

Health Economic Evaluation of Laparoscopic Cholecystectomy in Day Surgery: A Case Study From a No-Smoking Hospital in China

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Abstract: Health economic evaluation of day surgery is helpful for patients and hospitals to choose reasonable surgery modes. By taking laparoscopic cholecystectomy (LC) in a no-smoking hospital, the top 2 hospital in China (West China hospital), as a case, this paper conducted a health economic evaluation of day surgery mode of no-smoking environment in China. The clinical data of patients undergoing LC with benign gallbladder diseases was collected in the case hospital, in which 838 patients were included in the day surgery group and 1,620 patients were included in the control group. Results showed that there was no statistically significant difference between the two groups in terms of gender and discharge approaches ($p > 0.05$). The age, hospitalization expenses, and LOS in the day surgery group were significantly lower than those in the control group at $p < 0.05$. The cost-effectiveness ratios of the day surgery group and the control group were 8,046.40 and 29,558.25, respectively. The day surgery mode for LC is more cost-effective than inpatient surgery mode, and day surgery is recommended for LC patients who meet the indications of day surgery in China.

Key words: no-smoking hospital; day surgery; laparoscopic cholecystectomy; health economic evaluation

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In the last two decades, China has achieved a series of results in its medical reform. Yet, there are still intense concerns about inaccessible and quite expensive medical care, insufficient medical resources, the low utilization rate of medical

resources, especially in West China that is economically underdeveloped.^{1,2} Sun et al.³ conducted a questionnaire survey for 27,475 outpatients in 136 hospitals from 31 provinces in 2015, of which the results showed that the outpatients were least satisfied

with long waiting time for outpatient visits and outpatient examinations, highlighting the issue of inaccessible medical care in China. Li et al.⁴ reported 35 studies that met the inclusion criteria in a systematic evaluation of the factors associated with outpatient satisfaction in tertiary hospitals in China. These studies covered 45,930 outpatients from 185 hospitals, and the results showed that the outpatients reported the highest satisfaction with doctors and nurses, but the lowest satisfaction with outpatient procedures, especially with the long waiting time. Li et al.⁵ carried out a cross-sectional survey on patient satisfaction between primary care providers and hospitals in Jilin Province in China, which showed that patients in county and tertiary hospitals reported lower overall satisfaction with outpatient care due to long waiting time, high treatment expenses, and poor attitudes of medical staff. Accordingly, how to improve the utilization rate of medical resources, shorten the time for residents to see a doctor, and reduce their waiting time before admission has become a pressing problem nowadays.^{6,7}

In recent years, China has carried out nationwide smoke-free activities in public places. Hospitals, as very important public places, are of great health economic significance. Building smoke-free hospitals in response to the national call is not only conducive to creating a good medical environment, but also of great significance to patients' rehabilitation after surgery. The concept of day surgery, originating from European and American countries, has been rapidly developed and popularized in China in recent years.^{8,9} "Day surgery" refers to a surgery mode that a patient completes the preoperative examination and anesthesia evaluation before admission, make an appointment for the operating time, receives the operation on the day of admission, and discharge within 24 hours after the operation.¹⁰ It does not include the operation performed in the clinic and the outpatient operation done in the hospital.⁴ In January 2018, the National Health and Family Planning Commission of the People's Republic of China (now National Health Commission of the PRC) issued the *Action Plan*

for Further Improvement of Medical Services (2018-2020) (GWYF [2017] No.73), which stipulated that eligible tertiary hospitals should gradually expand the scope of diseases suitable for day surgery and increase the proportion of day surgery year by year. Compared with the inpatient surgery mode, day surgery can effectively shorten the preoperative waiting time and length of stay (LOS), reduce medical expenses, improve patients' healthcare experience, raise the bed turnover rate of a hospital, and allow more reasonable allocation and use of the limited medical resources, showing a promising application prospect.¹¹⁻¹³ Yet, few studies on the health economic evaluation of day surgery in China have been reported.

Since 1991, laparoscopic cholecystectomy (LC) has been widely applied in hospitals of various levels in China and has become the preferred choice for the treatment of benign gallbladder diseases due to its advantages of minimal trauma, mild pain, less bleeding, rapid recovery, and short LOS.¹⁴ LC in day surgery (LCDS) is a surgery mode for the patients with indications for cholecystectomy, the score of anesthesia risk assessment of no greater than American Society of Anesthesiologists (ASA) II, and the total duration from admission, operation, to postoperative hospitalization observation of no more than 24 hours. LCDS outstrips the LC in inpatient surgery (LCIS) due to its short LOS, desirable operation outcome, fewer postoperative complications, rapid postoperative recovery, and considerably fewer hospitalization expenses. It has become the preferred choice for the elective treatment of benign gallbladder diseases in European and American countries, accounting for over 80% of elective surgeries.^{15,16} Although LCDS has become a representative surgery mode of the day surgery mode, comparative studies on the day surgery mode and inpatient mode for LCDS from the perspective of health economics have not been reported yet.

Therefore, this paper makes a comparative analysis of the day surgery mode and the inpatient surgery mode of patients undergoing LC in a hospital in China from the perspective of health economics.

METHODS

Case hospital

West China Hospital of Sichuan University (WCH) is the largest grade A tertiary general hospital in Southwest China which integrates medical treatment, teaching, and scientific research. It is equipped with 4,300 registered beds, 52 centralized beds for day surgery, and 63 decentralized beds for day surgery. As one of the first eight member hospitals of China Ambulatory Surgery Alliance (CASA) to carry out day surgery in China, WCH has certain authority regarding day surgery in China. In 2017, WCH completed 22,643 day surgeries in total, accounting for 24.51% of the total elective surgeries (excluding outpatient surgeries and emergency surgeries).

Data collection

The data of patients who were admitted to WCH and underwent LC from January 1, 2017 to December 31, 2017 were retrospectively collected, including the admission number, age, gender, diagnosis, admission time, discharge time, inpatient department, surgery name, discharge diagnosis, and hospitalization expenses. The inclusion criteria were as follows: (1) Clinically diagnosed with benign gallbladder diseases, including gallbladder cholesterolosis or gallbladder polyp, gallstone, gallstone with chronic cholecystitis, and gallstone with acute cholecystitis; (2) Age: 16-65 years; (3) Score of anesthesia risk assessment: ASA I or ASA II. The exclusion criteria were as follows: (1) Nonbenign diseases of the gallbladder, including residual gallstone, gallstone with intrahepatic and extrahepatic bile duct stones, suppurative or gangrenous cholecystitis, gallstone with pancreatitis; (2) Patients who underwent other operations and conversion to laparotomy during hospitalization.

Evaluation method

Evaluation indicators

The patients were divided into a day surgery group and a control group according to whether the patient underwent LC in a day surgery ward or

inpatient ward. The medical data of patients in the two groups were collected and classified into demographics and economic indicators. The demographics included age, gender, discharge approaches, and other information, and the economic indicators included LOS (time from admission/registration to discharge/settlement) and hospitalization expenses (outpatient/preoperative examination costs and expenses incurred during hospitalization).

Cost-effectiveness analysis

The method of health economic analysis and evaluation, originated in foreign countries, primarily studies the mutual restriction between health services, people's health, and social development, and reveals the scope, form, and characteristics of the role of economics laws in the health field.^{12,17-20} It mainly incorporates the cost-minimization analysis (CMA), cost-benefit analysis (CBA), cost-effectiveness analysis (CEA), cost-utility analysis (CUA), and other analytical methods.²¹⁻²⁴

At present, more and more attention has been paid to studies on the health economics evaluation of cholelithiasis surgery in China. Most of the researches focused on the health economics evaluation of LC and traditional open cholecystectomy (OC)[25]. However, the health economics evaluation of different surgery modes for LC started relatively late. There are few papers related to this area, most of which mainly discussed the evaluation of clinical indicators. As one of the key methods of health economic evaluation, CEA has been widely used in the comparative study of day surgery²⁶⁻²⁸. It mainly measures the difference in health economics between the two surgery modes using cost-effectiveness ratio (CER) and incremental cost-effectiveness ratio (ICER).

The calculation formula of CER is $CER = C/E$, where C refers to cost, E refers to effectiveness. The smaller the CER, the lower the cost required to obtain the unit effectiveness and the more benefits for the implementation of the protocol.

ICER is the incremental change in costs divided by the incremental change in unit effectiveness. The calculation formula is $ICER = \Delta C/\Delta E = (C2$

$-C1)/(E2 - E1)$. The smaller the *ICER*, the lower the incremental cost required for each incremental change in unit effectiveness, and the greater the practical significance of the protocol.

Statistical methods

The data were statistically processed using SPSS 24.0 software. Measurement data normally distributed were expressed as the mean \pm standard deviation ($\bar{x} \pm s$), and the independent sample t-test was used for comparison between groups. Measurement data abnormally distributed were expressed as median \pm interquartile range ($m \pm q$), and Mann-Whitney *U* test was used for comparison between groups. The enumeration data were expressed as the number of cases and percentages, and χ^2 test was used for the comparison between groups. When the minimum theoretical frequency of a cell was < 1 or the theoretical frequency of at least two cells was ≥ 1 and < 5 , the Fisher exact probability test was used with the significance level of 0.05 ($\alpha = 0.05$).

RESULTS

Patient demographics

After the screening of research objects using relevant indicators, 2,458 eligible patients with benign gallbladder diseases were included for statistical analysis. There were 838 patients (male: 288; female: 550) in the day surgery group, with a mean age of 40.84 ± 10.58 years; there were 1,620 patients (male: 560; female: 1,060) in the day surgery group, with a mean age of 45.93 ± 11.58 years. Patients in both groups underwent LC. The patients in the day surgery group were younger than those in the control group, showing a statistically significant difference ($t = -10.940, p < 0.05$); there were no statistically significant differences between the two groups in terms of gender and discharge approaches ($p > 0.05$), as shown in Table 1.

Table 1
Comparison of basic indicators between the two groups (n = 2458)

Items	Day surgery group (n=838)	Control group (n=1620)	Test statistics	p value
Age ($\bar{x} \pm s$)	(40.84 \pm 10.58)	(45.93 \pm 11.58)	$t = -10.940$	0.000
Gender [n (%)]				
Male	288 (34.4)	560 (34.6)	$\chi^2 = 0.01$	0.921
Female	550 (65.6)	1060 (65.4)		
Discharge approaches [n(%)]				
Discharge following medical advice	837(99.9)	1613 (99.6)	-	0.167
Transfer following medical advice	1 (0.1)	1 (0.1)		
Others	0 (0.0)	6(0.4)		

Hospitalization expenses and LOS for different surgery modes

The hospitalization expenses of the day surgery group, including operation expenses, anesthesia expenses, nursing expenses, and drug expenses and other expenses, were significantly lower than

those of the control group, showing a statistically significant difference ($p < 0.05$). The median LOS in the day surgery group was one day, which was less than three days in the control group, indicating a statistically significant difference ($p < 0.05$), as shown in Table 2.

Items (<i>m ± q</i>)	Day surgery group	Control group	Z value	pvalue
Operation expenses	(1300.00 ± 1053.00)	(2353.00±1053.00)	-5.654	0.000
Anesthesia expenses	(1276.00 ± 0.00)	(1276.00±350.00)	-17.560	0.000
Nursing expenses	(23.00 ± 9.00)	(68.00±27.00)	-40.205	0.000
Drug expenses&otherexpenss	(5019.68 ± 870.26)	(6164.39±947.47)	-28.996	0.000
Total expense	(7951.62 ± 1519.08)	(9530.55±1612.66)	-26.003	0.000
LOS	(1 ± 0)	(3±1)	-41.808	0.000

Health economics evaluation of different surgery modes

The direct cost and indirect cost of patients were analyzed, the sum of the two items was calculated and analyzed as the total cost, and the reciprocal of the LOS was used as the efficacy value for a further CEA.

Cost analysis

In health economics, the costs include direct costs, indirect costs, and intangible costs, in which, the direct costs comprise direct medical costs and direct non-medical costs. The costs of this study only included direct medical costs and indirect costs. The direct costs were simplified to the total expense of the patient’s hospitalization settlement, which can be obtained through the charging information system of the hospital. The direct costs of the day surgery group and the control group were CNY 7,951.62 ± 1,519.08 and 9,530.55 ± 1,612.66, respectively.

The indirect costs in this study included the value of labor lost by patients and their families during

the patients’ illness. According to the average daily wage income standard and lost labor time of urban residents in Sichuan Province, the indirect costs were calculated as the wage standard multiplied by the effective labor time lost due to illness. In 2017, the per capita wage income of urban residents in Sichuan Province was CNY 17,299, as shown in the statistical data from the *China Statistical Yearbook*. As a result, the average daily income of urban residents in Sichuan Province was about CNY 47.39. Each patient in both groups only needs one family member to accompany during the hospitalization as LC is featured by minimal trauma, mild pain, less bleeding, rapid recovery, and short LOS. The indirect costs of the day surgery group and the control group were CNY 94.78±0.00 and CNY 284.34 ± 94.78.

The differences in the direct costs, indirect costs, and total cost between the day surgery group and the control group were statistically significant (*p*< 0.05).The statistical results are shown in Table 3.

Items (<i>m ± q</i>)	Day surgery group	Control group	Z value	pvalue
Direct costs	(7951.62 ± 1519.08)	(9530.55 ± 1612.66)	-26.003	0.000
Indirect costs	(94.78 ± 0.00)	(284.34 ± 94.78)	-41.808	0.000
Total cost	(8046.40 ± 1519.08)	(9852.75 ± 1659.38)	-28.432	0.000

Cost-effectiveness analysis

The reciprocal of the patients’ LOS was used as

the efficacy value for CEA. According to the results, the CER of the day surgery group was 8,046.40, lower than that of the control group (29,558.25), indicating that the cost for unit

effectiveness of treatment in the day surgery group was lower. Based on the control group, the ICER was -2,709.51, which showed that compared with the control group, application of day surgery mode

can not only effectively improve the efficacy but also reduce the medical cost, as shown in Table 4.

Group	Cost	Effectiveness	CER	ICER
Day surgery group	8046.40	1.00	8046.40	-2709.51
Control group	9852.75	0.33	29558.25	

Sensitivity analysis

The sensitivity analysis, including one-way sensitivity analysis and multi-way sensitivity analysis, is used to verify the degree of influence of different hypotheses or estimates on the analysis results. In this study, the one-way sensitivity analysis was used, with a 10% fluctuation in total cost as the observation point of

the upper and lower limits. Different combinations of upper and lower limits of each group and different effects were used to perform sensitivity analysis, and the CER was calculated. Regardless of the cost value within the range, the CER of the day surgery group was always lower than that of the control group, as shown in Table 5.

Group	Cost	Effectiveness	CER
Day surgery group	(7241.76, 8851.04)	1.00	(7241.76, 8851.04)
Control group	(8867.48, 10838.03)	0.33	(26602.44, 32514.08)

DISCUSSION

It can be found from the comparative analysis of the hospitalization expenses of the two groups that the four types of expenses of the day surgery group were lower than those of the control group ($P < 0.05$), which indicates that the day surgery is more cost-effective for patients with benign gallbladder diseases. The expense of day surgery is lower, principally because of the markedly shortened LOS of patients undergoing day surgery, reduced direct medical costs such as nursing expenses and drug expenses, and decreased indirect costs such as cost of lost labor incurred by family members' accompanying. Additionally, the hospital regulation that the day surgery should be operated per the clinical pathway plus the stringent control of expenses of drugs and

consumables also contribute to the reduction of hospitalization expenses. It should be noted that in this study, the control group and the day surgery group had the largest difference in drug expenses and other expenses, with the former being CNY 1,145 higher than the latter, indicating that day surgery is markedly cost-effective in drugs and treatment.

The LOS is not only a factor influencing the medical costs but also a direct indicator reflecting the utilization rate of medical resources. In this study, the LOS in the day surgery group was notably shorter than that in the control group ($p < 0.05$). Due to the reduction of LOS, patients and their family members can quickly set themselves apart from the "illness condition" and return to normal family life, social interaction, and work environment as soon as possible, which benefits the rapid recovery of

patients' physical and mental health. In addition, the total duration of day surgery from reservation before the operation to the discharge after the operation does not exceed 24 hours, and the patients only need to receive preoperative examinations and come to the hospital on the day of operation. The waiting time for day surgery is shorter than that for inpatient surgery.

Among the cases selected in this study, there was no difference in the distribution of discharge approaches between the day surgery group and the control group ($p > 0.05$), indicating that day surgery is safe and feasible after adequate preoperative preparation and strict postoperative management. Besides, the health economic analysis showed that the day surgery group had a lower cost for unit effectiveness of treatment and consequently lower CER than the control group, indicating greater health economic value that lies in day surgery. The relationship between the two surgery modes in health economics shown in this study can provide a reference for the evaluation of day surgery and the selection of operative techniques in local hospitals.

On the one hand, the patients undergoing surgery are not yet recovered at discharge as they leave the hospital on the same day of operation. On the other hand, the current postoperative extended medical services provided for the patients undergoing day surgery in China are relatively poor and the medical safety of the patients cannot be guaranteed, probably because of the lack of medical care. This may result in related complications, increase the patient's medical cost, and affect the patient's efficacy and quality of life. Therefore, we should actively promote the cooperation between general hospitals and community health service centers, improve the extended medical services related to day surgery, and offer high-quality and convenient diagnosis and treatment for patients undergoing day surgery for their postoperative recovery, so as to further enhance the medical safety of day surgery.

CONCLUSION

The construction of smoke-free hospitals is conducive to the physical cultivation of patients

before surgery, and helps patients to have a good recovery environment after day surgery. As an important supplement to surgery, day surgery has been well-developed in its medical procedures and management modes. At present, the day surgery mode has been applied to gallstone, gastric polyps, oblique inguinal hernia, preauricular fistula, and other diseases, effectively alleviating the medical pressure in general inpatient wards. With the rapid development of minimally invasive technology and anesthetics and the promotion of fast track surgery and the concept of day surgery, the mode of LCDS is bound to be popularized rapidly and benefit more patients. Additionally, cost-effectiveness evaluation is just a way of evaluating day surgery. We should establish a comprehensive evaluation system for day surgery as fast as we can from the perspectives of cost-effectiveness, cost-utility, cost-benefit to evaluate its scientificity, effectiveness, and applicability, in a bid to accelerate the development of day surgery in China.

Author Contributions

N.C. and Y.L. worked on forming ideas of this paper; L. L. and T.C. worked together in conducting statistical analysis and drafting the initial manuscript; Y.L. and H.M. collected the data; N.C., H.M. and H.Y. provided supervision during the whole process; All authors have read and approved the final manuscript.

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