Introduction

Although the mortality rates for acute myocardial infarction (AMI) and stroke in older patients have decreased in recent years, AMI and stroke are still leading causes of death for elderly people in Taiwan. AMI and stroke are also major contributors to medical expenditure in many countries. In the United States, more than 200,000 cases older than 65 years are admitted annually for...
AMI and account for 3 billion US dollars in hospital costs. In addition, approximately 30–40 billion US dollars is spent annually on stroke patients, with most of the expenditure for hospital care. Although we have already devised guidelines for sending AMI and stroke patients to medical centers, there is no evidence-based research focusing on the mortality rate of elderly AMI and stroke patients in different levels of hospital.

Our study, using nationwide population-based data in Taiwan, explored the mortality rate of elderly AMI and stroke patients in major medical centers and regional hospitals. Our findings may have major implications for policy makers in Taiwan and internationally for AMI and stroke care.

Materials and Methods

Database

Our data contains the original claim data of 1 million beneficiaries enrolled in 2007, and randomly sampled from the 2005 Registry for Beneficiaries (LHID2005) of the National Health Insurance Research Database (NHIRD), which includes the registration data of everyone who was a beneficiary of the Taiwan National Health Insurance program. There were approximately 25.68 million individuals in this registry. All the registration and claim data of these 1 million individuals were collected from the National Health Insurance (NHI) program and constituted LHID2005. There was no significant difference in the sex distribution ($\chi^2 = 0.008$, df = 1, $p = 0.05$) between the patients in the LHID2005 and the original NHIRD. The NHIRD is possibly the largest and most comprehensive population-based data source currently available in the world, and it includes primary diagnosis and up to 4 secondary diagnoses which are coded by the ICD-9-CM system.

Our files included Registry for contracted medical facilities (HOSB), Registry for beneficiaries (ID), Inpatient expenditures by admissions (DD), Details of inpatient orders (DO) and Ambulatory care expenditures by visits (CD).

Study sample

All hospitalized patients older than 50 years were identified from the 2007 database with the primary diagnosis of AMI, hemorrhagic stroke, or ischemic stroke (ICD-9-CM code 410, 430–432 or 433–438). Between January 1 and December 31, 2007, there were 338 hospital admissions for AMI, 293 for hemorrhagic stroke, and 1,290 for ischemic stroke. Patients who were transferred between hospitals were excluded because we could not evaluate the cause of death between hospitals.

Key variables of interest

The control variables investigated in our study included patient age, sex, triage classification, preexisting comorbidities and different hospital levels. Patient age was categorized as 50–64, 65–79 and ≥ 80 years old. Different triage classifications for patients were recognized by different payment codes. (Class I 00201A, Class II 00202A, Class III 00203A, Class IV 00204A) The triage classifications were categorized as severe (Class I, II) and others (Class III, IV). Data for patients’ illness severity were not available in this claims database, but to quantify the patient’s preexisting comorbidity, we used the Charlson Comorbidity Index (CCI), developed in 1987, to classify comorbid conditions which may have affected the risk of death from comorbid disease. It has been widely used in many datasets for risk adjustment. All the risk factors were scaled in accordance with the CCI, which ranged from prior congestive heart failure or myocardial infarction (weighted as 1) to acquired immune deficiency syndrome or a solid metastatic tumor (weighted as 6).

Statistical analysis

All the statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS 10.0; SPSS Inc., Chicago, IL, USA). Descriptive analyses were performed on all identified variables, including frequency, percentage, mean and standard deviation. A logistic regression analysis was then carried out to compare the mortality between different levels of hospital, adjusting for patient age, sex, preexisting comorbidities and hospital level.

Study hypothesis

The mortality rate for AMI and stroke in major medical centers is significantly lower than in regional hospitals, adjusted for age, sex, disease severity and comorbidities.

Results

The percentage of patients receiving thrombolytic therapy for ischemic stroke was 1.5–2% in our dataset, and there was no difference between major medical centers and regional hospitals. The percentage receiving
thrombolytic therapy for AMI was nearly zero in major medical centers and about 0–10% in regional hospitals. As shown in Figure, there were 338 hospital admissions for AMI, 293 for hemorrhagic stroke, and 1,290 for ischemic stroke in 2007. Fifty patients with ischemic stroke, 54 patients with hemorrhagic stroke and 45 patients with AMI died in hospital.

The mortality rate was 3.9% for ischemic stroke, 13.3%, for AMI, and was highest for hemorrhagic stroke at 18.4% (Table). Age, triage classification, and hospital level had significant effects on mortality only in patients with ischemic stroke. In AMI patients, only age had a significant effect on mortality. For hemorrhagic stroke, no factor had a significant effect on mortality.

In ischemic stroke patients, the odds ratio of mortality for patients older than 80 years was 2.1 times that for 50–64-year-old patients (Table). The odds ratio of mortality for triage I and II patients was 2.8 times that of lower triage patients. The odds ratio of mortality for patients in major medical centers was 0.4 times that of patients in regional hospitals. This indicates that major medical centers are safer for ischemic stroke patients after adjusting for patient age, sex, triage classification, and preexisting comorbidities.

In hemorrhagic stroke patients, however, the survival rate was not significantly different between hospitals after adjusting for age, sex, triage classification, preexisting comorbidities and hospital level.

Neither sex nor preexisting comorbidities were significant factors for mortality in patients with these three serious diseases.

Discussion

In our study, we investigated age, sex, preexisting comorbidities, triage classification and hospital level as major factors for mortality rate. We found that the rate of administration of thrombolytic therapy to ischemic stroke patients was 1.5–2% in our dataset, and there was no difference between major medical centers and regional hospitals. Therefore, we believed that thrombolytic therapy would not have a major effect on any difference between major medical centers and regional hospitals, so we did not include “thrombolytic therapy” in our model.

Dataset in CD files

CD

91,704 patients
> 50 y/o admitted

Dataset in DD/DO files

DD

11,526 patients
> 50 y/o admitted

HOSB

Date for ER visit
Registration fee by triage classification
Hospital for ER and admission
Primary diagnosis in admission

1,290 ischemic stroke
293 hemorrhagic stroke
338 acute myocardial infarction

Died

50 ischemic stroke
54 hemorrhagic stroke
45 acute myocardial infarction

Survived

1,240 ischemic stroke
239 hemorrhagic stroke
293 acute myocardial infarction

ID

Death?
Survive?

Figure 1. Flow chart of patients analysis for AMI and stroke. AMI = acute myocardial infarction; ER = emergency room; CD = ambulatory care expenditures by visits; DD = inpatient expenditures by admissions; DO = details of inpatient orders; HOSB = registry for contracted medical facilities; ID = registry for beneficiaries.
Table. Survival rate by patient characteristics in acute myocardial infarction and stroke

<table>
<thead>
<tr>
<th>Variables</th>
<th>Ischemic stroke</th>
<th></th>
<th>Hemorrhagic stroke</th>
<th></th>
<th>Acute myocardial infarction</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)</td>
<td>Died (%)</td>
<td>Survived (%)</td>
<td>n (%)</td>
<td>Died (%)</td>
<td>Survived (%)</td>
</tr>
<tr>
<td>Total</td>
<td>1,290 (100.0)</td>
<td>50 (3.9)</td>
<td>1,240 (96.1)</td>
<td>293 (100.0)</td>
<td>54 (18.4)</td>
<td>239 (81.6)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>731 (100.0)</td>
<td>31 (4.2)</td>
<td>700 (95.8)</td>
<td>162 (100.0)</td>
<td>26 (16.0)</td>
<td>136 (84.0)</td>
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<tr>
<td>Female</td>
<td>559 (100.0)</td>
<td>19 (3.4)</td>
<td>540 (96.6)</td>
<td>131 (100.0)</td>
<td>28 (21.4)</td>
<td>103 (78.6)</td>
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<td>Age group</td>
<td></td>
<td></td>
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<tr>
<td>=80</td>
<td>323 (100.0)</td>
<td>22 (6.8)</td>
<td>301 (93.2)</td>
<td>72 (100.0)</td>
<td>17 (23.6)</td>
<td>55 (76.4)</td>
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<td>65–79</td>
<td>636 (100.0)</td>
<td>17 (2.7)</td>
<td>619 (97.3)</td>
<td>96 (100.0)</td>
<td>18 (18.8)</td>
<td>78 (81.3)</td>
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<td>50–64</td>
<td>331 (100.0)</td>
<td>11 (3.3)</td>
<td>320 (96.7)</td>
<td>125 (100.0)</td>
<td>19 (15.2)</td>
<td>106 (84.8)</td>
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<td>Triage</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Class 1, 2</td>
<td>844 (100.0)</td>
<td>40 (4.7)</td>
<td>804 (95.3)</td>
<td>247 (100.0)</td>
<td>45 (18.2)</td>
<td>202 (81.8)</td>
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<tr>
<td>Class 3, 4</td>
<td>446 (100.0)</td>
<td>10 (2.2)</td>
<td>436 (97.8)</td>
<td>46 (100.0)</td>
<td>9 (19.6)</td>
<td>37 (80.4)</td>
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<tr>
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<td></td>
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<td></td>
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<tr>
<td>Severe</td>
<td>306 (100.0)</td>
<td>14 (4.6)</td>
<td>292 (95.4)</td>
<td>36 (100.0)</td>
<td>6 (16.7)</td>
<td>30 (83.3)</td>
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<tr>
<td>Moderate</td>
<td>401 (100.0)</td>
<td>13 (3.2)</td>
<td>388 (96.8)</td>
<td>68 (100.0)</td>
<td>15 (22.1)</td>
<td>53 (77.9)</td>
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<tr>
<td>Mild</td>
<td>583 (100.0)</td>
<td>23 (3.9)</td>
<td>560 (96.1)</td>
<td>189 (100.0)</td>
<td>33 (17.5)</td>
<td>156 (82.5)</td>
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<tr>
<td>Hospital level</td>
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<td></td>
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<tr>
<td>Med-center</td>
<td>465 (100.0)</td>
<td>12 (2.6)</td>
<td>453 (97.4)</td>
<td>113 (100.0)</td>
<td>18 (15.9)</td>
<td>95 (84.1)</td>
</tr>
<tr>
<td>Non-center</td>
<td>825 (100.0)</td>
<td>38 (4.6)</td>
<td>787 (95.4)</td>
<td>180 (100.0)</td>
<td>36 (20.0)</td>
<td>144 (80.0)</td>
</tr>
</tbody>
</table>

CCI = Charlson Comorbidity Index.
For AMI patients, the rate of administration of thrombolytic therapy was nearly zero in major medical centers, and about 0–10% in regional hospitals. Initially, we thought that a lower rate of percutaneous coronary intervention in regional hospitals would be associated with a higher mortality rate for AMI patients, but in our data, there was no significant difference between the two groups of patients.

In our dataset, more than 95% of patients were treated with aspirin, beta-blockers, and angiotensin converting enzyme inhibitors, with no significant difference between major medical centers and regional hospitals. The length of stay for AMI patients was 8.6 ± 7.9 days, and 99% of the cases stayed for less than 42 days. Because we only have 1 year’s data (2007), we could only calculate the in-hospital survival rate instead of long-term survival rate. Recent studies showed that beta-blockers and angiotensin converting enzyme inhibitors only increased the long-term survival rate, but did not have a significant effect on short-term survival. Based on that evidence, we did not think that those medications would have a significant effect on the in-hospital mortality rate between major medical centers and regional hospitals and did not include “medications” in our model.

Our study showed that major medical centers were safer only for ischemic stroke patients after adjusting for patient age, sex, triage classification and preexisting comorbidities. This finding suggests that all patients with acute onset stroke should be sent to a major medical center for further evaluation and treatment. Perhaps these centers have more manpower for taking care of acute stroke patients. Therefore, patients with ischemic stroke could have better survival rates in major medical centers. However, most neurosurgeons agree that the mortality rate for hemorrhagic stroke relies on the volume of hematoma and brain damage rather than surgery and critical care. Consequently, this may be the reason why major medical centers do not have better mortality rates for hemorrhagic stroke patients.

In our research for the Department of Health in 2006 on patient flow in emergency departments, we used the original claims data of 200,000 beneficiaries who were enrolled from 2001 to 2005. That study also demonstrated that AMI patients had similar mortality rates in major medical centers and regional hospitals. As most cardiologists were trained in major medical centers, perhaps they had enough experience and skill for taking care of AMI patients in any hospital. Most regional hospitals also had a catheterization laboratory for handling patients with myocardial infarction. Most patients dying from AMI did so before reaching hospital. Therefore, these are possible reasons for no significant difference in in-hospital mortality rates of AMI patients between major medical centers and regional hospitals.

A few study limitations need to be recognized in our research. Firstly, although we adjusted for the two major variables of triage classification and comorbidities (using the CCI), a potential weakness of our study is that we could not adjust for stroke severity (although our adjustments may serve as a considerable estimation of severity). Our research should use the ideal criteria for stroke such as the National Institutes of Health Stroke Scale or the Glasgow Outcome Scale, but they were not available in the NHIRD database. Secondly, although severity of infarction and left ventricular ejection fraction are important predictors for mortality rate in AMI, they are also not available in the NHIRD database. Thirdly, there could be some arguments about different mortality rates for patients who transferred from hospital to hospital. It was difficult to evaluate the rates, but from our research for the Department of Health in 2006, less than 5% of stroke patients and less than 1% of AMI patients were transferred to other hospitals. Based on this, we excluded the patients who were transferred to other hospitals. Fourthly, the diagnoses of AMI and stroke were sourced from the physician/hospital reported claims. Therefore, the accuracy of the diagnosis could be questionable. However, the NHI regularly samples a percentage of cases from hospitals to verify the validity of diagnosis and quality of care through chart reviews using touring professional teams. Hence, we consider that the validity of the diagnosis was acceptable.

Overall, our findings suggest that elderly patients with stroke should be sent to major medical centers for further evaluation and treatment but that elderly patients with AMI could be sent to the nearest regional hospital or medical center. Although this suggestion could change policies for regionalized or centralized programs, we need to recognize the physician–patient load and also perform further cost effectiveness studies.

**Conclusion**

Our study showed that major medical centers are safer only for ischemic stroke patients after adjusting for patient age, sex, triage classifications, and preexisting...
comorbidities. This finding suggests that all patients with acute onset stroke should be sent to major medical centers for further evaluation and treatment. However, patients with AMI should be sent to the nearest regional hospital or medical center.

Acknowledgments

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References