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Difference in resource utilization between patients with acute and chronic heart failure from Japanese administrative database

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Abstract

Background: Many studies have reported economic evaluation of evolving agents or therapies for patients with heart failure (HF). However, little is known whether the disease progression category (acute or chronic HF) would be considered as a risk adjustment in health service research.
Objectives: This study profiles the difference in resource use or medical care for acute versus chronic HF.
Methods: This study analyzed 17,912 HF patients treated in 62 academic hospitals and 351 community hospitals. Study variables included demographic variables, comorbid status, physical activity or disease progression at admission, procedures and laboratory tests, type and dose of heart-related medications, length of stay (LOS), and total charges (TC; 1 US$=¥100) for acute and chronic HF. The independent contributions of disease progression categories on LOS and TC were identified using multivariate analysis.
Results: We identified 9813 chronic and 8099 acute HF patients. Median LOS was 18 days for both chronic and acute HF, whereas TC was US$5731 and US$6447, respectively. Regression analysis revealed that acute HF was associated with a slightly greater TC, whereas performance of procedures was the most prominent factor. As NYHA class was the next most influential factor, class 3 or 4 resulted in longer LOS or greater TC, than did class 1.
Conclusions: This study suggests that acute HF increased resource use slightly, whereas use of some practices indicated in critical care was affected more by the procedures performed. Disease progression category should remain an indicator for appropriateness of medical care.

Keywords: Heart failure; Case-mix; Resource use; Outcome

1. Introduction

Heart failure (HF) has been attracting clinical and economical attention because of its increased incidence in a growing elderly population [1–4]. In developed countries, rapid increases in healthcare expenditures have inevitably required monitoring of the quality and efficiency of medical care delivered to HF patients. Therapeutic innovation and assessment of cost-effectiveness surely have benefited HF patients [5,6].

In Japan in 2006, the burden of heart failure was estimated to be 12.3 million cases (1.46%), 14.1 million hospital days, and approximately 5.98 billion US dollars. Patients at least 65 years of age represented 54.4% of the cases, 85.3% of durations of hospital stay, and 70% of the expenditures [7].

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In order to improve the limited functional conditions or life expectancy, several types of new treatments and therapeutic guidelines have been established. For example, several studies performed economic analysis on beta-blocker agents and ultra-filtration technology [5,8]. Epidemiologic studies examining gender differences and evaluating care systems (e.g., acute care units for the elderly) have explored quality and efficiency by focusing on resource use or practice behavior [3,9–12].

When studying these issues, many factors, such as heart-related comorbidities, clinical severity related to daily activities (e.g., New York Heart Association classification), hospital functions, and urgency status at admission should be considered [13–15]. Disease progression classification such as acute or chronic HF may be another promising factor influencing the amount of medical care [15]. Many reports have targeted only acute or chronic HF, however, and little is known about the difference in cost or practice pattern for patients with acute versus chronic HF. In these settings, it is meaningful to test the impact of disease progression on health services, because some clinical experts would anticipate that more severe illnesses will result in increased cost of care.

In the present study, we compared patient baseline characteristics, treatment, and total hospital resource utilization for HF patients according to classifications of disease progression.

2. Materials and methods

In order to develop a Japanese case-mix classification system, the Japanese administrative database has been constructed by our research team in collaboration with the Ministry of Health, Labor and Welfare (MHLW) since 2002. For the present study, we used the database gathered by the MHLW between July 1 and December 31, 2006. The Japanese administrative database contains both discharge summaries and claim data in an electronic format that is useful for detailed profiling of practice pattern.

The database was also utilized by the MHLW for the payment system and disclosure of hospital performance among 731 institutions (including 80 university hospitals, the National Cancer Center, the National Cardiovascular Center, and 649 community hospitals). These 731 hospitals located throughout Japan play important roles, including the delivery of acute care, advancement of medical research, and education of students and trainees. In the present study, we analyzed HF cases treated at these hospitals which voluntarily participated in our research project.

2.1. Definition of variables

The present study included patients with HF as the principal diagnosis according to the International Statistical Classification of Diseases, 10th version (ICD10). Following the opinions of clinical experts, we collected information about the status of disease progression (acute or chronic HF), which was not originally listed in the ICD10 code, at admission. Heart transplantation cases were excluded from our study.

Acute HF was defined as the rapid or gradual onset of signs or symptoms of HF requiring urgent unplanned hospitalization or an emergency visit. Chronic HF was defined as the inability of the heart to supply sufficient blood volume for meeting the oxygen demand of major peripheral organs, resulting in the impairment of daily activities, which are often associated with pulmonary or systemic congestion [16–18].

Independent variables in the study included age, gender, use of an ambulance, outcome, disease progression (acute or chronic) at admission, status of comorbid conditions, New York Heart Association class as a surrogate marker of physical activity at admission, hospital function, diagnostic test, type of procedure, medication, and cost of care.

In the present study, we used length of stay (LOS) and total charges (TC: 1 US$=¥100) billed during admission as proxies for total in-hospital costs. In Japan, charges for hospital care are determined by a standardized fee-for-service payment system and considered to be good estimates of the costs of healthcare [19]. In this study, TC included physician fees, instrument costs, the costs of laboratory or imaging tests, and administration fees.

Patients were stratified by age into two groups: <65 years and ≥65 years. We used transfer by ambulance as a proxy for emergency admission. Various types of diagnoses in this database were recorded as ICD10 codes. To assess the degree of chronic comorbid conditions, we used the Charlson Comorbidity Index (CCI) [20]. Although the original CCI included heart failure, HF was not considered a comorbidity in the current study. Other heart-related comorbidities, not defined in the original CCI, included hypertensive diseases (I10, I11$–13$, I15$), valve diseases (I05$–08$, I35$–37$, I38, I39$), and cardiomyopathy (I42$–43$, I514–5, I517).

Performance of surgical procedures was examined; for example, cardiac surgery included percutaneous intracoronary intervention, coronary-aortic bypass graft, anti-arrhythmic procedures (pacemaker implantation, implantable cardioverter-defibrillator, and catheter ablation), and valve surgery. Use of diagnostic tests (cardiac catheterization, radiography, electrocardiography, echocardiography, and Swan–Ganz catheter) and supportive care (ventilation, dialysis, and rehabilitation) were also counted. In addition, we surveyed use of medications: digoxin, dopamine, loop diuretic (furosemide), spinorolactone, thiazide diuretics, angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, isosorbide dinitrate, and certain beta-blockers (Bisoprolol, carvedilol, and Metoprolol).

2.2. Statistical analysis

The frequency and proportion of categorical data were reported. Comparisons were made using Fisher's exact test. Continuous variables were compared using the Mann–

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Whitney test. We used multiple linear regression models to identify the separate effect of disease progression on LOS and TC. In the models utilized, LOS and TC were right-skewed distributed and log transformed. Statistical analysis was performed using SPSS version 16.0. All reported *P*-values were two-tailed, and the level of significance was set at less than 0.05.

3. Results

Of the records of 17,912 patients examined, 15,282 were from 351 community hospitals, and 2630 were from 62 academic hospitals. We identified 9813 chronic HF patients and 8099 acute HF patients (1055 cases from academic hospitals).

The median age was 78 years for both chronic HF and acute HF patients, whereas the proportion of patients ≥65 years of age was 83.4% and 80.5% for chronic HF and acute HF, respectively. Male patients represented 51.5% of the chronic HF and 51.4% of the acute HF population, respectively. Emergency status occurred in 25.1% of chronic HF and 40.9% of acute HF cases. There were 1751 cases of mortality (866 cases in chronic HF and 885 cases in acute HF patients). Concerning the Charlson Comorbidity Index, the proportion of cases lacking comorbidity was 54.7% for chronic HF and 54.2% for acute HF ($P=0.133$). Regarding other HF-related comorbidities, the proportion of hypertensive disease differed significantly (33.9% for chronic HF, and 39.4% for acute HF). NYHA class 2 was a frequent classification in chronic HF cases (32.4%), whereas class 4 was a frequent classification in acute HF (32.8%) (Table 1).

Table 1
Heart failure (HF) patient characteristics by disease severity

Patient characteristics	Chronic HF ($n=9813$)	Acute HF ($n=8099$)	*P*
Median age [interquantile range]	78 [16]	78 [17]	0.000[a]
≥65 years of age (n=%)	8184 (83.4)	6521 (80.5)	0.000
Male (n=%)	5053 (51.5)	4161 (51.4)	0.881
Ambulance used (n=%)	2460 (25.1)	3311 (40.9)	0.000
Mortality (n=%)	866 (8.8)	885 (10.9)	0.000
Charlson Comorbidity Index category (n=%)			0.133
0	5366 (54.7)	4393 (54.2)	
1	2280 (23.2)	2005 (24.8)	
2	1459 (14.9)	1155 (14.3)	
3	470 (4.8)	366 (4.5)	
≥4	238 (2.4)	180 (2.2)	
Other comorbidities (n=%)			
Hypertensive diseases	3329 (33.9)	3194 (39.4)	0.000
Valve disorders	1347 (13.7)	1073 (13.2)	0.356
Cardiomyopathy	596 (6.1)	411 (5.1)	0.004
NYHA (n=%)			0.000
I	1798 (18.3)	1184 (14.6)	
II	3183 (32.4)	1961 (24.2)	
III	2949 (30.1)	2297 (28.4)	
IV	1883 (19.2)	2657 (32.8)	
Hospital (n=%)			
Academic	1575 (16.1)	1055 (13)	0.000

[a] Calculated by Mann–Whitney test, whereas other *P*-values by Fisher exact test.

Table 2
Use of procedure or diagnostic testing during hospitalization according to disease severity of heart failure

Procedure or diagnostic test	Chronic HF	Acute HF	*P*
Surgery (n, %)	1003 (10.2)	927 (11.4)	0.009
Cardiac surgery (n, %)	476 (4.9)	464 (5.7)	0.009
Artificial ventilation (n, %)	539 (5.5)	843 (10.4)	0.000
Median days	3 [7]	3 [5]	0.345[a]
Dialysis (n, %)	415 (4.2)	334 (4.1)	0.735
Median days	6 [9]	5 [9]	0.186[a]
Rehabilitation (n, %)	1826 (18.6)	1548 (19.1)	0.398
Median days	10 [15]	10 [14]	0.095[a]
Cardiac catheterization			
Right side (n, %)	943 [9.6]	940 [11.6]	0.000
Left side (n, %)	1390 [14.2]	1445 [17.8]	0.000
Radiography (n, %)	8976 (91.5)	7613 (94)	0.000
Median number	8 [10]	10 [10]	0.000[a]
Electrocardiography (n, %)	7751 (79)	6430 (79.4)	0.518
Median number	2 [2]	2 [2]	0.000[a]
Echocardiography (n, %)	6656 (67.8)	5807 (71.7)	0.000
Median number	1 [1]	1 [1]	0.000[a]
Swan–Ganz catheter (n, %)	124 (1.3)	213 (2.6)	0.000
Median days	3 [5]	4 [4]	0.301[a]

[ ]: interquantile range.
[a] Calculated by Mann–Whitney test, other *P*-values by Fisher exact test.

The use of diagnostic tests or procedures is reported in Table 2. The number of days differed significantly in cases in which conventional radiography, electrocardiography, and echocardiography were used for diagnosis. Approximately 10.2% of chronic HF cases and 11.4% of acute HF cases received any surgical procedures. In particular, 4.9% of chronic HF cases and 5.7% of acute HF cases underwent HF-related cardiac surgery. Use of ventilation support differed significantly (5.5% of chronic HF and 10.4% of acute HF). The number of days of ventilation support, however, was not statistically different ($P=0.345$). The difference in use of specific diagnostic tests (cardiac catheterization, radiography, echocardiography, and Swan–Ganz catheter) was statistically significant.

The percentage of chronic versus acute HF cases receiving prescription medication (digoxin, loop diuretics, thiazide, AT-receptor inhibitor, isosorbide, and metoprolol) differed. The total prescribed dose of digoxin, loop diuretics, spinorolactone, and isosorbide also varied during hospitalization. Median LOS was 18 days for chronic or acute HF, whereas the total charge was US$5731 and US$6447, respectively (Table 3).

After adjusting for demographic and clinical variables, the disease progression category was associated with resource use in, at best, a minor way. In comparison with other study variables, acute HF was significantly associated with LOS and TC (estimated values: −0.058 and 0.026, respectively). Performance of a procedure was more prominently associated with LOS and TC (estimated values: 0.580 and 1.146, respectively). The NYHA class increased the utilization of more resources. Cases categorized as class 3

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Table 3
Medication and resource use during hospitalization according to disease severity of heart failure

Medication	Chronic HF	Acute HF	P
Digoxin (n, %)	1682 (17.1)	1504 (18.6)	0.013
Dose (mg)	3 [4]	3 [4]	0.016 [a]
Dopamine (n, %)	1539 (15.7)	1596 (19.7)	0.000
Dose (mg)	1500 [3000]	1295 [2400]	0.009
Loop diuretics (n, %)	7822 (79.7)	6934 (85.6)	0.000
Dose (mg)	940 [1380]	800 [1230]	0.000 [a]
Spironolactone (n, %)	4178 (42.6)	3578 (44.2)	0.031
Dose (mg)	725 [738]	700 [675]	0.005 [a]
Thiazide (n, %)	639 (6.5)	306 (3.8)	0.000
Dose (mg)	42 [64]	43 [57]	0.727 [a]
AT-receptor inhibitor (n, %)	3712 (37.8)	3394 (41.9)	0.000
Dose (mg)	572 [1296]	600 [1304]	0.189 [a]
ACE inhibitor (n, %)	2184 (22.3)	1849 (22.8)	0.369
Dose (mg)	110 [151]	115 [143]	0.181 [a]
Isosorbide (n, %)	2893 (29.5)	2810 (34.7)	0.000
Dose (mg)	260 [1115]	100 [915]	0.000 [a]
Metoprolol, n (%)	201 (2)	222 (2.7)	0.003
Dose (mg)	700 [1210]	660 [1205]	0.490 [a]
Bisoprolol (n, %)	246 (2.5)	200 (2.5)	0.885
Dose (mg)	85 [97]	78 [100]	0.255 [a]
Carvedilol (n, %)	2682 (27.3)	2238 (27.6)	0.662
Dose (mg)	135 [200]	125 [185]	0.085 [a]
Length of stay (days)	18 [20]	18 [18]	0.037
Total charge (US$)	5731 [6492]	6447 [6803]	0.000 [a]

[ ]: interquantile range.
[a] Calculated by Mann–Whitney test; other P-values by Fisher exact test.

or 4 resulted in longer LOS or higher TC, as compared with class 1 cases (Table 4).

4. Discussion

Using a Japanese administrative database from 413 hospitals, this study presents descriptive characteristics of practice profiling and resource use and identifies the independent effect of disease progression on LOS and TC for heart failure cases. Regarding the total dose of prescribed medications during hospitalization, digoxin, loop diuretics, spinorolactone, and isosorbide were prescribed for more chronic HF patients than for acute HF patients.

Among diagnostic tests, conventional radiography and pulmonary artery monitoring were ordered for more acute HF cases than for chronic HF cases. Use of therapeutic procedures other than ventilation support was more frequent for chronic HF patients. After controlling for patient demographic factors, severity of comorbidity, use of procedures, and hospital functions, acute HF was associated with a slightly shorter LOS and a slightly higher TC, as compared with chronic HF.

Some limitations to interpretations of this study should be noted. First, information was gathered on discharged patients during only a six-month period in 2006. Although the short-term nature of the study might limit the general application

Table 4
Linear regression analysis of log-transformed length of stay (LOS) or total charge (TC) for heart failure patients

Parameter	Log LOS			Log TC		
	Estimation	S.E. (a)	P	Estimation	S.E. (a)	P
Intercept	2.579	0.024	0.000	8.348	0.021	0.000
Age (≥65 years)	0.044	0.017	0.008	−0.077	0.014	0.000
Male	−0.069	0.013	0.000	0.002	0.011	0.872
Ambulance	−0.091	0.014	0.000	0.024	0.012	0.043
Mortality	−0.305	0.022	0.000	−0.078	0.019	0.000
Disease severity (for chronic HF)						
Acute HF	−0.058	0.013	0.000	0.026	0.011	0.017
Charlson Comorbidity Index (for zero)						
1	0.064	0.015	0.000	0.067	0.013	0.000
2	0.131	0.018	0.000	0.087	0.016	0.000
3	0.169	0.030	0.000	0.116	0.026	0.000
≥4	0.168	0.041	0.000	0.125	0.036	0.000
NYHA (for NYHAI)						
NYHA II	0.070	0.019	0.000	0.035	0.016	0.033
NYHA III	0.196	0.019	0.000	0.147	0.016	0.000
NYHA IV	0.184	0.020	0.000	0.205	0.017	0.000
Other comorbidities						
Hypertensive diseases	−0.021	0.013	0.101	0.013	0.011	0.265
Valve disorders	0.035	0.018	0.049	0.032'	0.016	0.040
Cardiomyopathy	0.147	0.027	0.000	0.192	0.023	0.000
Surgical procedure	0.580	0.020	0.000	1.146	0.018	0.000
Artificial ventilation	0.216	0.024	0.000	0.524	0.021	0.000
Dialysis	−0.103	0.032	0.001	0.134	0.028	0.000
Rehabilitation	0.549	0.016	0.000	0.500	0.014	0.000
Hospitals (for community hospitals)						
Academic hospitals	0.160	0.018	0.000	0.231	0.015	0.000

F test for the model. Log LOS: $P<0.001$; Log TC: $P<0.001$.
Coefficient of determination. Log LOS: 0.147; Log TC: 0.334.
(a) S.E.: standard error.

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of these results, the sample size of this database is increasing each year due to more hospitals participating in this research. Thus, our findings might be strengthened by future use of a larger database covering a longer time-period.

Second, claims data limited to care delivered during hospitalization were analyzed in this study, and lack of outpatient department (OPD) data might influence these results. Our research project started to gather OPD information in the same electronic format as used in the structure of the inpatient data. By combining these types of databases, episodes of inpatient HF care eventually will be followed to the outpatient setting, so that researchers may identify the effect of new onset HF or readmission HF separately.

Third, this study analyzed important clinical data such as NYHA class and the presence of other heart-related comorbidities. On the other hand, clinical and laboratory data reflecting physiological conditions (such as serum creatinine levels or blood pressure) at admission were not surveyed in our study. Nevertheless, use of dialysis or dopamine in the present study might be surrogate markers for certain clinical data.

In Japan, LOS for all hospital admissions is two to three times longer than in hospitals in Western countries [21]. One reason for the increased LOS is that Japanese hospitals generally provide rehabilitation and nursing home services in addition to acute medical care. The fiscal impact of longer LOS includes the real costs consumed during each episode of HF, as well as the reductions in caregiver and economic burden on family members after patient discharge [22,23]. Therefore, our findings may indicate a more realistic comparison of the effects of disease progression categories, which would represent a strength of the current study.

In health policy research targeting practice variations or outcomes, risk adjustment should be taken into account. HF has been analyzed in many economic evaluations of new pharmaceutical agents and technologies because HF care has resulted in increased financial burden. When investigating the quality or efficiency of HF treatment, the disease severity of HF cases at admission may affect resource use or the practice pattern.

Kane-Gill et al. categorized HF patients into three groups: new onset HF, known HF, and readmission HF [15]. Total hospitalization costs were similar, whereas some service costs differed. If new onset HF is similar to the cases of acute HF analyzed in our study, their results seemingly match our results. However, their study did not input the variable of daily activity such as the NYHA class and did not consider the effect of the pre-hospital severity of chronic HF adequately. Residual heart capacity might buffer the degree of worsening heart function, thus sparing extra medical costs. In fact, our study demonstrated that NYHA classes 3 and 4, which have a diminished residual capacity, have greater effect on costs than do disease progression categories.

HF disease progression at admission might be a clinical concern when starting inpatient treatment. Clinical experts assumed that acute HF would cost more than chronic HF. To test such an assumption, the type of analysis we employed will be useful in indicating the impact of disease severity in clinical studies of healthcare costs. Unexpectedly, our results were contrary to clinicians' assumptions in the current study. A possible explanation is that HF patients admitted to acute care hospitals, whether they were acute of chronic, might have a condition so urgent that some interventions or care should be delivered without any delay. If chronic HF patients experience readmission during long-term clinical follow-up, they need incremental medical care corresponding to that required to treat the exacerbation of chronic HF meaning acute deterioration. Thus, disease progression status of HF patients might have a modest or no effect on resource use and may be an indicator of appropriateness for performing some critical medical procedures.

In conclusion, we used an administrative database to present descriptive characteristics and variations of resource use for acute versus chronic HF patients in Japan. Analysis of the independent effect of the disease progression status demonstrated modest or minimal effect on LOS and TC. Some laboratory tests or therapeutic agents were required in more chronic HF patients than in acute HF patients. Application of the disease progression status at hospital admission of HF patients may be limited to information for monitoring the clinical validity of performing some surgical procedures, other intensive procedures, or administration of medicines.

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The authors of this manuscript have certified that they comply with the Principles of Ethical Publishing in the International Journal of Cardiology [24].

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Original article

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Cost of open versus laparoscopic appendectomy

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Riassunto

Scopo. Vi sono diversi lavori scientifici sulla disparità dei risultati nei pazienti operati di appendicectomia a cielo aperto (OA) o per via laparoscopica (LA). Comunque, non vi sono studi che stabiliscano le differenze delle procedure OA e LA in termini di costi e di esiti che siano aggiustati per l'età, per la funzione dell'ospedale, e per la regione. Questo studio esamina le differenze tra OA e LA nei costi e nelle complicanze.

Materiali e Metodi. Lo studio riguarda 1703 pazienti appendicectomizzati, a causa di appendicite, in 76 ospedali accademici e in 80 ospedali comuni. Le variabili demografiche e cliniche, la durata del ricovero (LOS), le spese totali (TC; US$) ed il tasso di complicazioni sono stati identificati mediante analisi multivariata.

Risultati. 1469 (86,3%) pazienti erano stati sottoposti a OA, 234 (13,7%) a LA. Una appendicite complicata era stata diagnosticata nel 13,1% dei casi OA e nel 15,4% dei casi LA. Il tasso di complicazioni era del 3,4% in OA e del 2,6% in LA (p=0,504). Vi era una significativa differenza nella LOS e nelle TC in relazione alla severità dell'appendicite ed al tipo di procedura. Dopo aggiustamento del rischio per le altre variabili dello studio, la LA, rispetto a OA, appariva associata a più elevate TC ($1458, p<0,001). Comunque, non vi erano significative differenze nella LOS o nel tasso di complicazioni tra i due gruppi di trattamento.

Conclusioni. Questo studio suggerisce che la LA comporta un aumento del costo ma non ha un significativo impatto sulla LOS e sul tasso di complicazioni. Comunque, altri altri dati come la qualità della vita e l'analisi di sottogruppo per pazienti obesi si rendono necessari per una più completa analisi economica della OA e della LA. ***Clin Ter 2008; 159(3):155-163***

Parole chiave: *classificazione case-mix, appendicectomia laparoscopica, appendicectomia a cielo aperto, risultati, uso delle risorse*

Abstract

Aims. There are several literatures on outcome variations between patients treated with an open appendectomy (OA) and a laparoscopic appendectomy (LA). However, there are no studies assessing differences in cost and outcome that adjust for age and hospital function or region. This study examines the differences in cost and procedure-related complications of OA and LA procedures.

Materials and Methods. This study contains 1703 appendectomy patients treated for appendicitis in 76 academic hospitals and 80 community hospitals. Demographic variables, clinical variables, length of stay (LOS), total charges (TC; US$) and complication rates were analyzed for both OA and LA procedures. The specific contributions of LA to LOS, TC, and complication rate were identified using multivariate analysis.

Results. 1469 (86.3%) patients underwent OA and 234 (13.7%) underwent LA. Complicated appendicitis was diagnosed in 13.1% of OA cases and 15.4% of LA cases. The complication rates were 3.4% in OA and 2.6% in LA (p=0.504). There were significant differences in LOS and TC by severity of appendicitis and by procedure type. After risk adjustment for the other study variables, LA was associated with a higher TC than OA ($1458, p<0.001). However there were no significant differences in LOS or complication rates between the two treatment groups.

Conclusions. This study suggests that LA increases cost, but has no significant impact on LOS or complication rates. However, other outcomes such as quality of life or subgroup analysis for obese patients are needed for a more complete economic analysis of OA and LA. ***Clin Ter 2008; 159(3):155-163***

Key words: *case-mix classification, laparoscopic appendectomy, open appendectomy, outcome, resource use*

Introduction

New procedural technologies such as percutaneous coronary interventions or laparoscopic surgery are increasingly being employed in Japan as well as in many other developed countries. Many economic evaluations of these novel advancements have been published and proponents and criticisms of these articles abound (1-4). Some proponents argue that laparoscopic or video-assisted surgery gives the advantage of less postoperative pain and earlier mobiliza-

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tion, resulting in an earlier return to activity and an improvement in postoperative quality of life. Meanwhile, critics of these procedures site disadvantages such as increases in operative cost, increases in operative time, safety concerns of using new procedures, and higher complication rates. Regardless of opinion, rapid technologic advances, such as new medications, laboratory tests, and diagnostic imaging, have assuredly changed the field of medicine. Economic assessment of these novel technologies is required in order to promote their widespread use. These evaluations will give better answers to both policy makers establishing more efficient healthcare systems as well as to potential patients making therapeutic decisions.

Of these emerging surgical maneuvers, laparoscopic appendectomy is one of the oldest and most studied. Extensive research has been performed to compare conventional open appendectomy (OA) to laparoscopic appendectomy (LA) (5-10). Many of these literatures have concluded that LA reduces complications and enhances quality of life. However, these conclusions still leave many questions unanswered. Some of these include the effect of age or severity of disease on procedure related outcome and the value of decremental LOS or quality of life gained by incremental cost of using disposable instruments. The only study which evaluated the mean cost of LA and OA was from a single medical center with a limited number of cases, and so it lacks generalizability. Furthermore, regional practice variation and technology dilution need to be taken into consideration when conducting research on the cost-effectiveness of a new technology such as LA (11-15).

The Survey of National Medical Care Insurance Services, published by Ministry of Health, Welfare and Labor, demonstrated that LA use has been increasing in Japan. LA increased from approximately 240 procedures in 1996 (approximately 0.4% of all appendectomies) to 9,300 procedures in 2001 (13% of all appendectomies) (16, 17). Since 2002, the administrative database has been reformed in order to develop a new Japanese case-mix classification system. This system is utilized to profile hospital performance and to assess per diem payment for 82 special functioning hospitals (80 academic university hospitals, the National Cancer Center, and the National Cardiovascular Center) and 92 voluntary community hospitals. These hospitals, scattered throughout Japan, all play a leading role in the delivery of acute care, the advancement of medical research, and the education of students and residents. The database is derived from this case-mix system and contains both discharge summaries and claim data. It provides a resource to analyze practice variation of the treatment of appendicitis and to assess of LA and OA use.

This national administrative database has the statistical power to investigate differences in cost and outcomes between LA and OA, after controlling for age, disease severity, and regional variation. In this study, we analyzed all appendectomy cases treated for appendicitis patients at any of the special functioning or selected community hospitals in the database. This study aims to present descriptive statistics of resource use and outcomes of LA and OA in seven Japanese regions. It also uses multivariate regression analysis to determine the independent effect of these two procedures on cost and clinical outcomes.

Materials and Methods

This is a secondary data analysis embedded in a government sponsored research project on the development of a case-mix classification system. Anonymous claims and clinical data were provided via a research contract by the Ministry of Health, Labor and Welfare (MHLW) authority. Clinical information and claim data were gathered from 82 special functioning hospitals and 92 community hospitals. Data were gathered by MHLW and merged into a standardized electronic format for 441,142 patients discharged between July 1 and October 31, 2003. From this initial dataset, we selected 2679 patients who had been treated for appendicitis. We excluded patients who did not undergo an appendectomy or who underwent a concomitant bowel resection.

Variable definition

Independent study variables included age, gender, principal diagnosis, use of an ambulance, presence of a chronic co-morbidity, type of procedure (laparoscopic or open appendectomy), presence of procedure related complications, outcome at discharge, and hospital location and function. The main independent variable was type of procedure; the others were considered covariates. We used length of stay (LOS) and total charges (TC; US$1=¥120) billed during admission as proxies for total cost. In Japan, charges for hospital care are determined by a standardized fee-for-service payment system known as the nationally uniform fee table. TC in this study included physician fees, instrument costs, the costs of laboratory or imaging tests, and administration fees. Age was stratified into three groups: under 15 years, 15 through 64 years, and over 65 years. We used transfer by ambulance as a proxy for emergency admission.

A maximum of four co-morbidities were recorded in the database. To assess chronic co-morbid conditions, we used the Dartmouth-Manitoba (MD) index, which we translated from its original ICD-9CM form into ICD-10 code (17, 18). Co-morbid variables were identified as present if a patient had any of the following conditions in any of the four secondary diagnosis columns: mild diabetes mellitus (mDM), diabetes mellitus with end-organ damage (sDM), peripheral vascular disease (PVD), dementia (DEM), chronic obstructive pulmonary disease (COPD), congestive heart disease (CHF), chronic renal failure (CRF), connective tissue disease (CTD), mild liver disease (mLD), severe liver disease (sLD), and malignancy (MAL). The patient was coded as having a chronic co-morbid condition if at least one of these diagnoses was present. A maximum of three complications, defined as unexpected events after admission, were also recorded in the database. Complications were identified as present if any of the following conditions were recorded: wound infection, hematoma, bowel obstruction, peritonitis or other procedure related early complications (19). The principal diagnosis of appendicitis was recorded in ICD-10 as either complicated appendicitis (including acute appendicitis with panperitonitis or intra-abdominal abscess), acute appendicitis without panperitonitis or abscess, or appendicitis not otherwise specified (Annex table).

The database records a maximum of five operative procedures for each hospitalization. Patients receiving LA or OA without bowel resection were included in this study. LA procedures that were converted to OA were counted as OA. To create a variable for hospital location, we divided Japan into seven regions: Hokkaido & Tohoku, Kanto, Tokyo metropolitan, Chubu, Kinki, Chugoku & Shikoku, and Kyushu (Fig. 1).

Statistical analysis

All categorical data, except hospital region and function, were reported in terms of the proportion of each procedure performed there. Comparisons were made using Fisher's exact test. Data on age was compared using the Mann-Whitey test. Prevalence of OA and LA were shown for every hospital region and function. Distributions of LOS and TC were demonstrated by age, principal diagnosis, hospital region, and procedure. Differences between groups of age, principal diagnosis, or hospital region were tested for significance using an analysis of variance in OA or LA. We used multiple linear regression models to identify the separate effect of two procedures on LOS and TC. A logistic regression model was used to evaluate the relationship between the two procedures and the presence of complications. Statistical analysis was performed using SPSS version 14.0. All reported p values were two-tailed and the level of significance was set at less than 0.05.

Results

We identified 1,703 appendectomy patients across 156 hospitals (76 special functioning hospitals and 80 community hospitals). There were no cases that resulted in death in our study. Of the included cases, 1469 patients (86.3%) underwent OA and 234 (13.7%) underwent LA. The median age of the patients was 27 years for OA cases and 21 years for LA cases. The statistically significant majority of both procedures were performed on patient ages 15 through 64 years (66.5% in OA and 60.7% in LA). The proportion of male patients was 56.9% in OA cases and 51.7% in LA cases. An ambulance was used in 7.8% of OA cases and 8.1% of LA cases. The proportion of cases with a primary diagnosis of complicated appendicitis varied significantly by procedure with 13.1% of OA cases and 15.4% of LA cases. Chronic co-morbidities were present in 3.1% of OA cases and 2.6% of LA cases. Complications occurred in 3.4 % of OA cases and 2.6% of LA cases. The proportion of laparoscopic procedures varied significantly between regions and hospital functions. Kinki had the largest proportion of LA procedures (22.8%), whereas Chugoku and Sikoku had the least (3.7%). A larger proportion of appendectomy cases were done laparoscopically in community hospitals (17.0%) compared to special functioning hospitals (11.0%) (Table 1).

A comparison of LOS and TC between categorical variables is shown in Figures 2, 3 and 4. Both LOS and TC were highest in patients aged 65 years or older for both LA and OA procedures, however LOS for OA or LA and TC only for OA were significantly different (Fig. 2). Median LOS and TC were significantly higher in complicated appendicitis compared to uncomplicated cases in both OA and LA procedures (Fig. 3). Median LOS and TC were the lowest in LA procedures done in Hokkaido & Tohoku, Chubu, and Chugoku & Sikoku. However, most regional differences were statistically significant only in LOS for OA (Fig. 4).

Area	Population (1000 people)	Area mile^2
Hokkaido & Tohoku	15,406	55,627
Tokyo metropolitan	12,310	821
Kanto	28,775	11,737
Chubu	21,748	24,053
Kinki	22,761	12,864
Chugoku & Sikoku	11,834	19,766
Kyushu	14,785	16,477

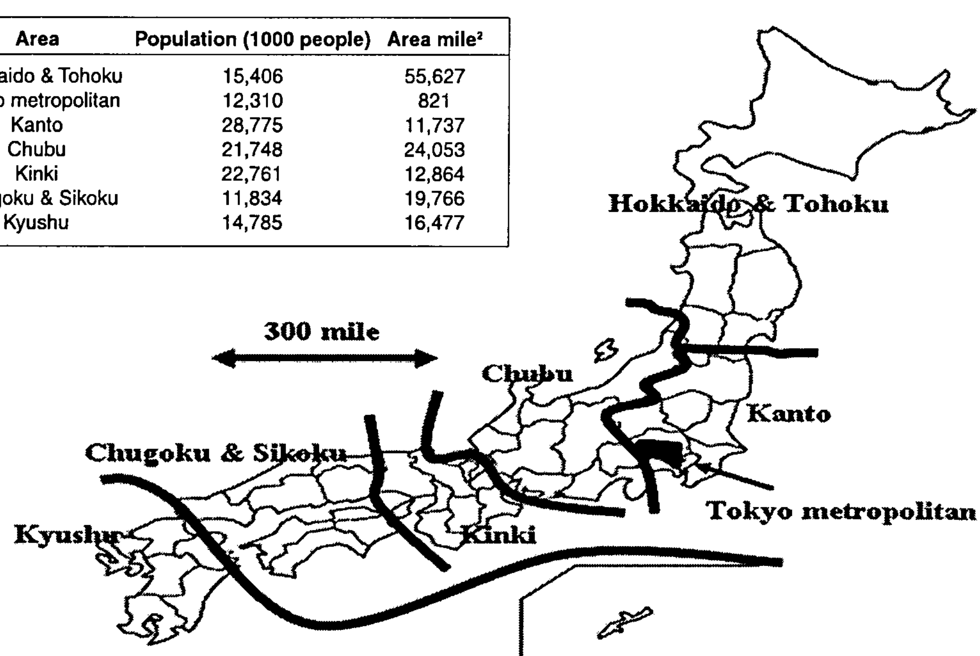


Fig. 1. Geographic region and vital statistic in Japan (2005).

Table 1. Characteristics of appendectomy patients (N =1703) stratified by procedure.

	Open appendectomy		Laparoscopic appendectomy		p
	n	%	n	%	
Total Number of Patients	1469	86.26	234	13.74	
Age					
median age (years)	27		21		0.000†
under 15 years	350	23.8	81	34.6	0.000
15 through 64 years	977	66.5	142	60.7	
65 years or older	142	9.7	11	4.7	
Gender					
male	836	56.9	121	51.7	0.136
Use of an Ambulance	114	7.8	19	8.1	0.849
Primary diagnosis					
complicated appendicitis	192	13.1	36	15.4	0.003
acute appendicitis	1179	80.3	169	72.2	
appendicitis NEC	98	6.7	29	12.4	
Presence of chronic comorbidities	45		6	2.6	0.677
Procedure related complications	50	3.4	6	2.6	0.504
Region					
Hokkaido & Tohoku	158	84.9	28	15.1	0.000
Kanto	336	87.0	50	13.0	
Tokyo metropolitan	291	84.3	54	15.7	
Chubu	203	86.0	33	14.0	
Kinki	132	77.2	39	22.8	
Chugoku & Sikoku	157	96.3	6	3.7	
Kyushu	192	88.9	24	11.1	
Hospital function					
Special function	649	89.0	133	11.0	0.000
Community	820	83.0	101	17.0	

p value for chi-square test and Mann-Whitney test †

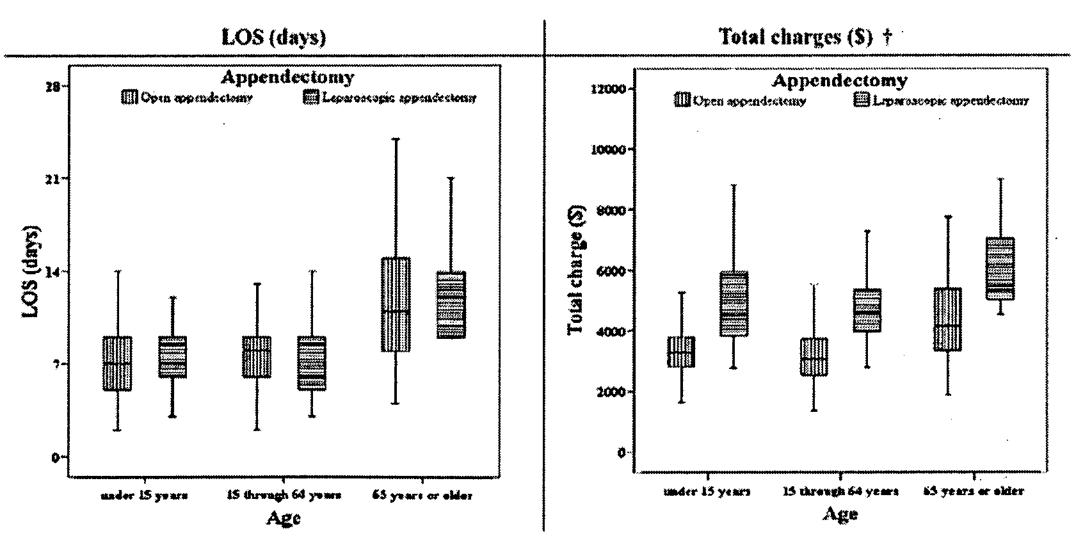


Fig. 2. LOS and total charge ($) by procedure and age.

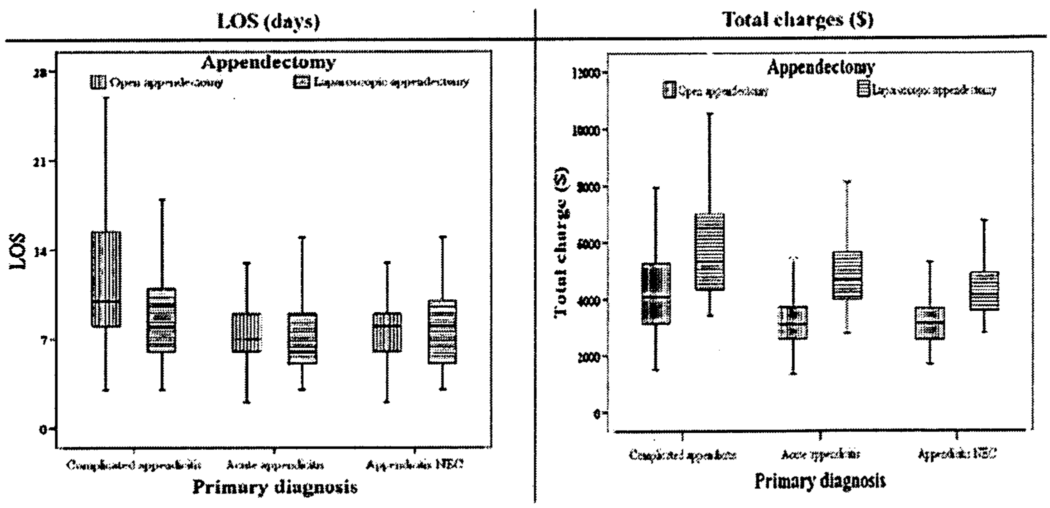
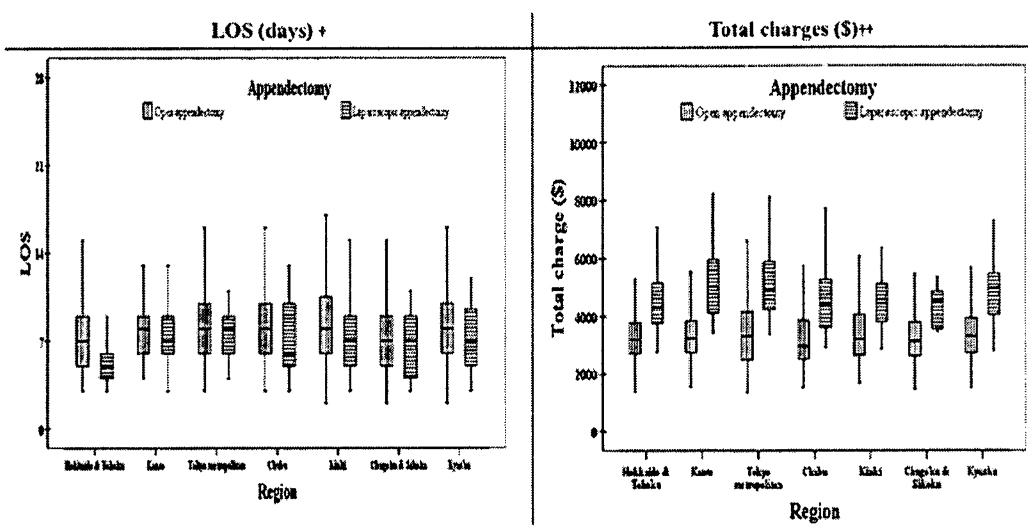


Fig. 3. LOS and total charge ($) by procedure and primary diagnosis.



†: statistically insignificance in LA (p=0.201)

††: statistically insignificance in OA and LA (p=0.389, 0.432, respectively)

Fig. 4. LOS and total charge ($) by procedure and region.

After adjusting for potentially confounding demographic and clinical variables, LA was not significantly associated with LOS (-0.45 days; CI=-1.22;- 0.32) but it was associated with an increased TC ($1458; CI=$1170;1746). The presence of a complication was the most significant factor in predicting LOS and TC (11.96 days; CI= 10.49;13.44, $3328; CI=$2773;3883). Regional variation did not significantly predict TC but it did predict LOS (Tables 2, 3). After controlling for covariates, LA no longer remained significantly associated with the rate of procedure-related complications (odds ratio [OR] = 0.656; CI=0.267-1.612). Complication was significantly higher in patients with a diagnosis of complicated appendicitis (OR=3.686; CI=1.186;11.451) (Table 4).

Discussion

This study presents descriptive characteristics of appendectomy cases and identifies the independent effect of procedure type on LOS, TC, and complication rate. It uses data from an administrative database of 76 special functioning hospitals and 80 community hospitals in Japan. This study shows the healthcare impact of laparoscopic surgery for appendicitis by using real world data to assess the incremental costs and outcome differences between OA and LA after controlling for age, severity of appendicitis and regional variation. After risk adjustment for other independent covariables, LA was found to have a significantly higher TC ($1458; CI=$1170;$1746; $p<0.001$), an insignificantly lower

Table 2. Linear regression analysis of factors associated with length of stay.

Independent variables	Unstandarized Coeffcient	95% CI	Standarized Coeffcient	p
Intercept	7.87	[6.66 - 9.08]		0.000
Age (reference: 15 to 64 years)				
Under 15 years	-0.53	[-1.15 - 0.09]	-0.040	0.090
65 years or older	4.26	[3.32 - 5.2]	0.190	0.000
Male	-0.16	[-0.68 - 0.36]	-0.010	0.550
Ambulance used	0.47	[-0.52 - 1.45]	0.020	0.350
Primary diagnosis (reference: appendicitis NEC)				
Complicated appendicitis	3.53	[2.33 - 4.73]	0.190	0.000
Acute appendicitis	-0.19	[-1.19 - 0.81]	-0.010	0.710
Chronic comorbidities				
Present	2.89	[1.35 - 4.43]	0.080	0.000
Outcome				
Procedure related complication	11.96	[10.49 - 13.44]	0.340	0.000
Procedure (reference: open appendectomy)				
Laparoscopic appendectomy	-0.45	[-1.22 - 0.32]	-0.020	0.250
Region (reference: Tokyo metropolitan)				
Hokkaido & Tohoku	-1.87	[-2.88 - -0.86]	-0.090	0.000
Kanto	-0.08	[-0.89 - 0.73]	-0.010	0.840
Chubu	0.12	[-0.79 - 1.04]	0.010	0.790
Kinki	-0.09	[-1.12 - 0.93]	0.000	0.860
Chugoku & Sikoku	-1.07	[-2.12 - -0.02]	-0.050	0.050
Kyushu	0.02	[-0.97 - 1.01]	0.000	0.970
Hospital function (reference: community hosp)	0.89	[0.32 - 1.47]	0.070	0.000

F test for the model; $P<0.001$, $R^2=0.267$

Table 3. Linear regression analysis of factors associated with total charges ($).

Independent variables	Unstandarized Coeffcient	95% CI	Standarized Coeffcient	p
Intercept	2638	[2184 - 3092]		0.000
Age (reference: 15 to 64 years)				
Under 15 years	37	[-195 - 270]	0.010	0.750
65 years or older	1452	[1100 - 1805]	0.180	0.000
Male	121	[-76 - 318]	0.030	0.230
Ambulance used	614	[244 - 985]	0.070	0.000
Primary diagnosis (reference: appendicitis NEC)				
Complicated appendicitis	988	[536 - 1441]	0.140	0.000
Acute appendicitis	98	[-279 - 475]	0.020	0.610
Chronic comorbidities				
Present	1240	[660 - 1821]	0.090	0.000
Outcome				
Procedure related complication	3328	[2773 - 3883]	0.250	0.000
Procedure (reference: open appendectomy)				
Laparoscopic appendectomy	1458	[1170 - 1746]	0.220	0.000
Region (reference: Tokyo metropolitan)				
Hokkaido & Tohoku	205	[-176 - 585]	0.030	0.290
Kanto	122	[-181 - 426]	0.020	0.430
Chubu	-129	[-473 - 215]	-0.020	0.460
Kinki	164	[-223 - 551]	0.020	0.410
Chugoku & Sikoku	-156	[-550 - 238]	-0.020	0.440
Kyushu	324	[-48 - 697]	0.050	0.090
Hospital function (reference: community hosp)	668	[451 - 884]	0.140	0.000

F test for the model; $P<0.001$, $R^2=0.238$

Table 4. Logistic regression analysis of factors associated with procedure-related complications.

Independent variables	Odds Ratio	[95% CI]	p
Age			
under 15 years	0.610	[0.285 - 1.304]	0.202
15 through 64 years	1.000		
65 years or older	1.560	[0.706 - 3.447]	0.272
Sex			
female	1.000		
male	1.774	[0.986 - 3.19]	0.056
Ambulance			
not used	1.000		
transferred	1.233	[0.535 - 2.839]	0.623
Primary diagnosis			
appendicitis NEC	1.000		
complicated appendicitis	3.686	[1.186 - 11.451]	0.024
acute appendicitis	0.934	[0.317 - 2.754]	0.902
Chronic comorbidities			
absent	1.000		
present	1.680	[0.531 - 5.317]	0.377
Procedure			
open appendectomy	1.000		
laparoscopic appendectomy	0.656	[0.267 - 1.612]	0.358
Region			
Tokyo Metropolitan	1.000		
Hokkaido & Tohoku	1.185	[0.445 - 3.153]	0.734
Kanto	0.384	[0.145 - 1.017]	0.054
Chubu	1.182	[0.517 - 2.699]	0.692
Kinki	0.896	[0.325 - 2.467]	0.831
Chugoku & Sikoku	1.411	[0.509 - 3.908]	0.508
Kyushu	0.684	[0.209 - 2.237]	0.530
Hospital function			
community	1.000		
academic	3.190	[1.66 - 6.129]	0.000

Hosmer Lemeshow goodness of fit; p=0.677

LOS (-0.45 days; CI=-1.22;-0.32; p=0.250), and an insignificantly lower complication rate (OR=0.656; CI=0.267;1.612; p=0.358) compared with OA.

There are some limitations to this study. First, information was gathered from discharged patients for only a four month period in 2003. This limits the generalizability of the results. Second, all types of procedure-related complications were combined into one group, whereas each would probably require a different level of resources. Claims data are now being collected throughout the year; this growing database will eventually allow researchers to identify the separate effect of each complication on LOS and TC. Third, this study lacked some important clinical data such as the results of any pathological findings or the presence of obesity[10]. However, we believe that the ICD-10 coded diagnosis was a close enough proxy for disease severity and pathologic findings would be superfluous. Furthermore, World Health Report 2002 indicated that body mass index is 23.4 in developed Western Pacific countries including Japan and 26.7 in developed European countries (20). So Japanese people in general have had so slender body structure that we felt that obesity would not greatly influence the results.

From an administrative as well as a clinical standpoint, this description of appendectomy cases will provide some answers as to the effectiveness of LA over OA, a matter which remains controversial. Other similar studies have been done in the past. For example, Guller and colleagues used a larger administrative database containing 46,101 appendectomy patients (OA=82.6% and LA=17.4%) (9). They reported a risk-adjusted median LOS of 2.88 days in OA and 2.06 days in LA. They also found that the risk-adjusted complication rate was lower in LA (OR=0.84) compared with in OA. Based on these findings, they concluded that LA has a significant advantage over OA. The differences in

LOS and in complication rates seemingly correspond to the directional trend of our results, although our results did not reach statistical significance.

One critique of the Guller study is the exclusion of hospital region and function in their analysis. Geographic location and hospital function both might have a significant impact on resource use variability (21, 22). In our study, the proportion of LA ranged from 3.7% in Chugoku & Sikoku to 22.8% in Kinki. Furthermore, significantly LA procedures were performed more in community hospitals (17.0%) than in special function hospitals (11.0%). Another critique of the Guller study is the exclusion of total cost as a dependent variable. Our study showed that only LOS, and not TC, significantly differed between the procedures (Fig. 4, Table 2 and 3).

Another study comparing LA and OA was done by Cothren and colleagues. They demonstrated a significant difference in total hospital charges between the two procedures ($12,310 in OA, $16,733 in LA) yet no significant differences in length of hospital stay (2.6 days in OA, 2.2 days in LA). This study concluded they submitted OA because it is cost effective procedure in teaching environment (21).

A few reports have assessed post-operative quality of life as a dependent variable in the comparison of LA and OA. Moberg investigated the time to full recovery and levels of physical activity, fatigue and pain at post-operative day 1, 5, and 10 after LA and OA by using visual analog scales. There was no difference in time to recovery between the two groups, though a statistically significant trend towards better physical activity was identified only at day 5 (8). A prospective randomized study by Katkhouda and colleagues assessed quality of life using the SF-36 and found improved scores after LA for three domains (physical functioning, general health and physical health) at two weeks post-surgery (6).

In Japan, LOS for all hospital admissions is two to three times longer than in Western countries (23, 24). One explanation for this is that Japanese hospitals generally provide care for wound management or for nursing home service in addition to their provision of acute medical care. These longer lengths of stay are thought to lessen the burden on family members after discharge. It is also thought that these longer hospital stays lessen patient anxiety about full recovery to normal life and prevent early readmission for procedure related complications. Furthermore, longer hospital stays are thought to reduce the chance of missing postoperative complications and thus they may actually reflect real costs consumed during each episode of acute illness.

Analysis of hospital stay lengths and medical costs are increasingly important, as most developed countries are tightening fiscal policy for healthcare delivery. Healthcare providers as well as health policy makers should take financial impact into account when clinical outcomes for various interventions are similar. This study is the first of its kind to report a significant difference in TC ($1,458), an insignificant difference of LOS (-0.45 days), and an insignificant difference in complication rate (OR=0.656) in LA compared to OA procedures after adjusting for potential confounders (e.g., age, hospital function or region).

Studies to date have demonstrated that laparoscopic treatment for appendicitis is more expensive and does not significantly affect hospital LOS or quality of life. However, it does offer other advantages. As such, more research needs to be done to evaluate the effectiveness of LA in selected cases (for example obese patients or children) for which LA is reported to improve wound management or psychological side effects(10). Physicians, patients, and researchers should make the decision to use a new medical technology if the benefits from improved quality of life were worth the burden of a higher total cost.

The methodology of this study could be applied to other procedures such as laparoscopic cholecystectomy or video assisted thoracic surgery. The new large standardized database of leading Japanese medical institutions can be used to understand how outcomes are influenced by any given set of independent variables. For example, if hospital region alone explains a large variation in resource use, as LOS was the case in this study, policy makers could further investigate the causes of such intra-regional and inter-hospital differences. If academic hospitals that deliver resident training consume more resources and encounter more complications, as we found in this study, these academic hospitals will need to evaluate their surgical curricula and request increased reimbursement rates for their care (21). Both of these interventions would lead to continuous quality improvement of appendectomy.

In conclusion, this study used data from an administrative database to present descriptive characteristics, costs, and outcome variations between open and laparoscopic appendectomy cases in Japan. Analysis of the independent effect of these procedures on length of hospital stay, total medical charges, and the rates of procedure related complications demonstrated TC for LA was significant higher than that for OA. However, LOS and procedure related complications were not significantly different between the two treatment types. Further study of short-term outcomes (such as quality of life) or of selected cases (such as obese patients) is needed to progress an economic analysis of new technologies.

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REGULAR ARTICLE

The association of the number of comorbidities and complications with length of stay, hospital mortality and LOS high outlier, based on administrative data

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Abstract

Objectives With greater concern for efficient resource allocation and profiling of medical care, a case-mix classification was applied for the per-diem payment system in Japan. Many questions remain, one of which is the role of comorbidity and complication (CC) in grouping logic. We examined the association of the number of CC with the length of hospital stay (LOS) and hospital mortality as well as the proportion of LOS high outliers in 19 major diagnostic categories (MDCs).

Methods This study was a secondary data analysis embedded in a government research project, including anonymous claims and clinical data during a 4-month period from July 2002. Every 19 MDC, LOS, hospital mortality or proportion of LOS high outliers was compared by the number of CC and presence of any procedures.

Results From 82 special function hospitals, 241,268 patients were enrolled in this study. Among all patients, 50.5% were identified without any CCs, 32.4% with one or two, 13.4% with three or four, and 3.7% with over five CCs. The overall mean LOS was 22.15 days and hospital mortality 26.05 cases per 1,000 admissions. In any MDC, LOS and the proportion of outliers increased as the number of CC rose. The mortality rate increased prominently in the respiratory system and the hematology system.

Conclusions This study demonstrated that the occurrence of more CC caused longer LOS and higher mortality in some major disease categories. Further study will clarify the association of the weighted CC with resource use through controlling procedures specific for MDC.

Keywords Comorbidity · Complication · Resource use · Mortality · Case mix

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Introduction

The role of comorbidities and complications (CC) in inpatient medicine has been an intense area of investigation, due to their impact on resource use, mortality, functional status, quality of life, and delivery of health care in Western societies [1–6]. Research on the impact of CC on healthcare utilization and quality of medical care is needed, as this is important to hospital payment systems and medical outcome studies [7, 8]. Many health-related problems increase with age, especially with respect to the number of chronic conditions [1]. As the proportion of chronic conditions increases across populations, practice behaviors will change that will impact hospital costs. Meanwhile, innovative procedures have been advocated for the elderly [9, 10]. Under these circumstances, the impact of CC or age on hospital resource utilization has been examined for diseases such as diabetes mellitus or for hospitalizations of trauma patients [11, 12].

In response to increasing costs associated with the rapid evolution of healthcare technology, cost containment policies and case-mix classification systems have advanced worldwide over the past 20 years [7, 8]. However, problems have emerged in situations where some patients are under-reimbursed if they have more CCs and have consumed more hospital resources than those with fewer CCs. Munoz et al. [13] reported major inequities in Diagnosis-Related Group (DRG) prospective payment systems for pediatric patients. Jencks et al. [14] showed that the number of recorded diagnoses was no higher for patients who died than for those who survived. These studies focused on selected conditions, such as pediatric illnesses, cardiovascular disease, and pneumonia.

In this study, our goal was to demonstrate the association of CCs with resource use and outcome by major diagnostic category (MDC) and treatment group (medical or surgical) using a large administrative database developed for the Japanese case-mix classification system (Diagnosis Procedure Combination; DPC). This type of systematic research has never been performed on this scale, and the results may have some important policy implications, in which MDC CCs may be considered in prior risk adjustment for payment or outcomes, such as resource use or mortality. The aims of this study were to generate descriptive statistics of CCs and to profile the association of length of stay (LOS) and hospital mortality with the number of CCs through the stratification of MDCs and treatments. Furthermore, we identified the relationship between the proportion of LOS high outliers and the number of CCs for each MDC.

Materials and methods

We conducted a secondary data analysis of a government research project on DPC development. Anonymous claims information and clinical data were provided by the Ministry of Health, Labor and Welfare (MHLW) through a research contract. Clinical data and claims information, merged into a standardized electronic format, were gathered by the MHLW for 266,677 patients who were discharged from 82 academic hospitals (80 university hospitals, National Cancer Center, and National Cardiovascular Center) between 1 July 2002 and 31 October 2002. The Japanese MHLW permits up to seven CCs (four comorbidities and three complications) to be listed in the DPC dataset. From this original dataset, we selected cases with a LOS of up to 365 days and excluded patients who died within 24 h of admission. A total of 241,268 patients were enrolled in the study. We categorized patients into three groups according to the number of CCs documented (absent, 1 or 2, 3 or 4, and 5 or more), based on a study by Munoz et al. [15].

The DPC system is made up of 16 MDCs. However, the 16th MDC consists of four different clinical entities: injury, poisoning, burns and the toxic effect of drugs; mental diseases and disorders; diseases and disorders of systemic infection; and miscellaneous. We therefore divided the 16th MDC into these four groups and analyzed a total of 19 MDCs (Table 1). The DPC database also allows a maximum of five operative procedures to be listed, for which the definition and pricing are determined from a nationally uniform fee table under the standardized fee-for-service payment system. Patients undergoing at least one surgical procedure, as defined by the Japanese fee table, comprised the "surgical group," while patients not undergoing any surgical procedure comprised the "medical group." We then divided patients into these two treatment groups for all 19 MDCs.

Statistical analysis

Patient characteristics were analyzed in terms of gender, age (under 15, 15–64, and 65 years or older), and number of procedures. The association between CC category and each of these patient characteristics was assessed using Fisher's exact test. The association between these patient characteristics and MDC was also assessed.

The mean age, LOS, and mortality rate per 1,000 admissions were calculated for each CC category and compared using analysis of variance (ANOVA). The mean LOS (days) and mortality rate (per 1,000 cases) were illustrated using spider-radar charts, stratified by treatment group (surgical or medical) and MDC. ANOVA was used to compare the mean LOS and mortality rate by treatment group for each MDC.

To define the proportion of high LOS outliers, we identified the 95th percentile of LOS for each MDC and categorized patients beyond that LOS into eight groups (e.g., four CC groups by two treatment groups). We then calculated the proportion of high LOS outliers (the numerator is the number of LOS outliers and the denominator is the number of all patients in the eight

Table 1 The proportion of comorbidity and complication category by presence of procedure and MDC (%)

Major diagnostic category			Absent	One or two	Three or four	Over five	N
Overall		Medical	47.8	33.8	14.9	3.5	123,895
		Surgical	53.4	30.9	11.8	3.9	117,373
MDC1	Nervous system	Medical	46.2	35.1	15.3	3.4	12,292
		Surgical	44.7	32.2	16.0	7.1	3,810
MDC2	Eye system	Medical	65.9	25.3	7.7	1.1	1,854
		Surgical	54.5	32.9	9.9	2.7	17,974
MDC3	Ear, nose, mouth, and throat system	Medical	62.4	26.8	8.5	2.3	5,881
		Surgical	65.0	26.5	6.4	2.1	8,374
MDC4	Respiratory system	Medical	44.2	36.8	15.4	3.6	14,666
		Surgical	47.0	33.5	13.3	6.2	3,609
MDC5	Cardiovascular system	Medical	32.0	40.2	24.4	3.4	12,264
		Surgical	31.5	37.3	23.7	7.5	10,768
MDC6	Digestive tract, hepatobiliary and pancreas system	Medical	49.3	35.3	12.7	2.6	20,697
		Surgical	48.2	34.2	13.4	4.2	24,383
MDC7	Muscuoskeletal and connective tissue system	Medical	51.1	31.2	13.9	3.8	7,671
		Surgical	63.5	24.9	8.8	2.8	11,018
MDC8	Skin and subcutaneous tissue system	Medical	50.3	35.1	11.9	2.7	3,500
		Surgical	69.6	22.8	5.2	2.4	671
MDC9	Breast system	Medical	60.0	27.3	9.9	2.9	1,144
		Surgical	69.7	23.4	5.8	1.1	2,532
MDC10	Endocrine, nutrition and metabolic system	Medical	36.0	36.1	23.7	4.2	8,156
		Surgical	44.0	35.1	15.7	5.2	2,784
MDC11	Kidney, urinary tract and male reproductive system	Medical	51.0	30.7	14.5	3.8	10,031
		Surgical	54.2	29.2	12.3	4.3	7,359
MDC12	Pregnancy, childbirth, puerperium and female reproductive system	Medical	61.1	28.7	7.7	2.5	6,195
		Surgical	59.5	29.6	8.4	2.4	10,951
MDC13	Hematology system	Medical	46.6	29.7	15.7	8.1	4,967
		Surgical	37.5	32.8	17.0	12.7	613
MDC14	Neonate system	Medical	49.6	32.0	12.9	5.5	4,386
		Surgical	66.0	24.0	7.3	2.8	4,202
MDC15	Pediatric system	Medical	64.0	28.8	6.4	0.8	1,916
		Surgical	70.0	20.0	5.0	5.0	20
MDC16	Injury, burns, poisonings and toxic effect of drugs	Medical	53.9	34.1	10.4	1.6	3,580
		Surgical	62.1	26.1	9.0	2.9	6,083
MDC17	Mental health system	Medical	47.1	31.4	16.7	4.8	1,256
		Surgical	0.0	0.0	0.0	0.0	0
MDC18	Systemic infection	Medical	41.9	34.1	16.4	7.6	962
		Surgical	29.2	30.3	17.8	22.7	185
MDC19	Miscellaneous	Medical	46.2	32.9	15.7	5.2	2,477
		Surgical	54.9	29.7	11.3	4.1	2,037

MDC major diagnostic category

groups) and demonstrated it with a broken line for each MDC. Statistical analyses were performed using SPSS version 14. All reported *P* values were two-tailed, and the level of significance was accepted as less than 0.05.

Results

The most frequently documented MDC was the digestive track, hepatobiliary, and pancreatic diseases (45,080 cases, 18.7% of all study cases) and the least frequently documented MDC was systemic infections (1,147 cases, 0.5%). Eye diseases were more common in the surgical group (17,974 cases, 80.7% of all eye diseases), while patients with mental disorders received no surgical treatment. When stratified by CC category, pediatric diseases had the highest proportion of no CCs (64% in the medical group and 70% in the surgical group) and cardiovascular diseases (32% in the medical group and 31.5% in the surgical group) had the lowest proportion of no CCs. On the other hand, hematological diseases (8.1% of medical patients and 12.7% of surgical patients) and systemic infections (7.6 and 22.7%, respectively) had the highest proportion of patients with five or more CCs (Table 1).

Among the 241,268 patients in the study population, 50.5% (47.8% of the medical group and 53.4% of the surgical group) had no CCs; 32.4% (33.8 and 30.9, respectively) had one or two CCs; 13.4% (14.9 and 11.8%, respectively) had three or four CCs; and 3.7% (3.5 and 3.9%, respectively) had five or more CCs. The proportion with no CCs ranged from 41.2% (38.6% of medical group and 43.8% of surgical group) in patients 65 years and older to 65.5% (60.4 and 72.8%, respectively) in patients less than 15 years. The proportion of patients with one or two CCs ranged from 25.9% for those less than 15 years to 35.4% for those 65 years or older; the proportion with three or four CCs ranged from 6.5 to 18.2%; the proportion with five or more CCs ranged from 2.1 to 5.2%. There was no gender difference in the proportion of the four CC categories. In both the medical and surgical groups, the proportion of patients with no CCs and with five or more CCs was statistically different by age and gender. There was a significant difference in the number of procedures for the four CC categories (Table 2).

Overall, the mean age was 51.23 years and the mean LOS was 22.15 days. For patients with no CCs, one or two CCs, three or four CCs, and five or more CCs, the mean ages were 47.09, 53.83, 59.05, and 59.26 years, respectively, and the mean LOS were 17.38, 23.44, 30.60, and 45.47 days, respectively. The overall mortality rate per 1,000 admissions was 26.05 cases (13.51, 26.94, 46.94, and 104.09, respectively). There were significant differences in age, LOS, and hospital mortality rate among the four CC groups (Table 3). As the number of CCs increased, the mean age, mean LOS, and mortality rate also increased.

Table 2 The proportion of comorbidity and complication category by age, gender, and presence of surgical procedure (%)

Category		Absent (%)	One or two (%)	Three or four (%)	Five or more (%)	*N*
Overall*		50.5	32.4	13.4	3.7	241,268
	Medical	47.8	33.8	14.9	3.5	123,895
	Surgical	53.4	30.9	11.8	3.9	117,373
Age*						
Under 15 years		65.5	25.9	6.5	2.1	25,969
	Medical	60.4	29.0	8.2	2.4	15,282
	Surgical	72.8	21.5	4.1	1.6	10,687
15-64 years		53.9	31.6	11.5	3.0	126,982
	Medical	51.1	33.2	12.8	2.9	64,097
	Surgical	56.8	30.0	10.1	3.0	62,885
65 years or more		41.2	35.4	18.2	5.2	88,317
	Medical	38.6	36.4	20.2	4.8	44,516
	Surgical	43.8	34.5	16.1	5.7	43,801
Gender*						
Female		52.3	31.9	12.4	3.4	112,243
	Medical	48.5	33.9	14.2	3.4	56,229
	Surgical	56.1	29.9	10.6	3.4	56,014
Male		48.9	32.8	14.3	4.0	129,025
	Medical	47.1	33.8	15.5	3.6	67,666
	Surgical	51.0	31.8	12.9	4.3	61,359
Number of procedures*						
	1	59.3	27.9	10.0	2.8	78,456
	2	46.1	35.1	13.7	5.1	25,108
	3	31.1	44.0	17.7	7.2	7,354
	4	41.7	34.3	17.2	6.7	4,698
	5	19.9	39.8	25.4	14.9	1,757

* Statistically significance at $P < 0.001$

The mean age and LOS were higher in the surgical group than in the medical group, although mortality was higher in the medical group.

The LOS for all MDCs, except for pediatric diseases, increased as the number of CCs increased. In particular, the mean LOS across the four CC categories was longer for hematological diseases, whereas for eye diseases, it was shortest and increased relatively slowly across the CC categories. There was a significant difference in mean LOS among the four CC categories within every MDC, except for the pediatric surgical group ($P = 0.084$) (Fig. 1).

Across the four CC categories, the mortality rate was higher for respiratory disease, digestive tract, hepatobiliary and pancreatic diseases, and hematological diseases than in other MDCs. The mortality rate was approximately zero for eye diseases, skin and soft tissue diseases, mental disorders, and in the pediatric surgical group. Apart from these MDCs, the surgical group had a lower mortality rate than the medical group for respiratory diseases, as well as for digestive tract, hepatobiliary and pancreatic diseases. There were significant differences in hospital mortality among the CC categories within every MDC, except for eye diseases (medical: $P = 0.793$, surgical $P = 0.928$), skin and soft tissue diseases ($P = 0.171$), endocrine, nutritional, and metabolic diseases (medical: $P = 0.920$, surgical $P = 0.416$), and mental disorders ($P = 0.223$) (Fig. 2).

Table 3 Descriptive characteristics of study variables by comorbidity or complication category and proportion of comorbidity and complication category by mean age, LOS, and mortality, stratified by treatment group

		Overall	Comorbidity and complication category			
			Absent	One or two	Three or four	Five or more
Mean age* (SD)		51.23 (23.39)	47.09 (24.15)	53.83 (22.34)	59.05 (20.02)	59.26 (20.72)
	Medical	50.51 (0.07)	46.15 (0.10)	52.56 (0.11)	58.19 (0.16)	57.53 (0.34)
	Surgical	52.18 (0.07)	47.98 (0.09)	55.29 (0.11)	60.20 (0.16)	60.91 (0.28)
Mean LOS* (SE)		22.15 (0.051)	17.38 (0.06)	23.44 (0.09)	30.60 (0.16)	45.47 (0.40)
	Medical	20.39 (0.07)	16.02 (0.09)	21.12 (0.12)	27.50 (0.20)	42.52 (0.56)
	Surgical	24.02 (0.07)	18.67 (0.08)	26.12 (0.14)	34.74 (0.27)	48.30 (0.56)
Mean mortality per 1,000 cases* (SE)		26.05 (0.32)	13.51 (0.33)	26.94 (0.58)	49.69 (1.21)	104.09 (3.24)
	Medical	36.92 (0.54)	21.90 (0.60)	37.22 (0.92)	62.29 (1.78)	130.63 (5.11)
	Surgical	14.58 (0.35)	5.58 (0.30)	15.06 (0.64)	32.91 (1.52)	78.76 (3.99)

SD standard deviation, *SE* standard error

* Statistically significance at $P < 0.001$

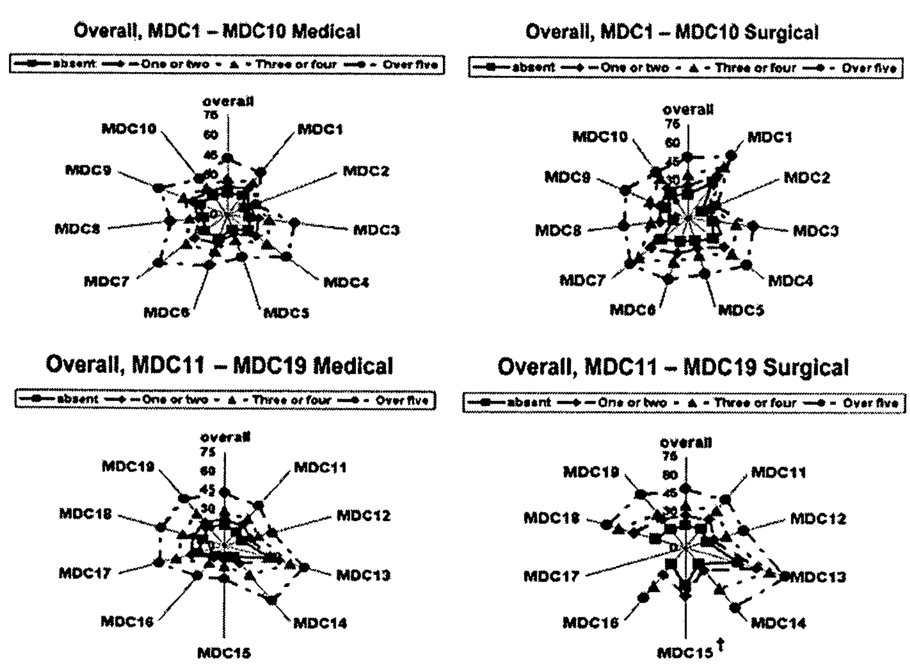

Fig. 1 LOS (days) and number of comorbidities and complications stratified by treatment group (medical or surgical) and major diagnostic category