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Cholecystectomy prevalence and treatment cost: an 8-year study in Taiwan

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Abstract

Background This study characterized the prevalence and treatment costs of laparoscopic cholecystectomy (LC) and open cholecystectomy (OC) procedures performed for a population-based patient cohort.

Methods This study analyzed 32,535 OC and 80,335 LC procedures performed in Taiwan from 1996 to 2004. The odds ratio (OR) and effect size were calculated to assess the relative change rate. Bootstrap estimation was used to derive 95% confidence intervals (CIs) for differences in effect sizes of LC and OC. Multiple regression models were used to predict total treatment cost.

Results The prevalences of OC and LC were respectively 18.19 and 25.44 per 100,000 persons in 1996. In 2004, OC gradually decreased to 13.21, but LC dramatically increased to 48.35, which represented change rates of −27.38% and 90.06%, respectively. The patient characteristics associated with an increased likelihood of undergoing LC were age, female gender, and lack of current comorbidities. The total treatment cost for the OC patients increased during the study period, whereas that for the LC patients declined. The LC patients were more responsive than the OC patients with respect to average length of hospital stay (ALOS) (−0.23; 95% CI, −0.33 to −0.13) and total treatment cost (−0.43; 95% CI, −0.63 to −0.23). Considerably increased total treatment cost was associated with advanced age, female gender, one or more co-morbidities, current treatment at a medical center, and long ALOS.

Conclusions Decreases in ALOS and total treatment cost were greater for the LC patients than for the OC patients. Government officials and health care providers should understand that total treatment cost depends on both patient and hospital attributes. These results can be generalized to patient populations elsewhere in Taiwan as well as to other countries with similar patient profiles.

Keywords Laparoscopic cholecystectomy · LC · Open cholecystectomy · OC · Prevalence · Treatment cost

Cholecystectomy, by either the laparoscopic (LC) or open (OC) approach, remains the definitive treatment for symptomatic cholecystolithiasis or cholecystitis [1–3]. However, LC currently is widely performed as an alternative to OC. The percentage of LCs performed in the United States grew from 83% in 1998 to 93% in 2005 [4]. Not only is LC less painful than OC. It also causes less scarring and has a shorter convalescence period. Surgeons also consider LC safer than OC. Finally, payers perceive LC as a less expensive alternative to OC because of its shorter average hospital length of stay (ALOS) (1–3 days vs. 4–7 days, respectively) [5, 6].

However, LC is not always the first-line therapy for patients with numerous comorbidities or tenuous prognoses. When performed by inexperienced surgeons, the costs for LC and the risk of complications may increase.

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Additionally, LC often is performed for patients who are not suitable candidates for OC because of comorbidity. Because of their higher risk status, LC patients tend to consume more resources and experience more complications than OC patients [7].

National registry studies such as those performed by the Bureau of National Health Insurance (BNHI) in Taiwan are an excellent source of population-based data for evaluating the current practice of cholecystectomy surgery. Unlike single-center series studies, data from registry studies provide an overview of practices in large populations while avoiding referral bias or bias reflecting the practices of individual surgeons or institutions [8].

Single-center reports represent ideal results, which may not reflect those in the general population. The literature shows no recent outcome studies comparing OC and LC procedures at the population level [4, 7]. Although studies have analyzed OC and LC in specific patient populations, no recent population-based study has examined the prevalence and costs of these procedures in Taiwan. This study therefore explored the increasing prevalence of factors affecting the costs of OC and LC procedures.

Materials and methods

This study analyzed administrative claims data obtained from the BNHI. Because the BNHI is the sole payer in Taiwan, its data set was assumed to be the most comprehensive and reliable data source for the study. Patients were classified as OC if their BNHI records showed the codes for a primary or secondary diagnosis of gallbladder stones, gallbladder polyps, or acute cholecystitis (ICD-9-CM codes 574.00 to 576.99) and a primary or secondary procedure code for total cholecystectomy (ICD-9-CM code 51.22) without a procedure code for either laparoscopy (code 54.21) or LC (code 51.23).

Patients were classified as LC if their records showed codes for a primary or secondary diagnosis of gallbladder stones, gallbladder polyps, or acute cholecystitis (ICD-9-CM codes 574.00 to 576.99) and a primary or secondary procedure code for LC (ICD-9-CM code 51.23). Patients with a diagnosis of gallbladder cancer were not included in the study sample.

This study analyzed attributes of patients who had undergone OC and LC procedures in Taiwan including age, gender, and number of comorbidities. The age categories were 64 years or younger and 65 years or older. The patients were categorized by total number of baseline comorbidities as follows: no comorbidity, one comorbidity, and two or more comorbidities. The analyzed hospital attributes were hospital level and medical resource usage. Hospital level was categorized as medical center, area hospital, or local hospital. Medical resource usage was measured by average length of hospital stay (ALOS).

The study period was divided into three approximately equal intervals: period 1 (1996–1998), period 2 (1999–2001), and period 3 (2002–2004). Odds ratio (OR) and effect size (ES) were determined to assess the relative change in each factor when period 1 was used as the reference group compared with period 3. The effect size was calculated by determining the difference between the mean pre- and postoperative scores, then dividing the difference by the standard deviation of the preoperative score [9]. Effect sizes of 0.2, 0.5, and 0.8 are typically considered to be small, medium, and large changes, respectively. Because previous studies did not attempt quantification of the uncertainty in their responsiveness estimates, the unknown precision of reported effect size values complicates comparisons of results from different studies across different populations or activity measures [10]. To address these issues, bias-corrected and accelerated bootstrapping with 1,000 replications was used to calculate the difference in effect size and associated 95% confidence intervals (95% CIs) [10].

Regarding treatment costs, the standard administrative claims data required by the BNHI are operating room fee, radiology fee, physical therapy fee, hospital room fee, anesthetist fee, pharmacy fee, laboratory fee, special materials fee, surgeon fee, miscellaneous fees, and total hospital fees. Multiple regression models used to predict total treatment cost included the following patient data: age, gender, number of comorbidities, hospital level, and ALOS. Treatment costs at different hospital levels were adjusted for differences in reimbursements from the BNHI, the largest of which are received by medical centers and smallest of which are received by local hospitals.

Statistical analyses were conducted using SPSS version 15.0 (SPSS Inc., Chicago, IL, USA). To reflect changes in real dollar value, all dollar values at the end of each year were adjusted to 2004 Taiwan currency values. Total treatment costs then were converted from Taiwan dollars to U.S. dollars at an exchange rate of 31.5 to 1, which was the average exchange rate during 1996–2004. All tests were two-sided, and p values less than 0.05 were considered statistically significant.

Results

In 1996, 18.19 OC and 25.44 LC procedures were performed per 100,000 persons. In 2004, the number of OC procedures per 100,000 persons decreased gradually to 13.21 (27.38% decrease), whereas that of LC increased dramatically to 48.35 (90.06% increase) (Fig. 1). The

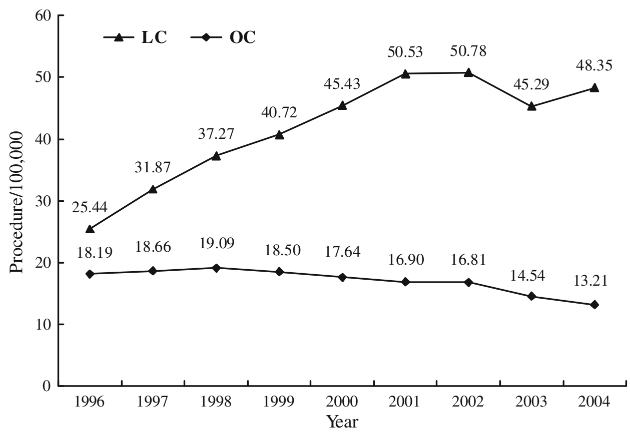

Fig. 1 Prevalence of open cholecystectomy (OC) and laparoscopic cholecystectomy (LC) procedures performed from 1996 to 2004

prevalence of LC was 1.98 times that of OC in 1996 but substantially increased to 3.66 that of OC by 2004.

During the study period, 32,535 OC and 80,335 LC procedures were performed nationwide (Table 1). Data comparisons for OC and LC patients showed significant differences ($P < 0.001$) in patient and hospital attributes.

Regarding patient attributes, the estimated mean age was 62.59 ± 14.88 years for the OC patients and 53.14 ± 15.18 years for the LC patients. In terms of gender, 43.89% of the OC patients and 60.16% of the LC patients were women. Additionally, 22.71% of the OC patients had no comorbidity, 23.85% had one comorbidity, and 53.44% had two or more comorbidities. For the LC patients, the figures were 58.83, 20.81, and 20.36%, respectively.

Regarding hospital attributes, 44.46% of the OC procedures were performed in medical centers, whereas 38.78% were performed in area hospitals, and 16.75% were performed in local hospitals. For the LC patients, the figures were 46.81, 39.29, and 13.90%, respectively. The ALOS was 13.13 ± 7.25 days for the OC patients and 4.90 ± 2.95 days for the LC patients.

Table 2 shows the changes in surgical volumes associated with different patient and hospital attributes. Approximately 40% of all OC patients treated from periods 1 to 3 were women, and the number of female patients significantly decreased between periods 1 and 3 (OR, 0.90; 95% CI, 0.85–0.94). Conversely, the number of male patients significantly increased between the same periods (OR, 1.09; 95% CI, 1.04–1.14). Approximately 45% of all the OC patients were 64 years old or younger. The number of OC patients age 64 years or younger decreased significantly between periods 1 and 3 (OR, 0.89; 95% CI, 0.85–0.94), but the number of OC patients age 65 years or older increased significantly (OR, 1.11; 95% CI, 1.06–1.16). Between periods 1 and 3, the number of OC patients with no comorbidities or one comorbidity decreased significantly (OR, 0.76; 95% CI, 0.72–0.81 and OR, 0.84; 95% CI, 0.79–0.90, respectively), but the number of OC patients with two or more comorbidities increased significantly (OR, 1.22; 95% CI, 1.17–1.28).

In terms of hospital attributes, the data showed a statistically significant increase in the number of procedures performed in area hospitals between periods 1 and 3 (OR, 1.20; 95% CI, 1.14–1.26) but a statistically significant decrease in the number of procedures performed in local hospitals between periods 1 and 3 (OR, 0.72; 95% CI, 0.67–0.77).

Table 1 Comparison of patient and hospital attributes of open cholecystectomy (OC) and laparoscopic cholecystectomy (LC) groups

	OC Procedure (n = 32,535)	LC Procedure (n = 80,335)	P value
Patient attributes			
Mean age (years)	62.59 ± 14.88	53.14 ± 15.18	<0.001
Gender (%)			<0.001
Male	56.11	39.84	
Female	43.89	60.16	
No. of comorbidities (%)			<0.001
0	22.71	58.83	
1	23.85	20.81	
≥2	53.44	20.36	
Hospital attributes			
Hospital level (%)			<0.001
Medical center	44.46	46.81	
Area hospital	38.78	39.29	
Local hospital	16.75	13.90	
Mean hospital stay (days)	13.13 ± 7.25	4.90 ± 2.95	<0.001

Table 2 Comparison of patient and hospital attributes of open cholecystectomy (OC) and laparoscopic cholecystectomy (LC) procedures by periods 1 to 3

	OC procedure					LC procedure				
	Period 1 (*n* = 11,402)	Period 2 (*n* = 11,336)	Period 3 (*n* = 9,797)	OR[a]	95% CI	Period 1 (*n* = 19,320)	Period 2 (*n* = 29,251)	Period 3 (*n* = 31,764)	OR[a]	95% CI
Patient attributes (%)										
Age										
≤64	50.47	47.23	45.04	0.89	(0.85–0.94)	72.57	73.21	74.39	1.03	(1.00–1.05)
≥65	49.53	52.77	54.96	1.11	(1.06–1.16)	27.43	26.79	25.61	0.93	(0.90–0.97)
Gender										
Male	53.60	56.67	58.39	1.09	(1.04–1.14)	38.87	39.59	40.65	1.05	(1.01–1.08)
Female	46.40	43.33	41.61	0.90	(0.85–0.94)	61.13	60.41	59.35	0.97	(0.94–1.00)
No. of comorbidities										
0	27.01	20.20	20.61	0.76	(0.72–0.81)	58.36	60.20	57.85	0.99	(0.96–1.02)
1	26.00	23.32	21.94	0.84	(0.79–0.90)	21.41	20.63	20.61	0.96	(0.92–1.01)
≧2	46.98	56.47	57.46	1.22	(1.17–1.28)	20.23	19.17	21.54	1.06	(1.02–1.11)
Hospital attributes (%)										
Hospital level	44.79	45.44	42.95			44.59	48.28	46.80		
Medical center	36.09	37.56	43.33	0.96	(0.91–1.01)	37.99	36.33	42.81	1.05	(1.02–1.08)
Area hospital	19.12	17.00	13.72	1.20	(1.14–1.26)	17.42	15.39	10.39	1.13	(1.09–1.17)
Local hospital	50.47	47.23	45.04	0.72	(0.67–0.77)	72.57	73.21	74.39	0.60	(0.57–0.63)

OR odds ratio, *CI* confidence interval

[a] Period 3 versus period 1 (reference group)

The analysis of patient attributes showed that 60% of all LC patients were women. Between periods 1 and 3, the number of male patients increased significantly (OR, 1.05; 95% CI, 1.01–1.08), whereas the number of female patients decreased significantly (OR, 0.97; 95% CI, 0.94–1.00). Approximately 75% of the LC patients were 64 years old or younger. The number of patients 64 years old or younger significantly increased between periods 1 and 3 (OR, 1.03; 95% CI, 1.00–1.05), but the number of patients 65 years old or older decreased significantly (OR, 0.93; 95% CI, 0.90–0.97). The number of LC patients with no comorbidities or one comorbidity did not differ significantly between periods 1 and 3, but the number of LC patients with two or more comorbidities increased significantly (OR, 1.06; 95% CI, 1.02–1.11).

In terms of hospital attributes, the number of patients treated in medical centers and area hospitals increased significantly between periods 1 (OR, 1.05; 95% CI, 1.02–1.08) and 3 (OR, 1.13; 95% CI, 1.09–1.17), and the number of patients treated in local hospitals decreased significantly (OR, 0.60; 95% CI, 0.57–0.63). In 1996, the total treatment costs were $2,423 for OC and $1,767 for LC. By 2004, however, the cost of OC had increased to $2,791 (15.18% increase), whereas the cost of LC had decreased to 1,490 (15.68% decrease) (Fig. 2). In 1996, the total treatment cost for OC was 1.37 times that for LC. By 2004, the cost of OC had substantially increased to 1.87 times that for LC.

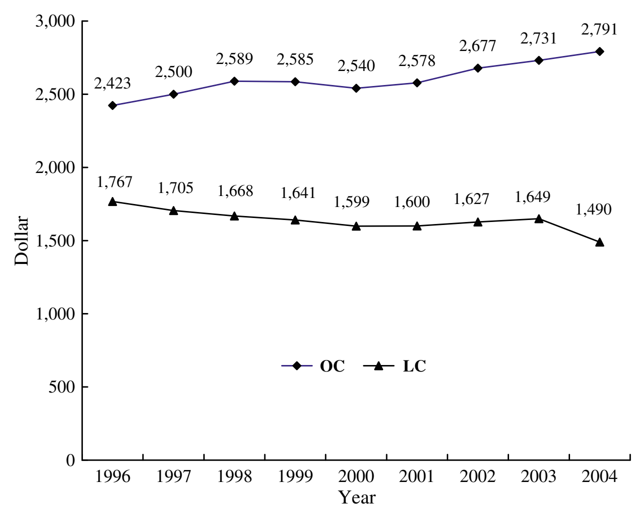

Fig. 2 Change in total treatment costs of open cholecystectomy (OC) and laparoscopic cholecystectomy (LC) procedures performed from 1996 to 2004

Table 3 compares the changes in ALOS and treatment costs between OC and LC. For OC, ALOS declined from 13.75 to 12.42 days (–9.67%), but total treatment cost increased from $2,506 to $2,729 (8.88%). For LC, ALOS decreased from 5.94 to 4.52 days (–23.91%), and total treatment cost also decreased from $1,707 to $1,588 (–6.96%). Moreover, the decline in effect size of differences in ALOS and treatment costs was greater for LC

Table 3 Comparison of average length of hospital stay (ALOS) and treatment costs for open cholecystectomy (OC) and laparoscopic cholecystectomy (LC) groups by periods 1–3

	OC procedure					LC procedure					LC–OC
	Period 1	Period 2	Period 3	Change (%)	Effect size	Period 1	Period 2	Period 3	Change (%)	Effect size	Estimate (95% CI)[a]
ALOS (days)	13.75 ± 7.59	13.10 ± 7.17	12.42 ± 6.85	−9.67	−0.18	5.94 ± 3.51	4.62 ± 2.72	4.52 ± 2.63	−23.91	−0.41	−0.23 (−0.33, −0.13)
Operating room ($)	635.30 ± 244.64	652.85 ± 231.58	695.38 ± 270.20	9.46	0.25	916.48 ± 161.81	933.02 ± 114.62	885.93 ± 160.18	−3.33	−0.19	−0.44 (−0.65, −0.22)
Radiology ($)	95.87 ± 142.45	96.55 ± 146.59	106.86 ± 158.64	11.46	0.08	36.63 ± 74.51	26.89 ± 65.26	30.27 ± 71.89	−17.36	−0.09	−0.17 (−0.33, −0.01)
Physical therapy ($)	166.80 ± 203.19	163.40 ± 205.56	171.79 ± 218.94	2.99	0.02	40.88 ± 45.61	27.88 ± 34.34	27.60 ± 47.55	−32.48	−0.29	−0.31 (−0.52, −0.10)
Hospital room ($)	75.23 ± 97.36	72.59 ± 112.88	74.93 ± 110.31	−0.40	0.00	25.15 ± 34.40	16.53 ± 24.86	19.77 ± 32.83	−21.39	−0.16	−0.15 (−0.28, −0.03)
Anesthetist ($)	418.89 ± 363.73	466.63 ± 411.56	526.11 ± 455.06	25.60	0.29	149.44 ± 96.78	133.64 ± 88.13	150.49 ± 98.70	0.70	0.01	−0.28 (−0.47, −0.09)
Pharmacy ($)	286.98 ± 116.38	287.58 ± 110.57	288.57 ± 107.26	0.55	0.01	236.59 ± 68.55	228.79 ± 56.79	227.60 ± 52.45	−3.80	−0.13	−0.14 (−0.27, −0.02)
Laboratory ($)	107.36 ± 59.49	118.42 ± 65.85	132.48 ± 76.84	23.40	0.42	48.54 ± 24.98	44.83 ± 23.07	50.18 ± 26.29	3.38	0.07	−0.35 (−0.57, −0.13)
Special materials ($)	391.57 ± 431.70	391.54 ± 444.31	391.54 ± 469.92	−0.01	0.00	118.30 ± 120.76	85.15 ± 95.20	74.11 ± 99.21	−37.35	−0.37	−0.37 (−0.56, −0.18)
Surgeon fee ($)	221.55 ± 176.11	211.14 ± 158.36	226.56 ± 168.80	2.26	0.03	106.95 ± 63.33	93.43 ± 48.92	100.90 ± 56.84	−5.66	−0.10	−0.13 (−0.23, −0.03)
Miscellaneous ($)	106.91 ± 200.72	107.08 ± 210.27	115.02 ± 226.44	7.58	0.04	27.62 ± 40.05	21.31 ± 40.94	21.10 ± 40.78	−23.61	−0.16	−0.20 (−0.33, −0.07)
Total hospital charge ($)	2,506.45 ± 1,421.63	2,567.77 ± 1,493.94	2,728.95 ± 1,602.93	8.88	0.16	1,706.58 ± 432.70	1,611.47 ± 365.92	1,587.87 ± 411.36	−6.96	−0.27	−0.43 (−0.63, −0.23)

CI confidence interval

[a] Differences are presented in terms of effect size (95% CI obtained by bootstrapping)

patients than for OC patients between periods 1 and 3. The difference was statistically significant at the 0.05 level for the confidence interval excluding zero. The overall data showed that the decline in the effect sizes of changes in ALOS and total treatment cost was greater for LC patients (−0.23; 95% CI, −0.33 to −0.13) than for OC patients (−0.43; 95% CI, −0.63 to −0.23).

Table 4 shows the data obtained by multiple regression models used to evaluate the predictors of total treatment cost. For both the OC and LC patients, the statistically significant predictors of total treatment cost were age, gender, number of comorbidities, hospital level, and ALOS ($P < 0.05$). These data indicated that advanced age, female gender, one or more comorbidities, current treatment at a medical center, and longer ALOS were associated with increased total treatment cost. Moreover, analysis of the standardized coefficients indicated that total treatment cost had a larger coefficient with ALOS than with age or gender. Additionally, when controlling for age, gender, number of comorbidities, hospital level, and ALOS, linear regression analysis showed a statistically significant association between surgery type and total treatment cost (regression coefficient, \$111.24; $P < 0.05$).

Table 4 Multiple regression model of the relationship between effective predictors and total treatment cost for open cholecystectomy (OC) and laparoscopic cholecystectomy (LC) procedures

Predictors	*B*	Beta	*P* value
OC compared with LC[a]	111.24	0.071	<0.001
Patient attributes			
Age			
≤64[a]	–	–	
≥65	279.01	0.185	<0.001
Gender			
Male[a]	–	–	
Female	268.96	0.205	<0.001
No. of comorbidities			
0[a]	–	–	
1	42.61	0.009	<0.001
≧2	175.14	0.045	<0.001
Hospital attributes			
Hospital level			
Medical center[a]	–	–	
Area hospital	−70.32	−0.012	0.009
Local hospital	−154.59	−0.028	<0.001
ALOS	123.19	0.540	<0.001
$R^2 = 0.91$, adjusted $R^2 = 0.91$			

ALOS average length of hospital stay

[a] Reference group

Discussion

This population-based study is the first to examine how patient and hospital attributes reflect changing trends in the prevalence of OC and LC procedures and the first study to identify factors that predict total treatment costs for these two procedures. This study demonstrated that the prevalence of LC was three times that of OC during the study period. Although this may not surprise surgeons who perform cholecystectomies, patient characteristics may substantially differ between OC and LC patients. This study confirmed previous reports [4, 7, 10] that female gender, age of 64 years or younger, and lack of current comorbid conditions are associated with increased likelihood of undergoing an LC procedure.

The findings of improved outcomes associated with LC in this study are consistent with other comparisons of LC and OC in the literature. Previous studies indicate that both ALOS and number of comorbidities are lower for LC patients than for OC patients [4, 7, 10]. The time required for resumption of work or other normal activity is reportedly longer for OC patients than for LC patients, which is consistent with the observation that the LC patients in this study required a shorter hospital stay than the OC patients.

However, the mean ALOS observed for both OC and LC in this study was longer than that reported for populations in other countries [3, 4]. In Taiwan, percutaneous transhepatic gallbladder drainage may be a major cause of increased ALOS [11]. Consequently, a longer preoperation hospital day also may increase ALOS. Thus, a final possibility is that ALOS is longer in Taiwan populations than in Western populations due to different treatment protocols or cultural differences.

Notably, the population-based data in this study showed a significantly greater number of comorbidities in the OC patients than in the LC patients, which is consistent with other series [4, 7, 12]. To determine whether OC procedures cause comorbidities that may then preclude patients from undergoing LC, Csikesz et al. [12] applied the Deyo modification of the Charlson comorbidity score, which adequately controls for comorbidity but may not accurately reflect the comorbid factors that surgeons consider when choosing between LC and OC [7]. As expected, the OC patients in the current study exhibited more comorbidities than the LC patients.

Although the need for laparoscopic equipment makes LC more expensive than OC, the total treatment cost of LC is offset by a shorter ALOS and a reduced incidence of complications. Although both procedures are considered safe, another advantage of laparoscopic surgery, in addition to its shorter ALOS and lower morbidity, is its protective effect against open surgery [13–16]. This study confirmed previous reports that the total cost of LC procedures is significantly lower than that of OC procedures [7, 13–16]. However, the increased incidence of postoperative hospitalization and disability may substantially increase the total cost of OC.

Moreover, as treatment costs increase, patients requiring LC or OC tend to prefer high-volume surgeons and hospitals. Previous studies [17, 18] show several clinical parameters strongly associated with treatment costs. However, the limited availability of claims data in the current study precluded analysis of many clinical parameters. Findings of gender differences in costs incurred for OC and LC procedures also indicated that women tended to incur higher total treatment costs than men. A study by Csikesz et al. [4] proposed that the difference resulted from the increased disease severity in women than in men before surgery. In that study, patients older than 65 years also showed more comorbidities than younger patients. A possible explanation is the higher total treatment cost incurred by older patients. This study also showed that the total cost of treatment in medical centers was substantially higher than in area and local hospitals.

This study has several limitations inherent in large database analyses. First, the clinical picture obtained in this analysis of claims data is not as precise as that of a prospective clinical trial data analysis due to possible errors in coding of the primary diagnosis and surgical method. Second, complications associated with the LC and OC procedures were not assessed, which limits the validity of the comparison. Finally, the analysis did not examine outpatient data such as patient outcomes and indirect costs incurred after discharge. However, compared with OC patients, fewer LC patients were discharged with home care. This suggests that LC patients enjoy faster recovery and therefore incur fewer indirect costs after discharge.

The volume of LC procedures is rapidly increasing, and the overall rate of medical resource usage is dramatically declining in Taiwan. This study showed that female gender, young age ($\leq$64 years), and low number of comorbid conditions are associated with increased likelihood of undergoing an LC procedure. This study also showed that OC procedure, advanced age, female gender, high number of comorbidities, treatment at medical center; and long ALOS are associated with considerably increased total treatment cost. For efficient allocation of medical resources, these factors must be carefully managed. Additionally, government officials and health care providers should understand that total treatment costs depend on both patient attributes and hospital attributes. These results can be generalized to patient populations elsewhere in Taiwan as well as to other countries with similar patient profiles.

Disclosures Chiu-E Hsu, King-Teh Lee, Chao-Sung Chang, Herng-Chia Chiu, Fang-Tse Chao, and Hon-Yi Shi have no conflicts of interest or financial ties to disclose.

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