Rates of Primary Percutaneous Coronary Intervention Worldwide

Susumu Ui, MD; Masao Chino, MD*; Takaaki Ishihiki, MD**

Background  Primary percutaneous coronary intervention (PCI) is at present the most effective procedure for reducing the mortality rate of patients with acute myocardial infarction (AMI). However, there is a great difference between Japan and other countries in the rate of primary PCI.

Methods and Results  Registration period, number of patients with AMI, rates of primary PCI or thrombolysis and in-hospital or 30-day mortality rates were analyzed in 3 Japanese, 4 European, 4 American and 2 world-wide databases of AMI. The primary PCI rate is higher (75–94%) in Japan than in the other countries (5.5–49.6%), particularly in low-volume hospitals, and the mortality rates at these centers were similar to those in high-volume hospitals (approximately 4–10%). The primary PCI rate has recently been rising (25–50%) worldwide and most PCI procedures are performed in large-volume centers, except in Japan.

Conclusions  Comparison of the AMI databases suggest there is a relationship between the primary PCI rate and annual PCI caseload in each country. It is interesting that in Japan even low-volume PCI hospitals have comparable numbers of primary PCI cases. (Circ J 2005; 69: 95–100)

Key Words: Annual rate; In-hospital mortality; Primary percutaneous coronary intervention; Thrombolysis

The mortality rate of patients with acute myocardial infarction (AMI) treated by percutaneous coronary intervention (primary PCI) is lower at high-volume hospitals, and so it is believed that primary PCI should only be performed in such institutions. Primary PCI is at present the most effective procedure for reducing the mortality rate of patients with AMI, but there are 2 limitations to its wider use.

The guidelines of the task force on the management of AMI of the European Society of Cardiology and those of the American College of Cardiology/American Heart Association recommend that angioplasty of the culprit artery should be performed within 12 h of the onset of symptoms (or within 90 min of the first medical contact), by experienced individuals (who perform >75 PCIs per year) in high-volume centers (that perform >200 cases per year). Under the recommendations of these guidelines, the rate of primary PCI is rising worldwide, but varies between countries. There is supposedly a great difference between Japan and other countries, so the aim of the present study was to clarify this issue by comparing the AMI databases from Japan, Europe, USA and other countries.

Methods

Databases

Japanese, European and American AMI databases and world-wide databases of acute coronary syndrome are shown in Tables 1–4. The selection of the databases involved researching published studies concerning primary PCI that were written in English (Keio University Medical Information Center) and from those selecting the multicenter studies that were representative of each country. A national survey was included in the Japanese databases, the data of which are available on the homepage of the Japanese Ministry of Health, Labor and Welfare.

Japanese Databases (Table 1) The Japanese databases comprised 2 AMI studies (MsAMI, Registry of Miyagi Study Group for AMI, R4 and JSIC, the Japanese Society of Interventional Cardiology) and one survey (NHAS, National Hospital AMI Study). Most AMI patients were taken directly to hospitals equipped with PCI facilities, so cases of interhospital transportation of patients with AMI is rare in these studies (Interhospital transportation refers to the transfer of AMI patients from hospitals without PCI facilities to tertiary PCI centers). The JSIC PTCA database consists of serial PCI cases, but cases of facilitated or rescue PCI with thrombolytic agents were excluded from our analysis because their numbers were too small. The JSIC PTCA database included the number of registered patients, each patient’s age, gender, admission and discharge dates, with or without AMI, with or without primary PCI, in-hospital death, 30-day mortality rate, number of hospital beds and number of AMI, PCI and coronary artery bypass surgery per year. As for medical therapy, glycoprotein IIb/IIIa receptor antagonist (abciximab) has not been approved in Japan as yet.

European Databases (Table 2) The European databases comprised a PTCA registry of German community hospitals (R6) a nationwide French Survey (R7) an AMI-Florence registry (R8) and an epidemiological study of AMI in the Italian CCU network (R9).

American Databases (Table 3) The American databases comprised data from the meta-analysis by Heidenreich (R10) a Cooperative Cardiovascular Project (CCP 1995, R11), Medicare National Claims History Files (R12) and...
the National Registry of Myocardial Infarction (NRMI3 1999, R13).13

Worldwide Databases (Table 4) The worldwide databases of acute coronary syndrome were the GRACE (The Global Registry of Acute Coronary Events: R14)14 and ENACT (European Network for Acute Coronary Treatment: R15)15 studies.

Analysis of the Databases (Table 5) First we analyzed the number of patients, rates of primary PCI and thrombolysis, length of hospital stay and the in-hospital or 30-day mortality rate.

We then investigated the relationship between the PCI volume of the hospitals and their mortality rates in the JSIC and R12 databases. In the American database (R12), the PCI volume was divided into 3 categories: small (low)-volume hospitals (<200 cases per year), intermediate-volume primary angioplasty hospitals (200–400 cases per year) and large (high)-volume primary angioplasty hospitals (>400 cases per year).

Statistical Analysis
Chi-square analysis was used to compare dependence of categorical variables. Data were analyzed using JMP Version 5.0 (SAS Campus Drive). A p-value of <0.05 was considered statistically significant.

Results
Japanese Databases (Table 1)
R4 is a community study performed by the Miyagi study group from 1998 to 2000 including 1,548 AMI patients in 41 hospitals in Miyagi prefecture. NHAS is the AMI survey by the national hospitals, which was supported by the Japanese Ministry of Health, Labor and Welfare, and included 658 AMI patients registered in 19 hospitals from 1999 to 2000. This survey was not published and reported only in Japanese.

JSIC is a PTCA database in which 50 consecutive PCI patients from 35 hospitals were registered between 1996 and 1999: 12 municipal or prefectural hospitals, 6 corpo-

Table 1 Japanese Databases of Acute Myocardial Infarction

<table>
<thead>
<tr>
<th>Database</th>
<th>Registration period</th>
<th>No. of patients with AMI</th>
<th>No. of hospitals</th>
<th>Primary PCI rate (%)</th>
<th>Thrombolysis rate (%)</th>
<th>In-hospital/30-day mortality rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MsAMI4</td>
<td>1998–2000</td>
<td>1,548</td>
<td>41</td>
<td>75</td>
<td>7.8</td>
<td>5.1*</td>
</tr>
<tr>
<td>NHAS</td>
<td>1999–2000</td>
<td>658</td>
<td>19</td>
<td>75</td>
<td>12</td>
<td>10.3*</td>
</tr>
<tr>
<td>JSIC</td>
<td>1996–1999</td>
<td>662</td>
<td>35</td>
<td>94</td>
<td>–</td>
<td>6.3*</td>
</tr>
</tbody>
</table>

AMI, acute myocardial infarction; PCI, percutaneous coronary intervention; MsAMI, Registry of Miyagi Study Group for AMI; NHAS, National Hospital AMI survey; JSIC, Japanese Society of Interventional Cardiology PTCA database.

*Crude data.

Table 2 European Databases of Acute Myocardial Infarction

<table>
<thead>
<tr>
<th>Database</th>
<th>Registration period</th>
<th>No. of patients with AMI</th>
<th>No. of hospitals</th>
<th>Primary PCI rate (%)</th>
<th>Thrombolysis rate (%)</th>
<th>In-hospital/30-day mortality rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTCA registry of German community hospitals</td>
<td>October 1992–December 1994</td>
<td>2,879</td>
<td>65</td>
<td>5.5</td>
<td>–</td>
<td>9.2*</td>
</tr>
<tr>
<td>Nationwide French Survey7</td>
<td>November 1995</td>
<td>2,152</td>
<td>312</td>
<td>7</td>
<td>26.4</td>
<td>9.2*</td>
</tr>
<tr>
<td>AMI-Florence8</td>
<td>March 2000–February 2001</td>
<td>930</td>
<td>6</td>
<td>49.6</td>
<td>4.8</td>
<td>6.6*</td>
</tr>
<tr>
<td>The BLITZ Study9</td>
<td>15–29 October–2001</td>
<td>1,275</td>
<td>296</td>
<td>15</td>
<td>50</td>
<td>9.5*</td>
</tr>
</tbody>
</table>

ALKK, Arbeitsgemeinschaft Leistender Kardiologischer Krankenhausarzte; The BLITZ Study, Epidemiology of acute myocardial infarction in the Italian CCU network.

*Crude data.

Table 3 American Databases of Acute Myocardial Infarction

<table>
<thead>
<tr>
<th>Database</th>
<th>Registration period</th>
<th>No. of patients with AMI</th>
<th>No. of hospitals</th>
<th>Primary PCI rate (%)</th>
<th>Thrombolysis rate (%)</th>
<th>In-hospital/30-day mortality rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meta-analysis10</td>
<td>1995</td>
<td>679,000</td>
<td>–</td>
<td>9</td>
<td>31</td>
<td>17.4</td>
</tr>
<tr>
<td>CCP11</td>
<td>1994–1995</td>
<td>149,177</td>
<td>4,672</td>
<td>0.7–9.8</td>
<td>12.6–19.3</td>
<td>18.4*</td>
</tr>
<tr>
<td>Medicare National Claims History Files12</td>
<td>1997</td>
<td>44,941</td>
<td>1,003</td>
<td>15–24</td>
<td>–</td>
<td>17*</td>
</tr>
<tr>
<td>NRMI 313</td>
<td>1999</td>
<td>213,665</td>
<td>1,432</td>
<td>24.4</td>
<td>47.9</td>
<td>9.8*</td>
</tr>
</tbody>
</table>

CCP, the cooperative cardiovascular project; NRMI 3, national registry of myocardial infarction 3.

*Crude data.
rate, 5 national, 5 Saiseikai, 3 university, 2 red cross and 2
Kyosai hospitals. The total number of PCI patients was
1,902, which included 662 AMI patients, of whom 518
were men (78%) with a mean age of 65±12 years old. The
number of primary PCI patients was 624, which accounted
for 94% of the AMI patients. The 30-day mortality rate of
the AMI patients was 6.3%. There were 13 low-volume
centers that treated 293 AMI patients, 19 intermediate-
volume centers with 342 AMI patients and only 3 large-
volume centers with 27 AMI patients treated. The ratio of
primary PCI to AMI patients ranged from 85% to 100%
among these centers without significant difference, which
indicates that most AMI patients in the JSIC database were
treated with primary PCI. The 30-day mortality rate in the
low-, intermediate- and large-volume centers was 8.5%,
4.4% and 7.4%, respectively, without a statistically signifi-
cant difference among them (p=0.10).

As shown in Table 1, the primary PCI rates ranged from
75% to 94% in Japan and the in-hospital or 30-day mortal-
ity rates were from 5.1% to 10.3%.

European Databases (Table 2)
R6 is the database of the PTCA registry of a German
study performed from 1992 to 1994. R7 is the database from
a nationwide French Survey performed during November
1995, including 2,152 patients admitted to 312 hospitals for
AMI. R8 is the database of the AMI-Florence registry in
which 930 cases were enrolled in 6 institutes between
March 2000 and February 2001. R9 is the database from
the Italian CCU network studied during 2 weeks in October
2001. The primary PCI rate was less than 10% in the data-
bases before 1995 (R6, R7), but has risen to more than 15%
recently (R8, R9), and the in-hospital or 30-day mortality
rate was 6.6–9.4%.

American Databases (Table 3)
R10 is a meta-analysis done by Heidenreich and
McClellan in 1995, R11 is the database from the Coopera-
tive Cardiovascular Project (CCP) for one year, from 1994
to 1995, R12 is the database from the Medicare National
Claims History Files for 1977 and R13 is the database from
the National Registry of Myocardial Infarction 3 (NRMI 3)
in 1999.

Worldwide Databases (Table 4)
R14 is the database of GRACE study of clinical practice
for acute coronary syndrome, which was an observational
study performed in 2001 at 94 hospitals in 14 countries
(Argentina, Australia, Austria, Belgium, Brazil, Canada,
France, Germany, Italy, New Zealand, Poland, Spain,
United Kingdom, United States).

R15 is the database of the ENACT registry, which was
performed in 1999 at 390 hospitals in 29 European coun-
tries.

Outcome of Patients With AMI
The rate of primary PCI was higher in Japan than in the
other countries, although recent reports show that it is
rising in both Europe and the USA. The rate of throm-
bolysis for AMI is higher in Europe and the USA than in
Japan. The recent studies show that in-hospital or 30-day
mortality rates are comparably lower among Japan, Europe,
the USA and other countries. Hospital stay is longer in
Japan than in the USA (median, 14–23 days vs 4.3 days).

Difference in the Rate of Hospital PCI Volume Between
JAPAN and the USA (Fig 1)
These data were derived from the JSIC and R12 data-
bases. The rate in low-volume hospitals is 39% in Japan
compared with 26% in the USA, for intermediate-volume
hospitals it is 44% in Japan compared with 25% in the
USA, and for high-volume hospitals it is only 17% in Japan
compared with 49%. The rate in lower-volume hospitals is
significantly higher in Japan than in the USA (p<0.0001).

Difference in the Rate of Hospital Primary Angioplasty
Volume Between Japan and the USA (Fig 2)
These data were derived from the JSIC PTCA and R16
databases. Although the JSIC does not include the category
of low-volume primary angioplasty hospital, the percent-
age of high-volume primary angioplasty hospital was
higher than in the USA with statistical significance

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**Table 4 World-Wide Databases of Acute Coronary Syndrome**

<table>
<thead>
<tr>
<th>Database</th>
<th>Registration period</th>
<th>No. of patients with AMI</th>
<th>No. of hospitals (countries)</th>
<th>Primary PCI rate (%)</th>
<th>Thrombolysis rate (%)</th>
<th>In-hospital/30-day mortality rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRACE</td>
<td>July–December 2001</td>
<td>1,136</td>
<td>94 (14)</td>
<td>26.7</td>
<td>4.7</td>
<td>9.5*</td>
</tr>
<tr>
<td>ENACT</td>
<td>April–June 1999</td>
<td>731</td>
<td>390 (29)</td>
<td>24.4</td>
<td>–</td>
<td>4.0*</td>
</tr>
</tbody>
</table>

GRACE, The Global Registry of Acute Coronary Events; ENACT, European Network for Acute Coronary Treatment.

*Crude data.

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**Table 5 Summary of Databases**

<table>
<thead>
<tr>
<th></th>
<th>Japanese</th>
<th>European</th>
<th>American</th>
<th>Worldwide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R4</td>
<td>A</td>
<td>B</td>
<td>R6</td>
</tr>
<tr>
<td>Analyzed items</td>
<td>Clinical data</td>
<td>Hospital stay</td>
<td>PCI volume</td>
<td>Primary angioplasty volume</td>
</tr>
</tbody>
</table>

*Data from survey by Magid et al16 which includes the original data from NRMI 313.
The primary PCI volume ranged from 20 to 260 cases per year in 35 Japanese hospitals. The ratio of primary PCI per annual PCI caseload was 51% in the lowest-volume centers and 22% in the largest-volume centers, which shows that in Japan the lower the PCI volume per year is, the higher is the primary PCI rate.

Discussion

Hospital PCI and Primary Angioplasty Volumes

Despite documentation of an inverse relationship between PCI volume and the mortality rate of AMI patients, more AMI patients undergo primary PCI in Japan than in Europe, the USA and other countries. The percentage of low-volume centers and 22% in the largest-volume centers, which shows that in Japan the lower the PCI volume per year is, the higher is the primary PCI rate.

Factors Influencing Patient Access to PCI-Equipped Hospitals

Geographical Position

It is supposed to be easier for a patient to access PCI-equipped hospitals in Japan than in Europe and the USA from the geographical point of view. Because Japan is a mountainous country, most of the population centers, and thus the hospitals, are concentrated on the plains, which may assist the emergency medical service and contribute to the good prognosis of AMI patients in Japan.

Payment System for In-Hospital Charges

In Japan the cost of PCI is fully covered by medical insurance and paid on a fee-for-services (FFS) basis, which includes the doctor’s fee, whereas in the USA the hospital charges are paid on a prospective payment system (PPS) basis. In-hospital charges have been compared between the JSIC and PAMI (the Primary Angioplasty in Myocardial Infarction trial) studies. Because the average number of balloon (coronary stents) used per AMI patient was 1.6 (0.7) in Japan and 1.8 (0.8) in USA, the catheter fee was estimated to be more expensive in Japan ($10,000) than in the USA ($2,600). However, the doctor’s fee is cheaper in Japan. The total in-hospital charge is greater in Japan ($20,700) than in the USA ($16,000). Kuroda et al also compared the cost of PCI devices in Japan and other countries and reported that the average numbers of balloon and stent used...
are 1.7±0.8 and 1.0±0.6, respectively. Although they studied elective PCI cases, the numbers of devices was nearly equal to that in R18.

The hospital charge for primary PCI is more expensive in Japan than in the USA because of the higher price of devices, not the cost of the room, which is approximately $180 per day in Japan. However, because the Japanese government pays for most of the in-hospital charges in the FFS system, a Japanese patient treated with primary PCI only pays approximately $500, which probably accounts for the higher rate of primary PCI in Japan.

**Price of PCI Device** According to the reports regarding the cost of PCI devices, the official reimbursement price of a PCI device in Japan consists of an import price, the sales profit of the importer, the margin of the wholesaler and the hospital's margin, which results in the device being nearly 4-fold more expensive than in the USA. Several measures to reduce the price of PCI devices have been proposed. One is to reform the distribution system in Japan; for example, joint purchasing of PCI devices by institutes. Another is the development of local devices made in Japan, which would reduce the cost. Finally, although the prices differential between Japan and other countries should continue to be monitored, we must remember that further advances in PCI technology will have an impact on medical reform and the reduction of medical costs.

**Ambulance Service** The ambulance service in Japan is also publicly funded and users are transported free of charge to PCI-equipped hospitals.

**Hospital Stay** There are 2 factors in the longer hospital stay in Japan than in the USA. One is the payment system, as mentioned earlier, and the other is the 1997 Japanese guideline on cardiac rehabilitation for AMI patients with reperfusion therapies, which recommends a hospital admission of 2 or 3 weeks for the AMI patients, a guideline that in the current interventional era might be out of date.

The paradox of the higher in-hospital charge for AMI patients and a higher rate of primary PCI rate has several factors. Because lower-volume hospitals in Japan perform most primary PCI, with a comparable mortality rate to that in other countries, interhospital transportation of AMI patients to tertiary centers is not necessary in Japan. In other words, Japanese AMI patients can be treated with primary PCI in hospital other than large-volume centers.

**Study Limitations**

The Japanese databases are limited to a regional study (R4: 41 hospitals), a survey by 19 national hospitals in Japan, which consists of an import price, the sales profit of the importer, the margin of the wholesaler and the hospital's margin, which results in the device being nearly 4-fold more expensive than in the USA. Several measures to reduce the price of PCI devices have been proposed. One is to reform the distribution system in Japan; for example, joint purchasing of PCI devices by institutes. Another is the development of local devices made in Japan, which would reduce the cost. Finally, although the prices differential between Japan and other countries should continue to be monitored, we must remember that further advances in PCI technology will have an impact on medical reform and the reduction of medical costs.

**Conclusion**

A comparison of Japanese, European, American and other countries’ databases regarding primary coronary intervention for AMI suggest that there is a relationship between the primary PCI rate and annual PCI caseload. It is of considerable interest that in Japan even low-volume hospitals have comparable numbers of primary PCI cases.

**References**


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