Table 3 Observed and risk-adjusted means of total hospital costs, antibiotic costs, post-surgical length of stay in total and by hospital

	Total hospital costs (US$)				Antibiotic costs (US$)				Post-surgical length of stay (days)			
	Uninfected		Infected		Uninfected		Infected		Uninfected		Infected	
	Observed	Adjusted	Observed	Adjusted	Observed	Adjusted	Observed	Adjusted	Observed	Adjusted	Observed	Adjusted
Total	11 252.9	11 543.6	15 676.3	14 310.6	42.9	45.9	277.9	248.3	16.1	17.5	29.2	28.1
A	11 041.2	11 334.7	19 919.8	17 848.0	28.9	31.0	838.9	795.6	15.1	16.6	38.4	40.6
B	11 597.7	12 205.9	16 785.4	13 897.1	7.9	8.9	161.2	114.4	21.1	23.0	31.3	27.7
C	13 270.0	11 740.7	14 981.6	12 776.0	69.6	67.7	208.8	196.7	17.7	17.4	24.8	23.1
D	10 314.6	10 783.7	14 271.6	13 696.7	56.8	59.7	335.4	313.2	14.6	16.0	24.6	24.9
E	12 407.0	12 205.4	15 937.8	14 001.7	14.8	15.5	124.4	114.2	18.8	19.5	28.5	25.7
F	10 736.8	10 644.5	12 601.3	11 811.6	8.3	9.3	218.9	207.2	12.5	13.2	18.0	18.1
G	11 541.3	12 759.4	16 375.3	17 681.3	42.5	50.7	250.7	275.0	14.9	17.6	33.3	38.2
H	10 771.2	11 421.2	14 687.9	13 602.8	51.2	56.9	289.2	247.4	15.7	18.1	27.2	27.0
I	11 476.4	11 745.3	16 937.2	14 230.7	37.1	38.3	302.9	254.9	17.4	18.3	33.6	29.5
J	11 329.9	11 750.8	17 167.6	15 266.5	23.0	24.8	222.1	175.7	16.2	17.5	34.0	31.1

In the case of antibiotic costs, the regression model was able to account for 34.9% of variation observed, and 66.3% with hospital stratification included. Age and gender were not significant with antibiotic costs in both models. When hospitals were not included in analysis, pre-surgical LOS and gastrectomy type were significantly associated with antibiotic costs. When hospitals were included, only gastrectomy type remained significant, and surgery duration gained significance.

The regression models developed were able to account for 28.2% of variations in post-surgical LOS, and 32.2% after taking into account hospital stratification. Age showed significant association in both models, while gender showed association only when hospitals were not included in analysis. The only co-morbid condition significantly associated with post-surgical LOS was diabetes with complications in the first model. Furthermore, pre-surgical LOS, gastrectomy type and number of surgeries were significant factors associated with post-surgical LOS.

The risk-adjusted differences for all three medical resource utilization indicators between infected and uninfected patients at hospital level were shown in Table 3. Risk adjustment resulted in reducing the variation between infected and uninfected patients. Infected patients showed a risk-adjusted increase in US$2767, or approximately 24% for total hospital costs (and a pre-adjusted increase of US$4423.4). At the hospital level, there was a range of adjusted infection-based increases in total hospital costs from US$1035 (Hospital C) to US$6513 (Hospital A).

In general, infections were associated with an increase in US$202.4 in mean antibiotic costs. Prior to adjustment, the difference in antibiotic costs between infected and uninfected patients was US$235. Hospital E showed the least amount of increase at a risk-adjusted mean of US$98.8. The highest increase in antibiotic costs as a result of infections was seen in Hospital A, at US$764.6. In addition, Hospitals B, E and F presented very low antibiotic costs for their respective uninfected populations, at less than US$15.

Hospital stay was extended by an adjusted average of 10.6 days post surgery, as a result of infection. While most hospitals managed to control the extended LOS to approximately 10 days or less, Hospitals A and G large increases of 24 days and 20.7 days, respectively. Hospital B showed the lowest increase in mean post-surgical LOS in infected patients at only 4.7 days.

Discussion

In this study, we used a combination of ICD codes and antibiotic utilization patterns in order to identify HAIs in gastrectomy surgery patients admitted into 10 hospitals in Japan. Regression analysis was conducted to estimate the impact of medical resource utilization increases involved with infections, with resource utilization measured in three indicators – total hospital costs, antibiotic costs and post-surgical LOS. Finally, we conducted risk-adjusted performance comparisons within the 10 hospitals.

Previous studies have shown that the use of ICD codes to identify HAIs has poor sensitivity and positive predictive value [13,14]. Furthermore, using claims data alone to derive secondary diagnoses has been found to lack distinguishing ability between pre-existing conditions and conditions that occur post admission [22]. In response to these issues, we complemented ICD code identification with antibiotic utilization data and adjusted selection criteria to reduce misidentification of pre-existing conditions. The use of ICD codes alone would have resulted in an infection incidence of approximately 8%. ICD codes alone may have been limited to the more serious infections, while antibiotic utilization allowed us to include less severe infections in our calculations that were not reflected in ICD codes.

Evidence-based medicine supports that even with gastrectomy surgeries, a single dose of cefazolin before surgery is sufficient prophylaxis [23,24]. However, the Japanese Society for Chemotherapy produced guidelines that recommended 3–4 days of prophylaxis for clean-contaminated surgeries such as gastrectomy. Furthermore, a previous study [25] showed that the mean prophylaxis given to gastrectomy patients was approximately 3–4 days. Taking this into account, we adjusted for this over-utilization of antibiotics by allowing for a 3-day prophylactic period post surgery, and identifying cases with 4 or more days of antibiotic utilization as infections. The failure to do so may have resulted in mistakenly identifying antibiotic over-utilization as infections. However, there would be an uncertainty as to the validity of cases identified as infected by this criterion alone, as cases with 4 or more days of antibiotic utilization may simply represent antibiotic administration practice variation. Despite this, all cases that were identified by this criterion were further confirmed by at least one other identification criterion.

A previous study of a single hospital in Japan showed a 13.8% incidence of SSIs associated with gastrectomy [26], while the sample population here presented a 20.3% incidence proportion of infections that included other infections in addition to SSIs, such as bloodstream infections and pneumonia.

In all six regression models that we used, post-surgical HAIs were significantly associated with increases in total hospital costs, antibiotic costs and post-surgical LOS. Among the independent variables, comparisons of standardized coefficients (Table 2) showed that HAIs had the third highest magnitude of impact on total hospital costs (after type of gastrectomy and pre-surgical LOS), and the highest magnitude of impact on antibiotic costs and post-surgical LOS. Total hospital costs and post-surgical LOS were sensitive to all surgery-associated factors, but antibiotic costs were unsurprisingly less sensitive to this group of variables.

Post-surgical LOS showed significant associations with both age and gender, with elderly (≥70 years) male patients associated with longer hospital stays. This was consistent with previous studies that showed longer LOS periods associated with elderly [27] and male patients [28]. The problems of increases in post-surgical LOS associated with HAIs are further exacerbated by the already-lengthy hospital stay durations in Japan [29].

Pre-existing co-morbid conditions did not seem to show consistent or strong influences on increases in medical resource utilization based on our models, which may be due to the low volume of cases with co-morbidity scores. The two most common co-morbidities (that occurred in approximately 10% of the dataset population) were diabetes and metastatic cancer, which showed significant association with total hospital costs and antibiotic costs, respectively.

Even after risk adjustment, we observed large degrees of variation in HAI-associated increases in all three indicators. The difference between mean total hospital costs uninfected and infected patients ranged as much as from US$1035 in Hospital C to US$6513 in Hospital A. Hospital A had approximately 2.4 times the overall mean of increased total hospital costs associated with HAI, and had the largest observed difference between infected and uninfected patients with regards to post-surgical LOS. A more detailed inspection of the cases in Hospital A revealed that two of the five had MRSA infections, which may have accounted for the increased medical resource utilization reflected.

The overall risk-adjusted mean of increased antibiotic costs associated with HAIs was US$202. Table 2 showed that the R^2 value for the regression model using antibiotic costs as the dependent variable that had included hospital stratification was much higher than that of the model that did not. Furthermore, when hospital stratification was included in analysis, most of the hospitals showed significant association, implying high variation in antibiotic use at the hospital level. Hospital B showed the lowest adjusted antibiotic costs for uninfected patients at US$8.9, while Hospitals E and F also had very low values in this category. An analysis of the cases in these hospitals revealed that all uninfected cases were given the appropriate 1-day-only prophylaxis method as prescribed by evidence-based medicine. In addition to these laudable achievements, Hospitals B and E managed to control the increase in antibiotic costs in infected patients to US$99 and US$105, respectively. Increases in antibiotic costs in Hospital F were closer to the overall average at US$198. This could imply that there may be stringent antibiotic utilization guidelines in place at Hospitals B and E, and that they are strictly adhered to even in infected cases. The other seven hospitals had higher adjusted antibiotic costs in their uninfected cases, and an analysis of these hospitals showed that the majority of cases were given approximately 2–3 days of prophylaxis. This unfavourable utilization rates for uninfected cases reflected the results reported previously [25], and resulted in unnecessary cost as well as increase the risk of developing resistant bacteria.

With regards to limitations of this study, the sampled hospitals were part of a database known as the QIP. These hospitals had voluntarily entered this project in order to improve health care quality and management, and as such, may not represent the general situation of hospitals in Japan. Therefore, there may be a degree of selection bias and resulting generalizability issues.

We believe the method presented here can be similarly applied to analysing patients with other diseases and procedures. We have used this technique to quantify the increases in medical resource utilization associated with post-surgical HAIs, and also shown that even after adjusting for variations in patient characteristics and other variables, a large degree of variation still exists between hospitals in terms of resource utilization. In this study, we observed both good performers in terms of controlling infection incidence and the resulting resource utilization, as well as hospitals that did not perform as well. The results of this study were reported back to the participating hospitals in order to commend and encourage further good practice in good performers, as well as to bring attention to problem areas in the other hospitals. This information is highly useful for the hospitals involved as they represent not only information about their own hospitals, but provide a context of other hospitals in which to compare their own performance.

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Management patterns and healthcare costs for hospitalized patients with cerebral infarction

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Abstract

Objectives: Although evidence shows the importance of specialized intensive care of patients with cerebral infarction, it is not well known whether resources are generously applied in the initial period and how patterns of medical resource utilization are associated with characteristics of providers and patient outcomes. In this study, we analyzed changing patterns of daily medical cost using administrative healthcare claim data and identified a management pattern in each case.

Methods: We used Japan's administrative data to identify medical costs on a day-to-day basis. Data of 3136 patients with acute cerebral infarction from 14 medical institutions were included in the analyses. Using the data, we calculated the costs from the perspective of the third-party payer. Institutions were divided into three groups according to the distribution of medical costs in the first 2 days, and patient background, treatment process, and outcomes were compared across the groups.

Results: Medical cost was not necessarily intensively allocated during the early hospitalization period. Wide variations were observed in medical cost utilization patterns across institutions. The differences in medical cost for the initial hospitalization period appears to be more influenced by ICU utilization and management policies of institutions than the clinical condition of patients.

Conclusions: We proposed a methodology that uses administrative claim data to examine management patterns of ischemic stroke. We believe that the use of our method, in conjunction with accurate and detailed clinical data, can help elucidate the relationship among acute-period medical resource utilization, process of care, and patient outcomes.

Keywords: Cerebral infarctions; Cost of illness; Health resources; Utilization review; Hospital costs

1. Introduction

The utility of administrative healthcare data for evaluating the delivery of healthcare services is well established [1,2]. Japan's administrative healthcare data has been developed based on its unique medical payment system, the fee schedule system. This system determines a unified fee for each itemized service [3]. As such, medical charges are calculated by summing the fees for all procedures and products, and medical institutions are reimbursed on a fee-for-service basis. From these data, we not only can identify medical costs

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from the perspective of the third party payer, but also can itemize the daily quantity, type, and cost of all tests, medications, procedures, use of intensive or special care, and nursing services.

In this study, we investigated the changing patterns of daily hospitalization costs over time for patients with acute cerebral infarction by using administrative data. Currently, cerebral infarction places a large burden on Japanese society in terms of both morbidity and cost. The healthcare expenditure for stroke in 2004 was estimated to be 1900 billion yen (US$17 billion), with ischemic stroke patients accounting for about 60% of all stroke patients [4,5]. Many studies have demonstrated the importance of early diagnosis and treatment to reduce morbidity and mortality [6]. Under the slogan "time is brain," stroke management worldwide has focused on acute phase care due to growing evidence supporting the effectiveness of early intensive treatment [6–9]. However, it is not well known whether Japanese citizens enjoy these policy benefits.

A tacit acknowledgement exists that resources are more generously applied in the initial period after stroke admission but will decrease as patient conditions stabilize. However, it is unknown if this trend is true for all patients and healthcare providers. To answer this question, we identified characteristics of care provided to cerebral infarction patients and examined how patterns of medical resource utilization associate with traits of healthcare providers and patient outcomes. In this study, we analyzed the changing patterns of daily medical costs using administrative healthcare claim data and identified a management pattern in each case.

2. Methods

2.1. Study settings and subjects

All data for this study was extracted from the Quality Indicator/Improvement Project (QIP). The QIP collects administrative healthcare data from institutions and analyzes healthcare processes, patient outcomes, and management efficiency to provide feedback to participating medical institutions. Sixteen institutions participated in the project nationwide, most of which are designated as teaching hospitals. Administrative data were comprised of clinical information and healthcare claim data. Clinical information included patient demographics, primary and secondary diagnoses, comorbidities at the time of and after admission, operative data, severity of illnesses, as well as any special treatments (i.e., radiation therapy, artificial respiration, chemotherapy). Furthermore, healthcare claim data itemized the type, quantity, and fees for all tests, medications, procedures, use of intensive or specialized care, and nursing services. Using this data, we calculated costs from the perspective of the third-party payer.

Of 4895 patients with cerebral infarction discharged between January 2004 and March 2006 from the 16 QIP participant institutions, data were analyzed for patients greater than 20 years of age who had an urgent or emergent hospital admission. Specifically, patients whose ICD-10 primary diagnosis code was "I63 (cerebral infarction)" were selected for this study. The following cases were excluded after analyzing their primary and secondary diagnosis codes and comorbidities: those without a conclusive diagnosis of cerebral infarction (74); treatment of cerebral infarction in subacute phases (51); transient ischemic attacks (260); and deaths within 24 h from the time of admission (23). Also, patients who underwent surgical treatment (208) or who completed treatment at the time of discharge (322) were excluded. Also excluded were cases lacking medical cost data (44), a Japan Coma Scale (JCS) score [7] at the time of admission (78), or a JCS score at the time of discharge (96). Institutions that had less than 50 cases (2 institutions, a total of 44 cases) also were not included in the study. In the end, a total of 3136 cases from 14 institutions were included for analyses.

3. Data analysis

3.1. Analysis of medical costs during the acute period of cerebral infarction hospitalization

First, we plotted the daily costs from days 1 to 14 following admission to identify medical resource utilization patterns for each case. Next, the 14 institutions were divided into three groups based on their distribution of medical costs billed in the first 2 days after admission, during which cerebral infarction

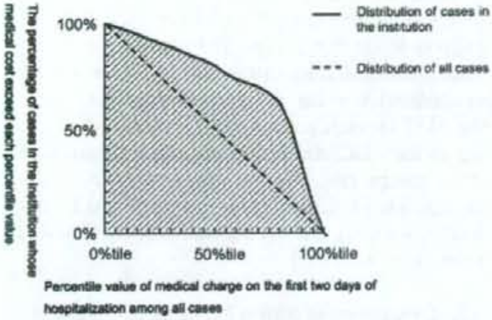

Fig. 1. Classification method for institutions, based on the distribution of medical cost in the first 2 days of hospitalization. Within the graph, the percentage of all cases in which medical costs exceed each percentile figure is illustrated by a reference line. The area under the distribution curve for each institution (shaded portion) was calculated in order to categorize the institutions into the following three groups. A graph with an upwardly convex top portion indicates high medical cost relative to the distribution of all cases.

management requires intense medical resources. The institutional distribution of medical costs in the first 2 days was plotted in comparison to the overall distribution (Fig. 1). From these graphs, we calculated the area under the distribution curve (AUC) for each institution before categorization into one of the following three groups: (1) institutions with high medical cost in the initial 2 days ($AUC > 0.5$); (2) institutions with low medical cost in the initial 2 days ($AUC < 0.5$); and (3) institutions with medium medical costs in the initial 2 days ($AUC \approx 0.5$).

3.2. *The relationship between medical cost usage during the acute period of hospitalization, management recourse, and patient outcome*

The following parameters were compared between groups: patient background, treatment process, patient outcome, medical resource utilization, and cerebral infarction care infrastructure. Patient background included demographics and the Charlson Score [10] at the time of admission (excluding cerebral infarction). The level of consciousness on admission was categorized into four levels, based on the JCS [9]: (i) alert; (ii) JCS Grade I (disoriented: awake without stimulation); (iii) JCS Grade II (somnolent: arousable only in the presence of stimulation); and (iv) JCS Grade III (comatose: unarousable despite stimulation). Treatment process measures included use of intensive care unit (ICU), medications, and rehabilitation. We also investigated the average cost for high-priced drugs (Ozagrel sodium, Argatroban, and Edaravone) during the hospitalization period.

Outcome measures included mortality and incidence of major infectious complications (pneumonia, urinary tract infections, and hematologic infections). Mortality was classified into three categories: death within 7 days, death within 30 days, and death during hospitalization. Outcomes at discharge were used in place of outcomes on the 7th day and those on the 30th day for those patients who were discharged before the 7th and the 30th day, respectively. The incidence rate of each outcome was adjusted by age (two categories: <75 years old versus >75 years old), JCS on admission (four categories), as well as the Charlson Score (two categories: 0 and over 1). Logistic regression analyses were used to calculate adjusted mortality rates and to test statistical differences in mortality rates among groups. Medical resource utilization was compared based on the length and cost of hospitalization, which were transformed into logarithmic values, and statistically tested. We also compared structures for stroke management systems such as staffing, specialized care facilities, and equipment among the three groups.

We conducted a multiple linear regression analysis to identify factors influencing medical cost for the initial 2 days following admission. Independent variables included age, sex, JCS score on admission (three categories: alert, Grade I, and Grades II–III), Charlson Score, prescription of high-priced drugs, utilization of specialized care facilities (emergency or intensive care unit), and utilization of stepdown care units. Due to a strong association between the JCS score on admission and the utilization of specialized care facilities, a combination of these two variables was further divided into six categories and included into our model.

Data were analyzed with one-way analysis of variance, the Bonfferoni test for consecutive measurements, the Kruskal–Wallis test and the Mann–Whitney's *U*-test for older measurements, and the χ^2 test for nominal measurements, using SPSS Version 12.0 statistical software.

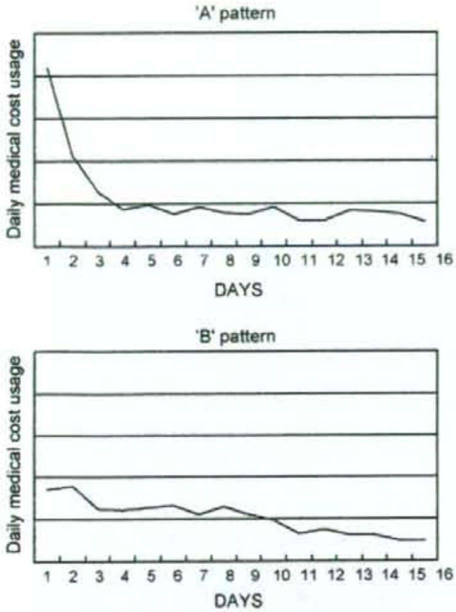

Fig. 2. Two representative medical cost usage patterns. In pattern A, medical costs are intensively spent immediately after hospitalization; in pattern B, medical costs are spent constantly throughout the course. Patterns which did not conform to either A or B were relegated into group C.

4. Results

4.1. Analysis of medical resource utilization during the acute period of cerebral infarction hospitalization

Medical costs were plotted against number of hospitalized days, from 1 to 14, for each case to illustrate changes in cost over time (Fig. 2). Three primary patterns arose from the graphical analysis of all acute cerebral infarction cases. Pattern A reflected a concentrated use of medical resources during the initial hospitalization period. Pattern B demonstrated an even distribution of medical resources from admission to discharge. Patterns that did not conform to either A or B were relegated into group C. Although it was difficult to classify each case into one of these three patterns explicitly, only 10% or less of cases clearly displayed pattern A for costs. Pattern distribution differed by institution.

Next, we tried to classify institutions into three groups according to their medical resource utilization patterns in the first 2 days. The institutional distribution of medical costs in the first 2 days was plotted in comparison to the overall distribution (Fig. 1), and the AUC for each institution was calculated. According to the AUC, the institutions were classified into three groups (Fig. 3): (1) high-cost (AUC > 0.5, 4 institutions, $n = 1016$); (2) low-cost (AUC < 0.5, 5 institutions, $n = 920$); and (3) medium-cost (AUC $\approx$ 0.5, 5 institutions, $n = 1200$).

4.2. Comparison of patient background, treatment process, outcomes, and medical resource utilization among different cost groups

Patient background and treatment process are summarized in Table 1

. No remarkable differences were observed among the three hospital cost groups in terms of gender, age, or comorbidity on admission. A greater percentage of cases with lucid consciousness levels were found in the low-cost group than in higher-cost groups for admissions. Tissue plasminogen activator (t-PA) was administered in only one case among all examined. Patterns of drug prescriptions among the three groups differed significantly for all drugs except ticlopidine. The percentage of patients receiving rehabilitation was lowest in the high-cost group. Medium-cost institutions commenced rehabilitation the earliest and also had the highest percentage initiating rehabilitation within 2 days of cerebral infarction admission.

We found no remarkable difference in patient outcomes between the groups. The incidence of infectious complications did not differ among the three groups. Although the adjusted mortality rate during hospitalization was significantly higher in the low-cost group compared to the other two groups ($p = 0.02$), there was no statistically significant difference in 7-day and 30-day mortalities. High-cost institutions had the shortest hospitalization durations compared to low- and intermediate-cost institutions. However, patients at high-cost institutions were more likely to change their location of care to long-term care facilities and were less likely to receive ambulatory care after discharge. Total medical charges during hospitalization were lower in the low-cost group and higher in the medium-cost group, though the differences were

Table 1
Comparison of patients' characteristics, treatment process, outcomes, and medical resource use between high-, intermediate-, and low-cost groups

Group	High	Intermediate	Low	All	*p*-Value
No. of hospitals	4	5	5	14	
AUC, range	0.55–0.73	0.48–0.51	0.25–0.42	0.25–0.73	
No. of CI cases	1016	1200	920	3136	
Sex, % of males	56.0%	59.1%	55.1%	56.9%	0.145
Age, mean ± S.D.	73.8 ± 12.0	72.4 ± 11.6	74.3 ± 11.7	73.4 ± 11.8	<0.001
Charlson Score, mean ± S.D.	0.8 ± 1.1	0.5 ± 0.8	0.7 ± 1.0	0.6 ± 1.0	<0.001
JCS on admission					
0	57.3%	47.7%	69.1%	57.1%	<0.001
1–3	30.2%	41.7%	22.3%	32.3%	
10–30	9.7%	6.9%	6.4%	7.7%	
100–300	2.8%	3.8%	2.2%	3.0%	
Proportion of cases prescribed CI drugs					
Urokinase	2.4%	19.4%	0.0%	8.2%	<0.001
Heparin	21.2%	9.8%	10.9%	13.8%	<0.001
Aspirin	60.2%	41.6%	41.2%	47.5%	<0.001
Ticlopidine	12.5%	13.4%	10.8%	12.3%	0.180
Warfarin	17.4%	15.4%	10.2%	14.5%	<0.001
Ozagrel sodium	41.9%	14.6%	38.5%	30.5%	<0.001
Argatroban	20.0%	25.3%	19.1%	21.8%	0.001
Edaravone	38.7%	36.1%	26.1%	34.0%	<0.001
Costs for high-priced drugs (US$)[a]					
Ozagrel sodium	635	393	775	643	<0.001
Argatroban	890	561	725	701	<0.001
Edaravone	1125	1059	1511	1185	<0.001
Proportion of cases received rehabilitation	74.6%	83.2%	79.3%	79.3%	<0.001
Timing of rehabilitation initiation					
First day	9.1%	7.1%	5.9%	7.4%	<0.001
Second day	30.2%	47.7%	32.6%	37.9%	
Third day or later	60.7%	45.2%	61.5%	54.7%	
Proportion of cases with infectious complications					
Crude (adjusted[b])	7.6% (7.3%)	7.8% (7.1%)	7.2% (7.7%)	7.6% (7.6%)	0.86[†]
Mortality rate					
Crude (adjusted[b])					
7 days	2.0% (1.9%)	1.9% (1.7%)	1.6% (1.9%)	1.8% (1.8%)	0.75[†]
30 days	3.9% (3.7%)	3.3% (3.0%)	4.1% (4.8%)	3.7% (3.7%)	0.08[†]
Discharge	5.0% (4.8%)	5.3% (4.9%)	6.4% (7.5%)	5.5% (5.5%)	0.02[†]
Location of care after discharge (excluding death cases)					
Crude (adjusted[b])					
Outpatient follow-up	62.4% (63.2%)	72.6% (75.0%)	75.3% (73.8%)	70.1% (70.1%)	<0.001
Chronic care facilities	34.7% (34.1%)	20.4% (18.4%)	19.3% (20.5%)	24.7% (24.7%)	
Others	2.9% (2.8%)	7.0% (6.6%)	5.5% (5.7%)	5.2% (5.2%)	
Length of stay (day), mean (median)	24.6 (15.0)	31.5 (21.0)	31.9 (19.0)	29.4 (18.0)	<0.001
Total medical cost during hospitalization (US$ 1000), mean (median)	9.5 (7.0)	10.1 (7.3)	8.9 (5.9)	9.5 (6.7)	<0.001

Table 1
(*Continued*)

Group	High	Intermediate	Low	All	*p*-Value
Medical cost during the 1st and 2nd days of hospitalization (US$)					
Total, mean	2038	1644	1366	1690	<0.001
Diagnostic exams, mean	340	396	352	365	<0.001
Drug, mean	352	245	253	282	<0.001
Specialized care units, mean	761	221	19	337	<0.001
Others, mean	585	782	742	706	<0.001
Proportion of patients utilized specialized care unit					
ICU[c]	49.5%	12.6%	1.2%	21.2%	<0.001
Stepdown unit[d]	0.7%	5.7%	0.4%	2.5%	<0.001

Emergency care unit.
[a] Mean values among cases which used the drug.
[b] Proportion of cases with infectious complication, mortality rate, and location of care after discharge was standardized by age JCS score on admission, and Charlson Score. Statistical analyses were conducted on the proportion before standardization.
[c] Intensive care unit.
[d] High care unit.
[†] Difference in adjusted rate between groups was statistically tested.

not statistically significant. In contrast, daily medical costs ran highest within high-cost institutions and lowest within low-cost institutions. Medication fees were slightly higher in the high-cost group and about equivalent between the medium and low-cost groups. ICU utilization differed significantly among the three groups, with high-cost institutions having the highest percentage of cases with ICU admission.

4.3. *An analysis of factors contributing to medical cost in the first 2 days of hospitalization*

Factors significantly contributing to total medical cost on the first 2 days of hospitalization were determined through multiple regression analysis (Table 2). Age, Charlson Score, and JCS score made little impact on medical cost. In cases without utilization of emergency or intensive care unit, medical cost tended to

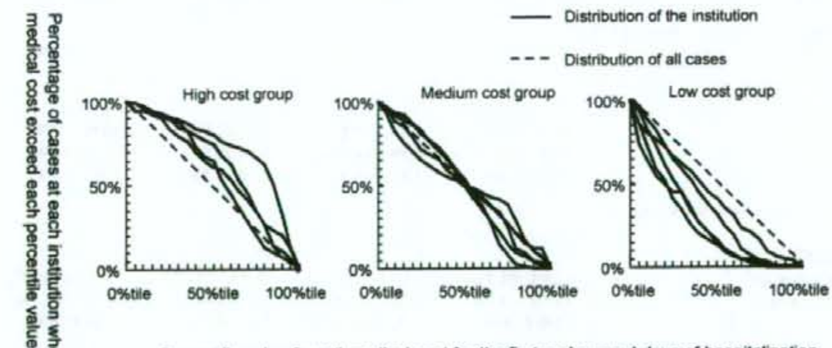

Fig. 3. Categorization of institutions by distribution of medical cost for the first and second days of hospitalization. The AUCs for the high-cost institutions were 0.56, 0.59, 0.62, and 0.73; those for the medium-cost institutions were 0.49, 0.49, 0.50, and 0.51; and those for the low-cost institutions were 0.25, 0.26, 0.29, 0.38, and 0.42.

Table 2
Multiple linear regression analysis for factors associated with medical cost within first 2 days

	Reference	β	95% CI		p-Value
			Lower	Upper	
Intercept		159,629	154,313	164,946	<0.001
Age, 75≦	≦74	−6,207	−9,202	−3,212	<0.001
Charlson Score, 1≦	0	840	−2,144	3,825	0.581
Utilization of ICU and JCS score					
ICU(−) × JCS 1-300	ICU(−) × JCS 0	−7,529	−11,238	−3,820	<0.001
ICU(−) × JCS 10-300		−20,927	−27,358	−14,497	<0.001
ICU(+) × JCS 0		109,037	103,607	114,466	<0.001
ICU(+) × JCS 1-3		101,859	96,289	107,430	<0.001
ICU(+) × JCS 10-300		107,931	100,766	115,096	<0.001
Costs for high-priced drugs (yen)					
Ozagrel sodium	None	1,307	−2,082	4,695	0.450
Argatroban	None	19,140	15,333	22,947	<0.001
Edaravone	None	33,462	30,260	36,664	<0.001

ICU(+): utilization of intensive care unit.

be lower with poor levels of initial consciousness, although the differences were small. However, after adjusting for utilization of specialized care facilities, consciousness level on admission had little association with medical costs. Treatment in specialized care facilities was associated with a mean difference of approximately 100,000 yen (US$ 909) in total cost. Moreover, ICU costs escalated the average medical cost more than high-priced drugs.

4.4. Cerebral infarction care infrastructure

Infrastructures for cerebral infarction care were compared between the three groups (Table 3). Around-the-clock diagnostic imaging was available at most of the participating institutions. The annual volume of cerebral infarction cases was highest at the high-cost institutions, but this value was not statistically different from the medium-cost group. In the low-cost group, the number of specialized physicians certified by the Japan Stroke Society was small, and no institution had stroke care units (SCUs).

5. Discussion

This study revealed that medical costs are not necessarily intensively invested in the acute hospital care of ischemic stroke. In fact, medical resources were focally devoted to the early hospitalization period in only about 10% of all cases. Our findings also showed wide variations in medical cost usage patterns for the first 2 days of hospitalization across institutions. Such variations were still observable after adjusting for patient risk factors such as age and level of consciousness on admission.

To categorize management patterns for acute cerebral infarction care, we used the medical charge billed during the first 2 days of admission as an indicator of intense medical resources utilization. Since differences in healthcare cost across institutions largely derived from costs on the first 2 days of hospitalization, we categorized the participating medical institutions across a distribution of medical costs during this initial inpatient period. This classification appeared appropriate in light of actual clinical practice, since a predominance of diagnostic examinations and treatments were administered on the first 2 days of hospitalization. Thus, the 14 institutions were categorized into three groups according to their institutional distribution of medical costs during the first 2 days: high-cost, low-cost, and medium-cost groups. The differences between high-cost and low-cost groups were remarkable. In the high-cost group, about half of the patients utilized the ICU while only 1.2% of low-cost hospital patients utilized the ICU.

Medical cost appeared to be more heavily influenced by provider practices and management policies than

Table 3
Structure of stroke care (setting, staffing, and organizational context) by cost group

Cost group	High cost (4 facilities)	Intermediate cost (5 facilities)	Low cost (5 facilities)
No. of cases per institution, range	302–1116	142–862	315–1097
Annual volume of cases (estimated), mean (range)	295 (123–401)	212 (117–366)	198 (92–362)
No. of physicians involving stroke care (including resident), mean (range)	12 (4–29)	9 (2–16)	8 (2–21)
No. of specialists of stroke care, mean (range)[a]	5 (1–9)	6 (2–11)	3 (0–6)
No. of institutions with SCU	2	1	0
No. of institutions providing around-the-clock diagnostic services			
CT[b]	4	5	5
MRI[c]	4	5	4
Angiography	4	5	3
No. of institutions with specialized care facilities			
ICU[d]	4	4	3
Stepdown care Unit	2	3	0

[a] Certificated physician by any of Japanese Society of Neurology, Japan Neurological surgery, and The Japan Stroke Society.
[b] CT, computed tomography.
[c] MRI, magnetic resonance imaging.
[d] ICU indicates intensive or emergency care unit.

by the patient clinical conditions. When we divided institutions into three groups based on distribution of medical cost for the first 2 days, the mean medical cost in the first 2 days was yen 74,000 (US$ 673) higher in the high-cost group than the low-cost group. ICU utilization accounted for the major difference in medical costs. However, such difference in ICU utilization could not be explained by patient clinical conditions. Although high and medium-cost institutions differed minimally in the availability of ICUs, high-cost institutions used the ICUs for significantly more cases. Among patients with a clear level of consciousness, ICU utilization was 5% in the medium-cost group versus 44% in the high-cost group. Moreover, after adjusting for ICU utilization and patient age, medical costs were not associated with level of consciousness on admission.

Our study showed large variations among providers in management of patients with cerebral infarction. The length of hospital stay was significantly different among the three cost categories of hospitals. The high-cost group reported the shortest hospitalization duration but a higher rate of transferring to alternative facilities for subacute and chronic care at discharge. This may be explained by an institutional difference in availability of alternative care facilities. In Japan, long-term care services are not completely separate from acute medical care and social services, and many acute care hospitals are forced to provide subacute and chronic care. Thus, most of the high-cost group institutions had affiliated facilities that provide chronic care, consequently contributing to their short inpatient hospitalization time. In high-cost group institutions, total costs over an entire hospitalization period were comparable to those in the other two groups; their short length of hospitalization was countered by high medical costs during the early days of hospitalization.

This study did not find a clear association between intensive resource utilization during the early hospitalization period and patient outcomes. However, we cannot make a definite conclusion regarding the relationship. First, we analyzed data from only 16 institutions, and the sample size is too small to discuss the relationship between medical resource utilization and outcomes. Second, our data lacked information on prognosis-related factors, such as the type of cerebral infarction, the distinction between first occurrence and relapse, and the time lapse between symptom development and admission. We used the JCS as the index for evaluating severity of cerebral infarction as a substitute of NIHSS scores [11] which are widely used in Europe and North America to evaluate the severity of cerebral infarction. Although the JCS represents the most widely used clinical tool for evaluating consciousness level in Japanese emergency care, there is currently little data as to how accurately the JCS measures the severity of cerebral infarction. Third, we analyzed only mortality and incidence of infectious complications as outcome measures. Activity of daily life at the time of discharge is an important index for treatment outcome that we were unfortunately unable apply to this study due to incompleteness of data. Finally, as a caveat, the cases analyzed in this study derive from only 16 participating institutions, which do not necessarily represent the state of Japanese medical care. However, all of the institutions are designated teaching hospitals providing emergency care as well as tertiary care. It is noteworthy that we observed such a large variation in cerebral infarction treatment across institutions despite the small sample size.

Considerable evidence supports the importance of specialized care for ischemic stroke such as SCUs [12–15]. However, our study did not show a clear relationship between utilization of specialized care facilities and patient outcome. Although adjusted in-hospital mortality rate was significantly lower in the high-cost group compared to the low-cost group, mortality rates within 7 days and 30 days were similar between the groups. Given that the length of hospitalization was much shorter in high-cost group, it is possible that this lower mortality merely reflects a shorter observation period in this population.

Alternatively, several other possible reasons may account for the relationship between utilization of specialized care unit and patient outcomes. First, the care provided by ICUs in our cohorts was not equivalent to that provided by SCUs where stroke specialists administer multidisciplinary care. In our settings, ICUs specially admit critically ill patients to allow for close monitoring with ready access to advanced life-saving equipment, which are not necessary for majority of patients with cerebral infarction. Moreover, although many studies support the effectiveness of SCUs, they are not reported to benefit mild and moderate cerebral infarction [16]. Frequent utilization of ICUs in high-cost institutions may be a major reason for the weak association between favorable outcome and a high-cost of care. Second, during the period represented by data used for this study, t-PA treatment was not covered by the Japanese national healthcare insurance, and therefore our data included only one case in which t-PA was administered. Given the greatly improved outcome following t-PA, this may partially account for why ICU utilization did not correspond to excellent outcome.

In this study, we investigated management patterns of stroke patients using Japanese administrative healthcare claim data. This method is facilitated by several traits of the Japanese healthcare system. Although there are a number of studies on medical costs for acute illnesses, no studies have examined changes in daily hospitalization cost for the period of time immediately following disease presentation. Instead, previous studies on medical costs have mostly focused on analyses of total cost over an entire hospitalization period. Unlike western countries where length of hospitalization tends to be minimized, the length of hospitalization is often very long in Japan so that total medical cost is predominantly influenced by the number of days in the hospital. Furthermore, length of hospitalization is often more strongly influenced by provider policies and regional or institutional medical infrastructure than by the actual clinical condition of patients. As such, total medical cost does not necessarily reflect the intensity of medical care for each patient.

In Japan, stroke care programs are under development but frequently under-resourced. According to a 2004 national survey, only 8.3% of acute care hospitals had organized stroke units, and 64% managed acute stroke patients in the general ward [17]. Recently, the Japanese government has launched a number of measures towards acute care of ischemic stroke. In October 2005, the national health insurance system began to cover t-PA treatment. Presence of a stroke care unit or stroke care team was required for institutions to provide t-PA treatment. In April 2007, treatment in SCU has begun to be reimbursed by insurance. In such situations, our method to analyze daily medical resource utilization can be used to explore institutional management patterns for acute ischemic stroke and to identify the relationship among severity of illness, resource utilization, and patient outcomes.

6. Conclusion

The current study analyzed data from over 3000 cases at 14 medical institutions across Japan. We believe that our study provides interesting findings on the procedures and cost of medical care for acute cerebral infarction. In this study, we proposed a methodology that uses administrative claim data to examine management patterns of ischemic stroke. Findings revealed that medical cost is not necessarily intensively allocated to the early (day 0–2) hospitalization period. Rather, differences in medical cost for the initial hospitalization period appear to be more influenced by ICU utilization and institutional management policies than by the clinical condition of patients. We believe that the use of our method, in conjunction with accurate and detailed clinical data, can help elucidate the relationship among acute-period medical costs, the quality of medical care, and patient outcome not only for cerebral infarction but also other acute illnesses.

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