cholecystectomy and the length of hospital stay. We also examined whether such changes have had an effect on patients, as determined by three outcome measures: rates of death, readmission and in-hospital complications.

METHODS

We obtained hospital discharge data for the fiscal years 1989–90 to 1993–94 for Ontario from the Canadian Institute for Health Information. The data extracted included demographic information, health care number, dates of hospital admission and discharge, surgical procedures (coded according to the Canadian Classification of Diagnostic, Therapeutic and Surgical Procedures [CCP][25]) and diagnoses (coded according to the International Classification of Diseases, 9th revision[26]). All records with a primary procedure code for cholecystectomy (CCP code 63.12) or LC (CCP code 63.14) were selected. A supplementary code available for 1992 and 1993 allowed the determination of cases converted from LC to OC. These cases are tabulated with the OC procedures in the tables.

Records in which cholecystectomy was not the first procedure either were associated with a diagnosis of cancer or were "incidental" to other major gastrointestinal surgery. Because these cases would not have had the same indications and patterns of use as primary cholecystectomy, they were excluded from the study. For similar reasons, we also excluded cases with bile duct exploration or cancer of the bile ducts. Other cases were excluded because of missing codes for age, sex or residence (less than 3% of records).

To assess whether there had been changes in patient case-mix over time, we determined from the hospital discharge records the proportion of patients who had undergone cholecystectomy by age, sex, presence of other condition(s),[27] type of admission (emergency or elective) and discharge diagnosis (acute or chronic gallstone disease) (Appendix 1) for the 5 years and by surgical approach (OC or LC).

We used the admission and discharge dates from the hospital discharge record to determine the length of hospital stay. Since some patients with numerous medical problems had very long stays not related to cholecystectomy, our analysis of length of stay included only "typical" cases. These are patients receiving a complete course of treatment whose length of stay is less than a statistical trim point.[28] The Canadian Institute for Health Information uses Tukey's formula[29] to calculate the trim point. The range of lengths of stay, in days, is divided into quartiles. The number of days at the first quartile is subtracted from the number of days at the third quartile to give an interquartile range. The trim point is determined by adding the number of days at the third quartile to twice the interquartile range. Since even with typical cases very long stays could skew the average, both average (mean) and modal lengths of stay are presented.

We determined rates of death after cholecystectomy from information on in-hospital deaths on the hospital discharge records. Only deaths that occurred within 30 days after the procedure were included because deaths occurring after that are much less likely to be related to the primary procedure.[30–33] As well, we included any deaths of patients readmitted to an Ontario hospital who died within 30 days after the initial procedure. The rate of death was determined for OC, LC and all cholecystectomy procedures over time.

All the hospital discharge records were entered into a software program (COMBINE) based on record linkage[34] that has previously been used to determine the rate of readmission after surgery.[35] We determined the number of patients who had undergone primary cholecystectomy who were readmitted to an Ontario hospital within 30 days regardless of the reason for readmission.[36–38] Most related complications requiring readmission to hospital would be evident within 30 days after the primary procedure.[36] The rate of readmission was determined for OC, LC and for all cholecystectomy procedures.

We used criteria from the Health Care Financing Administration based on 1986–87 data for Medicare patients in the United States[39] to determine the rate of in-hospital complications. The criteria were developed by an expert panel of four general surgeons who identified adverse events of three types: "complications related to a particular procedure, failure of the procedure to achieve its therapeutic goal, and untoward events associated with the natural history of the disease."[39] We examined each hospital discharge record for adverse events of interest in any of eight diagnostic or procedure code fields on the record. Complications were grouped into six categories (bile duct injuries, other bile-duct-related problems, gastrointestinal, infectious, surgical or other). However, if one hospital stay contained more than one diagnostic code of interest, more than one complication for the same patient would be counted. Thus, we also determined the number of patients with at least one complication.

The case-mix of patients undergoing cholecystectomy has changed. Using multiple logistic regression, we determined the relative odds over time of dying, of being readmitted within 30 days and of having at least one complication as compared with OC in 1989–90. We controlled for differences in age, sex, residence, type of hospital (teaching or community), comorbidity index,[27] type of admission (emergency or elective) and type of diagnosis (acute or chronic). A p value of less than 0.05 was considered statistically significant. We used multiple linear regression to compare length of stay over time with that in 1989–90 after adjusting for the same factors. We assessed trends in complications over time using the

Table 1: Characteristics of patients who underwent primary open or laparoscopic cholecystectomy in Ontario between 1989–90 and 1993–94

Characteristic; surgical approach*	No. (and %) of patients; year 1989–90	1990–91	1991–92	1992–93	1993–94	% change (1989–90 to 1993–94)
Type of procedure						
OC	18 451 (100.0)	19 151 (99.0)	12 605 (58.5)	5 118 (20.4)	3 452 (14.3)	
LC	0	195 (1.0)	8 946 (41.5)	19 920 (79.6)	20 604 (85.6)	
Total	18 451 (100.0)	19 346 (100.0)	21 551 (100.0)	25 038 (100.0)	24 056 (100.0)	30.4
Rate per 10 000 population	27.5	28.2	30.1	32.5	30.4	
Males						
OC	4 963 (26.9)	5 036 (26.3)	3 693 (29.3)	1 919 (37.5)	1 461 (42.3)	
LC	0	42 (21.5)	2 120 (23.7)	4 841 (24.3)	4 971 (24.1)	
Total	4 963 (26.9)	5 078 (26.2)	5 813 (27.0)	6 760 (27.0)	6 432 (26.7)	29.6
Age, yr						
15–34						
OC	4 613 (25.0)	4 845 (25.3)	2 823 (22.4)	803 (15.7)	414 (12.0)	
LC	0	67 (34.4)	2 541 (28.4)	5 199 (26.1)	5 081 (24.7)	
Total	4 613 (25.0)	4 912 (25.4)	5 364 (24.9)	6 002 (24.0)	5 495 (22.8)	19.1
35–49						
OC	4962 (26.9)	5 209 (27.2)	3 265 (25.9)	1 095 (21.4)	716 (20.7)	
LC	0	67 (34.4)	2 764 (30.9)	5 916 (29.7)	5 997 (29.1)	
Total	4 962 (26.9)	5 276 (27.3)	6 029 (28.0)	7 011 (28.0)	6 713 (27.9)	35.3
50–64						
OC	5 093 (27.6)	5 228 (27.3)	3 441 (27.3)	1 469 (28.7)	1 019 (29.5)	
LC	0	42 (21.5)	2 990 (33.4)	5 219 (26.2)	5 594 (27.2)	
Total	5 093 (27.6)	5 270 (27.2)	6 431 (29.8)	6 688 (26.7)	6 613 (27.5)	29.8
≥ 65						
OC	3 783 (20.5)	3 869 (20.2)	3 088 (24.5)	1 745 (34.1)	1 303 (37.7)	
LC	0	19 (9.7)	1 351 (15.1)	3 566 (17.9)	3 932 (19.1)	
Total	3 783 (20.5)	3 888 (20.1)	4 439 (20.6)	5 311 (21.2)	5 235 (21.8)	38.4
With at least one coexisting condition						
OC	1 495 (8.1)	1 704 (8.9)	1 437 (11.4)	829 (16.2)	551 (16.0)	
LC	0	10 (5.1)	537 (6.0)	1 394 (7.0)	1 468 (7.1)	
Total	1 495 (8.1)	1 174 (8.9)	1 974 (9.2)	2 223 (8.9)	2 019 (8.4)	
Diagnosis						
Chronic disease						
OC	16 071 (87.1)	16 585 (86.6)	10 450 (82.9)	3 685 (72.0)	2 315 (67.1)	
LC	0	192 (98.5)	8 525 (95.3)	18 526 (93.0)	19 152 (93.0)	
Total	16 071 (87.1)	16 777 (86.7)	18 975 (88.0)	22 211 (88.7)	21 467 (89.2)	33.6
Acute disease						
OC	2 380 (12.9)	2 566 (13.4)	2 155 (17.1)	1 433 (28.0)	1 137 (32.9)	
LC	0	3 (1.5)	421 (4.7)	1 394 (7.0)	1 452 (7.0)	
Total	2 380 (12.9)	2 569 (13.3)	2 576 (12.0)	2 827 (11.3)	2 589 (10.8)	8.8
Type of admission						
Elective						
OC	13 236 (71.7)	13 859 (72.4)	8 575 (68.0)	3 013 (58.9)	1 976 (57.2)	
LC	0	177 (90.8)	7 865 (87.9)	17 406 (87.4)	17 652 (85.7)	
Total	13 236 (71.7)	14 036 (72.6)	16 440 (76.3)	20 419 (81.6)	19 628 (81.6)	48.3
Emergency						
OC	5 215 (28.3)	5 292 (27.6)	4 030 (32.0)	2 105 (41.1)	1 476 (42.8)	
LC	0	18 (9.2)	1 081 (12.1)	2 514 (12.6)	2 952 (14.3)	
Total	5 215 (28.3)	5 310 (27.4)	5 111 (23.7)	4 619 (18.4)	4 428 (18.4)	–15.1

*OC = open cholecystectomy, LC = laparoscopic cholecystectomy.

Cochrane–Armitage test for trend,[40] with significance accepted at the $p < 0.05$ level. All the data were analysed with the use of the SAS statistical package (version 6.09, SAS Institute, Inc., Cary, NC, 1995).

Results

The number of cholecystectomy procedures in Ontario rose from 18 451 in 1989–90 to 24 056 in 1993–94, an increase of 30.4% (Table 1). The rise was not equally distributed: the number increased by 19.1% among patients aged 15 to 34 years, as compared with 38.4% among those aged 65 years or more. The number of patients with chronic gallstone disease rose by 33.6% over the study period, in contrast with an increase of 8.8% among those with acute disease. The number of elective cases increased by 48.3%, whereas the number of emergency cases fell by 15.1%. The increase in the numbers of cholecystectomy procedures was paralleled by a rise in the rate of such procedures per 10 000 population (aged 15 years or more).

In 1990–91, 1.0% of cholecystectomy procedures were performed by the laparoscopic approach, as compared with 85.6% in 1993–94. The rates of conversion from LC to OC were 4.3% and 5.5% in 1992–93 and 1993–94 respectively. The proportion of OC procedures that had been converted from LC was 17% in 1992–93 and 34% in 1993–94 (data not shown).

Male patients accounted for 26.9% of the OC procedures in 1989–90; this proportion rose to 42.3% in 1993–94 (Table 1). Similarly, patients aged 65 years or more accounted for 37.7% of the OC procedures in 1993–94, as compared with 20.5% in 1989–90. A higher proportion of patients who underwent OC than underwent LC had at least one coexisting condition, had acute disease and underwent surgery on an emergency basis. OC was more frequently performed at community hospitals over time; LC, which was first performed mainly at teaching centres, also was more frequently performed in community hospitals over time (data not shown).

Despite marked shifts between OC and LC over time, overall the proportions of total cholecystectomy procedures performed in male patients, among the various age groups and in patients with at least one coexisting condition were essentially unchanged. In contrast, the proportion of patients with acute disease fell over time, as did the proportion of emergency or urgent cases.

The mean length of stay for cholecystectomy fell from 7.5 days in 1989–90 to 2.6 days in 1993–94 (Table 2). The length of stay for LC decreased from 4.0 days in 1990–91 to 1.8 days in 1993–94; the respective figures for OC were 7.5 and 7.3 days. After case-mix differences were adjusted for, the average length of stay for cholecystectomy was significantly lower in 1993–94 than in 1989–90 ($p < 0.05$).

The crude rate of death after cholecystectomy fell from 0.3% in 1989–90 to 0.2% in 1993–94 (Table 3). After differences across time in case-mix were adjusted for, the relative odds of dying were not significantly different in 1993–94 as compared with 1989–90 (relative odds 1.10, 95% confidence interval [CI] 0.72 to 1.69). The number of deaths after LC were few but increased from 7 in 1991–92 to 14 in 1993–94, 6 of which occurred on readmission to hospital. The total number of deaths after cholecystectomy was essentially unchanged over the 5 years.

The number of patients readmitted to hospital within 30 days after cholecystectomy doubled over the study period (440 v. 882), and the readmission rate increased from 2.4% to 3.7% (Table 3). The increase in readmission rates was statistically significant; the relative odds of

Table 2: Mean* and modal length of hospital stay

	Year				
Variable; surgical approach	1989–90	1990–91	1991–92	1992–93	1993–94
Mean length of stay (and standard deviation), d†					
OC	7.5 (6.0)	6.9 (6.3)	6.5 (5.5)	7.2 (8.0)	7.3 (6.7)
LC	–	4.0 (5.4)	2.6 (2.6)	2.0 (1.7)	1.8 (2.1)
Total	7.5 (6.0)	6.9 (6.3)	4.9 (4.9)	3.0 (4.5)	2.6 (3.8)
Modal length of stay, d					
OC	6	5	5	5	5
LC	–	2	2	1	1
Total	6	5	2	1	1

*For "typical" patients. See the Methods section.
†Adjusted for age, sex, residence, type of hospital (teaching v. community), presence of coexisting condition(s), type of admission (emergency v. elective) and type of diagnosis (acute v. chronic). The adjusted length of stay in 1990–91 to 1993–94 was significantly lower than that in 1989–90 ($p < 0.05$).

being readmitted in 1993–94 were 1.38 (95% CI 1.19 to 1.58) as compared with 1989–90.

In 1989–90 the rate of bile duct injury after cholecystectomy was 0.3%; by 1993–94 this rate had increased to 0.7% for LC and 2.1% for OC (Table 4). The 1992–93 and 1993–94 rates for all cholecystectomy procedures were higher than the "historical" values in 1989–90. The number of such injuries increased by 305% over the study period. The overall rate of other bile duct complications also increased, from 0.8% in 1989–90 to 1.5% in 1993–94. The number of such complications rose by 130% over the 5 years.

The overall rate of gastrointestinal complications was 0.7% in 1989–90 and 1.2% in 1993–94; the rates for LC and OC in 1993–94 were 0.9% and 3.2% respectively. The rates for infectious and general surgical complications following LC decreased over the study period from the historical rate in 1989–90, and the rates for other complications stayed the same (0.3% in both 1989–90 and 1993–94). All time trends between 1989–90 and 1993–94 were statistically significant ($p < 0.0001$) except for the category "other complications" ($p = 0.65$).

The proportion of patients who had at least one complication in 1989–90 was 7.9%; in 1993–94 this rate was 5.6% for LC and 21.4% for OC. However, after differences in case-mix were adjusted for, the relative odds of having a complication in 1993–94 were 1.90 (95% CI 1.75 to 2.07) as compared with 1989–90. The number of patients with at least one complication increased by 30.6% over the study period.

Discussion

The introduction of LC in Ontario has been associated with a marked change in the practice of cholecystectomy in terms of the number of procedures performed, the types of patient undergoing cholecystectomy, the rapid shift from OC to LC and the length of hospital stay.

An increase of 30% in the number of cholecystectomy procedures performed in Ontario occurred between 1989–90 and 1993–94, but the age, sex and comorbidity profiles of the patients were similar over the 5 years. In contrast, the proportion of patients with uncomplicated gallstone disease or with elective admission increased significantly. These findings are similar to

Table 3: Rates of death and readmission following cholecystectomy

	Year				
Variable; surgical approach	1989–90	1990–91	1991–92	1992–93	1993–94
No. of deaths					
OC	54	55	45	40	36
LC	–	0	7	12	14
Total	54	55	52	52	50
Crude death rate per 100 procedures					
OC	0.29	0.28	0.36	0.78	1.0
LC	–	0	0.08	0.06	0.07
Total	0.29	0.28	0.24	0.21	0.21
Relative odds* of dying (and 95% confidence interval [CI])	1.00	0.84 (0.57–1.24)	0.89 (0.59–1.32)	1.03 (0.68–1.56)	1.10 (0.72–1.69)
No. of people readmitted to hospital within 30 d					
OC	440	497	415	227	161
LC	–	7	337	701	721
Total	440	504	752	928	882
Crude rate of readmission per 100 procedures					
OC	2.4	2.6	3.3	4.5	4.7
LC	–	3.6	3.8	3.5	3.5
Total	2.4	2.6	3.5	3.7	3.7
Relative odds* of readmission (and 95% CI)	1.00	1.08 (0.95–1.23)	1.38 (1.22–1.57)	1.42 (1.24–1.63)	1.38 (1.19–1.58)

*Adjusted for age, sex, residence, type of hospital (teaching v. community), type of admission (elective v. emergency) and type of diagnosis (acute v. chronic). Patients who underwent OC in 1989–90 constituted the reference population.

those reported in a US study[11] and support the theory that the increase in cholecystectomy rates is attributable to a lowering of the threshold for surgery. To support or refute this theory more definitively, the indications for the procedure before LC was introduced could be compared with those after its diffusion to determine whether indications have changed. Such a study may be feasible: a large-scale medical record review may provide these data. Given that the rates of cholecystectomy in the mid-1980s in Ontario were already three times those in Europe,[1] such a study may provide valuable insights into the reasons for the rate increases.

The shift from OC to LC has taken place in a remarkably short time. The rapid changes were accompanied by shifts in patient populations. By 1993–94 patients undergoing OC tended to be elderly, to be sicker, to undergo the procedure on an emergency or urgent basis and to have previously undergone failed LC. In less than 4 years hospitals in Ontario acquired equipment for LC, surgeons were trained in the new procedure, and hospitals decreased their length of stay for cholecystectomy. Yet, all these events were taking place during an era of severe monetary constraints in the health care system. This shows that hospitals and providers can change their

Table 4: Rates of in-hospital complications following cholecystectomy per 100 primary procedures

Complication; surgical approach	No. (and rate per 100 primary procedures);* year 1989–90	1990–91	1991–92	1992–93	1993–94	% change (1989–90 to 1993–94)
Bile duct injury						
OC	55 (0.30)	74 (0.39)	78 (0.62)	101 (2.0)	72 (2.1)	
LC	–	3 (1.5)	95 (1.1)	188 (0.94)	151 (0.73)	
Total	55 (0.30)	77 (0.40)	173 (0.80)	289 (1.2)	223 (0.93)	305.5
Other biliary duct						
OC	155 (0.84)	215 (1.1)	168 (1.3)	122 (2.4)	89 (2.6)	
LC	–	1 (0.51)	86 (0.96)	227 (1.1)	267 (1.3)	
Total	155 (0.84)	216 (1.1)	254 (1.2)	349 (1.4)	356 (1.5)	129.7
Other gastrointestinal						
OC	133 (0.72)	154 (0.80)	153 (1.2)	92 (1.8)	110 (3.2)	
LC	–	2 (1.0)	77 (0.86)	177 (0.89)	187 (0.91)	
Total	133 (0.72)	156 (0.81)	230 (1.1)	269 (1.1)	297 (1.2)	123.3
Infectious						
OC	656 (3.6)	700 (3.7)	550 (4.4)	377 (7.4)	328 (9.5)	
LC	–	5 (2.6)	102 (1.1)	236 (1.2)	237 (1.2)	
Total	656 (3.6)	705 (3.6)	652 (3.0)	613 (2.4)	565 (2.3)	–13.9
General surgical						
OC	689 (3.7)	794 (4.1)	565 (4.5)	395 (7.7)	345 (10.0)	
LC	–	6 (3.1)	203 (2.3)	455 (2.3)	510 (2.5)	
Total	689 (3.7)	800 (4.1)	768 (3.6)	850 (3.4)	855 (3.6)	24.1
Other						
OC	54 (0.29)	45 (0.24)	53 (0.42)	28 (0.55)	17 (0.49)	
LC	–	2 (1.0)	16 (0.18)	49 (0.25)	52 (0.25)	
Total	54 (0.29)	47 (0.24)	69 (0.32)	77 (0.31)	69 (0.29)	27.8
No. of patients with at least one complication						
OC	1452 (7.9)	1628 (8.5)	1268 (10.1)	862 (16.8)	740 (21.4)	
LC	–	15 (7.7)	484 (5.4)	1120 (5.6)	1156 (5.6)	
Total	1452 (7.9)	1643 (8.5)	1752 (8.1)	1982 (7.9)	1896 (7.9)	30.6
Relative odds† of having a complication (and 95% CI)	1.00	1.12 (1.04–1.20)	1.34 (1.24–1.45)	1.80 (1.66–1.96)	1.90 (1.75–2.07)	

*All time trends between 1989–90 and 1993–94 were statistically significant ($p < 0.0001$, Cochrane–Armitage test) except for "other."
†Adjusted for age, sex, residence, type of hospital (teaching v. community), type of admission (elective v. emergency) and type of diagnosis (acute v. chronic). Patients who underwent OC in 1989–90 constituted the reference population.

practice patterns in very short order and that innovations can be put into place even in times of fiscal constraints, especially if they promise to save money. The increase in the rate of cholecystectomy over the study period suggests that there has not been difficulty of access for patients to this surgical procedure. However, we do not know whether the decrease in 1993–94 was because of declining numbers of patients or restrictions in operating room time or hospital beds.

There were significant changes in the patterns of practice of cholecystectomy across the province over the study period. What, however, has been the effect on patient outcomes? Rates of death after cholecystectomy were virtually unaffected, a finding similar to that of Steiner and colleagues[9] in Maryland over approximately the same period. The low death rates following LC are likely due to the selected patient population and the increase in the number of healthy patients undergoing cholecystectomy and cannot be shown to be due necessarily to any inherent benefits of LC itself. Patients dying after cholecystectomy in 1992–93 and 1993–94 tended to be elderly and sicker, the same types of patient who were at risk for dying after OC in 1989–90.

The rate of bile duct injuries tripled over the study period. We have too few years of data to confirm or refute the learning-curve hypothesis, but the decrease in the numbers of such injuries from 1992–93 to 1993–94 is reassuring. The rate of bile duct injuries after LC that we observed is probably underestimated, and the rate after OC likely overestimated. This is because at least 34% of the OC procedures in 1993–94 were cases that had been converted from LC. Although we did not examine the reasons for conversion, it is likely that a considerable proportion were because of bile duct injuries.[41]

We found that the adjusted rates of other complications after LC, such as infectious or general surgical problems, were similar to or lower than those observed after OC in 1989–90. The much higher rates of complications after OC in 1992–93 and 1993–94 are due to the fact that older patients with more complex indications have been undergoing OC in recent years. After case-mix differences across time were controlled for, the odds of having any complication after cholecystectomy was very much increased. Thus, a true assessment of patient outcomes after cholecystectomy must consider overall rates, not solely rates after LC. This means that the "burden" of complications after cholecystectomy has essentially not declined but, rather, has been shifted from one group of patients to another, namely, those undergoing OC.

The rate of readmission to hospital was also markedly increased over the study period. The reasons for this are unclear. It is possible that the decreasing length of hospital stay may mean that some patients may have been discharged too early[42] or may have had a planned readmission.[43] However, a study in Manitoba on other conditions did not show an increase in rates of planned readmission.[44] Bile duct injuries after LC may at least partially explain some of the observed increase. Clearly, this is an area for further study.

As with any study using administrative data, our study has a number of limitations. First, our data are from hospital discharge abstracts, and we did not perform a chart review to confirm the diagnosis or the extent of complications. It is possible that the rate of conversion from LC to OC was underestimated owing to the dependence on a supplementary code.

Second, there may be variations across hospitals in the stringency with which coding is performed, and coding may have been more rigorous in recent years; these may account for some of the increases seen. However, given the magnitude of the increases, it is unlikely that they could be ascribed solely to coding practices.

Other study limitations relate to the unavailability of information on other patient outcomes. We could not trace deaths that occurred outside of hospitals, nor could we determine visits to physician offices or emergency departments that may have been related to the surgery. More important, however, we did not have information on the patients' point of view regarding decreased disability and earlier return to work; these benefits may be of considerable magnitude.

In conclusion, the introduction of LC has had a substantial effect on practice patterns and patient outcomes in Ontario. The main benefits may lie in enhanced patient satisfaction rather than in savings to the hospital sector. Patient surveys to determine whether LC is associated with less postoperative disability, a better cosmetic result and earlier return to work or usual activities are indicated. Future research should also evaluate methods to reduce bile duct injuries and determine the reasons for the increase in the numbers of cholecystectomy procedures being performed.

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Appendix 1: Discharge diagnoses

Category; ICD-9 code*	Diagnosis
"Acute" diagnosis	
574.0	Calculus of gallbladder with acute cholecystitis
574.3	Calculus of bile duct with acute cholecystitis
575.0	Acute cholecystitis
575.2	Obstruction of gallbladder
"Chronic" diagnosis	
574.1	Calculus of gallbladder with other cholecystitis
574.2	Calculus of gallbladder without mention of cholecystitis
574.4	Calculus of bile duct with other cholecystitis
574.5	Calculus of bile duct without mention of cholecystitis
575.1	Other cholecystitis
575.3	Hydrops of gallbladder
575.4	Perforation of gallbladder
575.5	Fistula of gallbladder
575.6	Cholesterolosis of gallbladder
575.8	Other
575.9	Unspecified
Bile duct injury	
576.3	Perforation of bile duct
998.2	Accidental puncture or laceration during a procedure
Other bile duct problem	
576.1	Cholangitis
576.2	Obstruction of bile duct
576.4	Fistula of bile duct
574.5	Calculus of bile duct without mention of cholecystitis
998.6	Persistent postoperative fistula
576.0	Postcholecystectomy syndrome
63.82, 63.86†	Endoscopic sphincterotomy

*International Classification of Diseases, 9th revision.[26]
†Canadian Classification of Diagnostic, Therapeutic and Surgical Procedures.[25]