Impact of the Japanese Diagnosis Procedure Combination-based Payment System on Cardiovascular Medicine-related Costs

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SUMMARY

In 2003, a lump-sum payment system based on Diagnosis Procedure Combinations (DPC) was introduced to 82 specific function hospitals in Japan. While the US DRG/PPS system is a “per case payment” system, the DPC based payment system adopts a “per day payment.” It is generally believed that the Japanese system provides as much of an incentive as the DRG/PPS system to shorten the average length of stay (LOS). We performed an empirical analysis of the effect of LOS shortening on hospital revenue and expenditure under the DPC-based payment system, particularly in cardiovascular diseases. We also point out fundamentally controversial aspects of the current system.

A total 109 cases were selected from patients hospitalized at the University of Tokyo Hospital from May to July, 2003 and classified into one of three categories: (1) cardiac catheter interventions, (2) cardiac catheter examinations, and (3) other conservative treatments. We analyzed the changes in profit per day in cases of a reduction in average LOS and an increase in the number of cases.

In category (1) profit increased significantly in conjunction with reduced LOS. In category (2) profit increased only minimally. In category (3), profit increased rarely and sometimes decreased.

In cases of conservative treatment, profits sometimes decreased because an increase in material costs exceeded the increase in revenue. It therefore became clear that the DPC-based payment system does not decisively provide an economic incentive to reduce LOS in cardiovascular medicine. (Int Heart J 2005; 46: 855-866)

Key words: Diagnosis procedure combination, Per day payment, Per case payment

THE concept of Diagnosis Related Groups (DRG) is a tool for medical standardization originally developed by a research group at Yale University. In 1983, the US federal government applied a DRG/PPS (Diagnosis Related Groups/Prospective Payment System) to Medicare in order to control increasing medical expenses.
Japan has maintained a total fee-for-service (FFS) system since universal health care coverage was implemented in the 1960s. However, health policy makers in the Japanese government, troubled by the escalation of medical expenses and a long average LOS, drew on the US DRG/PPS to build an original Japanese payment system. This “Japanese version of DRG” was called the Diagnosis Procedure Combination (DPC) system. The DPC system is made up of 16 Major Diagnosis Categories (MDC) and includes 1727 diagnosis groups. A lump-sum payment system based on DPC was initially introduced in 82 Japanese specific function hospitals (80 university and two national hospitals) in April, 2003. Since 2004, the introduction of this system has been expanded to dozens of private hospitals.

The DPC-based payment system substantially differs from the DRG/PPS. The DPC-based payment system is divided into a DPC component and a fee-for-
service (FFS) component. Thus, the traditional total FFS system is partly inherited. The DPC component corresponds to the hospital basic fee, and charges for medications, injections, laboratory examinations, radiological examinations (except angiography), and most simple treatments. The FFS component corresponds to charges for surgical procedures, anaesthesia, intravascular catheter intervention or examination, and endoscopic examination. The DPC-based payment system is a “per day payment” system, which is essentially different from the “per case payment” DRG/PPS. The amount of payment per day in the DPC component decreases gradually on three levels, as shown in Figure 1. During hospitalization period I (first quartile of all LOS in 82 hospitals), 15% of the average payment amount is added.

Japan has a very long average LOS compared to that in other advanced countries (Figure 2A). Japan also has a greater number of beds than the United States\(^1\)-\(^3\) (Figure 2B). The US DRG/PPS unfortunately had only a very limited effect on a reduction in national medical expenses. However, it did have a dramatic effect on a reduction in average LOS. It is generally believed that introduction of the DPC-based payment system will inevitably move Japan towards a reduction in LOS.\(^4\)-\(^8\)

Up to now there have been few analyses of the effect of the DPC-based payment system, particularly reports analyzing the effect in connection with cost data.
such as material costs. Recent research comparing the influence of the DPC system on cardiovascular medicine with that of the traditional fee-for-service system showed that diagnosis groups with a high DPC component are prone to produce income losses.\(^9\)

Previously we analyzed the influence of the DPC-based payment system on hospital income and expenditure using a simulation model and general solutions, and we reported that the current system may not necessarily offer incentives for shortening LOS.\(^{10}\)

In this report, we apply the empirical data of cardiovascular diseases to the simulation model of the preceding report and analyze the influence of the DPC-based payment system on hospital revenue and expenditures, especially in cardiovascular medicine. We also point out fundamental problems in this system and examine the influence this system has on hospitals in Japan.

**METHODS**

**Target:** The target cases for the analysis were 109 patients extracted from among patients with cardiovascular diseases hospitalized at the University of Tokyo Hospital from May to July, 2003. Patients also met the following requirements:

**Table I.** Elected DPC Code, Diagnosis, Procedure, and Average LOS for the Three Study Categories

<table>
<thead>
<tr>
<th>DPC code</th>
<th>Diagnosis</th>
<th>Procedure</th>
<th>Number</th>
<th>m</th>
<th>period I</th>
<th>a</th>
<th>period II</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1: cardiac catheter intervention</td>
<td>0500503x04x000  angina pectoris</td>
<td>intracoronary stenting</td>
<td>12</td>
<td>14.8</td>
<td>7</td>
<td>32080</td>
<td>13</td>
<td>23710</td>
</tr>
<tr>
<td>0500503x01000x  angina pectoris</td>
<td>PTCA</td>
<td>16</td>
<td>12.6</td>
<td>6</td>
<td>33860</td>
<td>12</td>
<td>25770</td>
<td></td>
</tr>
<tr>
<td>Category 2: cardiac catheter examination</td>
<td>63</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0500501xxxxxxx  angina pectoris</td>
<td>catheter examination</td>
<td>63</td>
<td>6.1</td>
<td>4</td>
<td>61430</td>
<td>7</td>
<td>45400</td>
<td></td>
</tr>
<tr>
<td>Category 3: conservative treatments</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0501303x99x00x  chronic heart failure</td>
<td>none</td>
<td>5</td>
<td>19.2</td>
<td>12</td>
<td>32160</td>
<td>24</td>
<td>24120</td>
<td></td>
</tr>
<tr>
<td>0501401xxxxxxx  hypertensive diseases</td>
<td>none</td>
<td>2</td>
<td>21.0</td>
<td>8</td>
<td>35480</td>
<td>15</td>
<td>26230</td>
<td></td>
</tr>
<tr>
<td>0500653x99x0xx  dilated cardiomyopathy</td>
<td>none</td>
<td>4</td>
<td>21.0</td>
<td>17</td>
<td>35280</td>
<td>34</td>
<td>26350</td>
<td></td>
</tr>
<tr>
<td>0500703x99x00x  tachyarrhythmia</td>
<td>none</td>
<td>7</td>
<td>8.9</td>
<td>5</td>
<td>35390</td>
<td>12</td>
<td>28140</td>
<td></td>
</tr>
</tbody>
</table>

DPC indicates diagnosis procedure combinations; LOS, length of stay; and PTCA, percutaneous transluminal coronary angioplasty.

m (days): Average LOS in our hospital.

*period I (days): First quartile of all LOS of each diagnosis group in 82 hospitals,

*period II (days): Average LOS of each diagnosis group in 82 hospitals,

*a (yen): Amount of payment per day for days shorter than period I,

*b (yen): Amount of payment per day for days equal to or longer than period I and shorter than period II,

Category 1. 28 cases of elective cardiac catheter intervention for angina pectoris, including 16 cases of percutaneous transluminal coronary angioplasty (PTCA) and 12 cases of intracoronary stenting. Emergency cases such as acute myocardial infarction or unstable angina pectoris, and cases with other severe complications were excluded.

Category 2. 63 cases of hospitalization for cardiac catheter examination. Cases with other severe complications were excluded.

Category 3. 18 cases treated conservatively without cardiac catheter examination, including 5 cases of chronic heart failure (CHF), 4 cases of dilated cardiomyopathy, 7 cases of tachyarrhythmia, and 2 cases of hypertensive disease. Cases with other severe complications were excluded.

Table I shows the elected DPC code, diagnosis, procedure, and average LOS in each category.

**Analytical method:** *Calculation of revenue and material costs per case.* Average revenue and material costs per case were calculated for each diagnosis group (*‘material costs’ refers to actual costs for purchasing medical materials from the market and does not mean official reference costs, which are the costs approved by the Japanese government*). Average revenue per case was then subdivided according to the DPC component and FFS component. The proportion of material costs in terms of revenue (material costs/revenue) was also calculated. Revenue under the DPC-based payment system was also compared to the revenue under the traditional total FFS system.

“Material costs” is the total cost of medical materials (e.g., specific medical devices such as cardiac catheters, disposable medical materials such as injection syringes and needles, and hygienic materials such as gauze) and pharmaceuticals (e.g., internal medicines, injection drugs, contrast agents).

Data on material costs were obtained as follows. The total amount for specific medical devices (cardiac catheters, balloon catheters, coronary stents, etc.) used per patient was added. The total amount for pharmaceuticals used per patient was also added. The cost of disposable materials (disposable medical materials, hygienic materials, etc.) was estimated as follows. In our hospital, we prepare a set of disposable materials for each treatment. The approximate sum of the cost for disposables was calculated by multiplying the unit price of each set by the number of treatments provided to each patient.

**Derivation of function expressing profit increase per day.** Assuming a case where a constant hospital bed occupancy rate is maintained through a reduction in the LOS and an increase in the number of hospital patients, parameters are defined as follows.

\[
m: \text{Average LOS in our hospital}
\]

\[
N_1: (\text{Hospitalization period I}) - 1
\]
\( N_2: \) (Hospitalization period II) - 1  
\( a: \) Amount of payment per day for days shorter than period I  
\( b: \) Amount of payment per day for days equal to or longer than period I and shorter than period II  
\( v: \) Revenue from DPC component per case  
\( w: \) Revenue from FFS component per case  
\( I: \) Total revenue per case \( (v + w) \)  
\( H: \) FFS rate \( (w/I) \)  
\( M: \) Material costs per case  
\( p: \) Material costs rate \( (M/I) \)  
\( x: \) Reduction in days from \( m \)  
\( z: \) Profit increase per day when reducing \( x \) days  
\( t: \) Reduction rate of average LOS \( (x/m) \)

**1) Assumptions in derivation of the function.**

1. Material costs per case are constant.

Figures 3A, 3B, and 3C show typical examples of the daily distribution of material costs in each category. The cost of materials used on days of catheter intervention or examination accounted for most of the total material costs per case.

In category 3, materials are consumed intensively at the start of hospitalization. Thus, shortening the LOS by advancing the hospital discharge date has only a limited effect of reducing material costs per case.

In all cases, the modification in total material costs per case can be ignored even when the LOS is shortened.

2. Costs per day other than material costs are constant.

“Costs other than material costs” include personnel expense, depreciation expense, and overhead expenses such as utilities. In the short run, all these costs are little affected by a change in the LOS.

**2) Function expressing profit increase per day \( (z) \).**

Assuming a case where the average LOS \( m \) decreases by \( x \) days, when \( N_1 < m < N_2, 0 < x < m - N_1 \), in the case of LOS \( m \), revenue per case is \( I = N_1a + (m - N_1) b + w \), and the material cost per case is \( pI \).

In the case of reduction of \( x \) days, the increase in revenue per day is \( \frac{I - bx}{m - x} = \frac{(I - mb)x}{m(m - x)} \), and the increase in material costs per day is \( \frac{plI}{m - x} = \frac{pIx}{m(m - x)} \).

Thus, the profit increase per day, \( z \), is \( \frac{(I - mb)x}{m(m - x)} - \frac{pIx}{m(m - x)} = \frac{((1-p)(I - mb)x}{m(m - x)} \)
From $t = \frac{x}{m}$, we have $z = \frac{(1-p)l-mb}{m} \cdot \frac{t}{1-t}$ \hspace{1cm} (*)

and profit increase per day ($z$) may be estimated for each diagnosis group on the basis of the foregoing simplified, approximate formula.

(3) Creation of the $t$-$z$ graph.

The sign of the coefficient $\frac{(1-p)l-mb}{m}$ on the right-hand side of the formula (*) corresponds to that of $z$, and the critical value of the material costs rate when $z$ is 0 is called $p_1$. Thus,

$$\frac{(1-p_1)l-mb}{m} = 0 \Leftrightarrow p_1 = 1 - \frac{mb}{l}$$

$z > 0$ when $p < p_1$, $z < 0$ when $p > p_1$.

A $t$-$z$ graph is created for each diagnosis group.

RESULTS

Calculation of revenue and material costs per case: Figures 4A, 4B, and 4C show the daily amount of the DPC and FFS components in cases of PTCA, catheter
examination, and CHF. In Categories 1 and 2, the FFS component accounts for most of the total revenue, while in Category 3, the DPC component accounts for most of the total revenue.

Table II shows a summary of the results, including revenue per case, breakdown of the DPC and FFS components, FFS rate, material costs, material costs rate, critical value of material costs rate, and coefficient of $z$.

In Category 1, both revenue and material costs are extremely high. Material costs rates are 62.6-69.3%, and FFS rates 78.8-81.7%. In Category 2, the material costs rate is 22.9%, and the FFS rate is 21.2%. Category 3 shows a relatively low FFS rate of approximately 10%. Material costs rates are 15.2-26.6%.

In Category 1, the value $p_1$ becomes extremely high (0.805-0.834). Since $p < p_1$, $z$ becomes positive. In Category 2, $p < p_1$ and $z > 0$, but the profit increase is minimal compared to that in Category 1. In cases of CHF or hypertensive disease, $p > p_1$, and $z$ becomes negative.

*Figure 4.* Daily revenues for DPC and FFS components.
Table II. Summary of the Results

<table>
<thead>
<tr>
<th>Diagnosis Procedure</th>
<th>$m$</th>
<th>$I$</th>
<th>$v$</th>
<th>$w$</th>
<th>$M$</th>
<th>$H$</th>
<th>$p$</th>
<th>$p_1$</th>
<th>$(1 - p)I - mb/m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1: cardiac catheter intervention</td>
<td>angina pectoris intracoronary stenting</td>
<td>14.8</td>
<td>2,118,483</td>
<td>387,382</td>
<td>1,731,102</td>
<td>1,467,265</td>
<td>0.817</td>
<td>0.693</td>
<td>0.834</td>
</tr>
<tr>
<td></td>
<td>angina pectoris PTCA</td>
<td>12.6</td>
<td>1,664,957</td>
<td>352,235</td>
<td>1,312,722</td>
<td>1,041,594</td>
<td>0.788</td>
<td>0.626</td>
<td>0.805</td>
</tr>
<tr>
<td>Category 2: cardiac catheter examination</td>
<td>angina pectoris catheter examination</td>
<td>6.1</td>
<td>402,636</td>
<td>313,687</td>
<td>88,950</td>
<td>92,304</td>
<td>0.212</td>
<td>0.229</td>
<td>0.312</td>
</tr>
<tr>
<td>Category 3: conservative treatments</td>
<td>chronic heart failure none</td>
<td>19.2</td>
<td>607,926</td>
<td>538,840</td>
<td>69,086</td>
<td>151,614</td>
<td>0.114</td>
<td>0.249</td>
<td>0.238</td>
</tr>
<tr>
<td></td>
<td>hypertensive diseases none</td>
<td>21.0</td>
<td>632,740</td>
<td>588,070</td>
<td>44,670</td>
<td>96,195</td>
<td>0.071</td>
<td>0.152</td>
<td>0.129</td>
</tr>
<tr>
<td></td>
<td>dilated cardiomyopathy none</td>
<td>21.0</td>
<td>762,493</td>
<td>685,068</td>
<td>77,425</td>
<td>203,129</td>
<td>0.102</td>
<td>0.266</td>
<td>0.274</td>
</tr>
<tr>
<td></td>
<td>tachyarrythmia none</td>
<td>8.9</td>
<td>312,756</td>
<td>277,204</td>
<td>35,551</td>
<td>50,540</td>
<td>0.114</td>
<td>0.162</td>
<td>0.203</td>
</tr>
</tbody>
</table>

$m$: Average length of stay in our hospital [days], $I$: Revenue per case [yen], $v$: DPC component [yen], $w$: FFS component [yen] ($I = v + w$), $M$: Average material costs per case [yen], $H$: FFS rate ($= v/I$), $p$: Material costs rate ($= M/I$), $p_1$: the critical value of material costs rate, $(1 - p)I - mb/m$: the coefficient value of $z$ ($z$: profit increase per day). Approximately 110 Japanese yen/$US.

Table III. Revenue, in Japanese yen, Under the Traditional Total FFS System and the DPC-based Payment System

<table>
<thead>
<tr>
<th>Diagnosis Procedure</th>
<th>$I$</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1: cardiac catheter intervention</td>
<td>angina pectoris intracoronary stenting</td>
<td>2,118,483</td>
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<tr>
<td></td>
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<tr>
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<td>chronic heart failure none</td>
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<td></td>
<td>hypertensive diseases none</td>
<td>632,740</td>
</tr>
<tr>
<td></td>
<td>dilated cardiomyopathy none</td>
<td>762,493</td>
</tr>
<tr>
<td></td>
<td>tachyarrythmia none</td>
<td>312,756</td>
</tr>
</tbody>
</table>

$I$: average revenue under the DPC-based payment system, $F$: average revenue under the total FFS system. Approximately 110 Japanese yen/$US.

Table III shows revenue under the traditional total FFS system and the current DPC-based payment system. There is almost no difference in Category 1. However, in Categories 2 and 3, revenue in the DPC-based payment system is higher without exception.

**Function expressing $z$:** For each diagnosis group, the function expressing $z$ can be derived by assigning values to the variables in the formula (*). The coefficient $(1 - p)I - mb/m$ for each diagnosis group is shown in Table II. The $t$-$z$ graph is shown in Figure 5.
In catheter intervention, a shortened LOS is linked to a significant increase in profit. In catheter examination, a shortened LOS is also linked to increased profit, but the increase is minimal compared to that in catheter intervention. In conservative treatment, the increase in material costs often exceeds the increase in revenue and consequently reduces profit.

**DISCUSSION**

**Validity of the function expressing $z$:** Our analysis was based on the assumption that material costs per case are constant and are not affected by shortening of LOS. There are materials that are used continuously even in chronic stages, such as regularly prescribed drugs, and these can be considered factors affecting material costs per case. However, considering that the proportion of these material costs in total material costs per case is small, omission of these costs from the function does not decrease its validity.

It is also the case that only hospital patients are subject to DPC. Consequently, when some prescriptions and examinations are transferred to outpatient treatment, they are subject to the total FFS system, and outpatient revenue increases. Material costs for inpatient treatment also decrease slightly. In this case, the aforementioned assumption does not hold. In deriving the $z$ function,
this report excludes the factor of inpatient-outpatient transition.

**Economic influence of the DPC-based payment system on cardiovascular medicine:** Since the actual material costs rate $p$ falls greatly below the critical value $p_1$ in catheter intervention, increased profit can be anticipated, and an incentive to shorten the LOS usually operates.

The FFS rate is low in catheter examination versus intervention, and the effect of reduction in revenue is comparatively strong, so the increase in profit remains small. Attention must be paid to the fact that the difference between $p$ and $p_1$ is small. In the data obtained from this research, $p$ falls just below $p_1$ but this relationship is easily reversed, depending on the case. In other words, a slight increase in material costs can bring about a decrease in profit.

The FFS rate is surprisingly low in conservative treatment; $p_1$ is distinctly low, and there are diagnosis groups whose $p$ exceeds $p_1$. For these groups, a reduction in the LOS and an increase in the number of cases, on the contrary, decrease profit. In order to prevent a decrease in profit, it is necessary to reduce material costs or to maintain the LOS.

Key points for improving the balance of revenue and expenditures in cardiovascular medicine under the DPC-based payment system are, firstly, to increase catheter interventions, and secondly, to reduce material costs effectively while maintaining the quality of medical care.

**Merits and controversies of DPC introduction:** The introduction of DPC is of great significance for creating a database of medical information, boosting medical standardization, and furthering medical transparency. The system is, in a manner, an information infrastructure for evaluating the quality and efficiency of medical care and a profiling tool that provides a comparative evaluation among medical institutions.

DPC is also linked to the payment system. The Japanese government may have designed this system with the intention of reducing the long average LOS. However, what has resulted is a system with an ambiguous orientation. The incentive to shorten LOS is now in a paradoxical state. Many researchers and doctors believed that the DPC-based payment system would create a reduction in LOS.\(^4\)\(^-\)\(^8\)

Previously we analyzed the influence of this system using a simulation model and reported that an economic incentive to shorten LOS may not necessarily operate.\(^10\) In this report, we applied empirical data of cardiovascular diseases to the simulation model, and it became clear that the current system does not always offer incentives for shortening LOS in cardiovascular medicine, particularly in cases of conservative treatment. An increase in profit can be anticipated reliably only in cardiac catheter interventions. Large-sized hospitals may be able to accommodate an increased number of such procedures; however, it may be
comparatively difficult for small- and medium-sized hospitals to increase cardiac catheter interventions. Thus, an incentive to reduce LOS in cardiovascular medicine may operate only in large-sized hospitals, and not in small- and medium-sized hospitals.

The same situation may also occur in other fields such as major surgery, and it may be the case that the national average LOS might not be successfully shortened even if the DPC-based payment system were introduced to all general hospitals in Japan.

**Conclusion:** We found that shortening of the LOS does not necessarily increase profits under the DPC-based payment system, particularly in cardiovascular medicine. In diagnosis groups with high FFS rates, such as cases of cardiac catheter intervention, profit increased in accordance with the reduction in LOS and the increase in number of cases. But in diagnosis groups with low FFS rates, such as cases of conservative treatment, profit often decreased. The DPC-based payment system does not decisively provide an economic incentive to reduce LOS in cardiovascular medicine.

**REFERENCES**