Refereed

The implications of success rewards on complications and length of hospital stay: A retrospective study on esophageal cancer patients following esophagectomy

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Abstract

Background: In Japan, the medical fee system for acute care (Diagnosis Procedure Combination/Per Diem Payment System (DPC/PDPS)) does not incentivize improvements in the quality of surgery. This retrospective study aimed to clarify the necessity of success rewards for reducing complications in patients who underwent esophagectomy and analyze the effects of complications from surgery on hospital stay.

Methods: This study analyzed 67 in-patients who underwent esophagectomy between June 2004 and December 2008. Stepwise multiple regression analysis to estimate the effect of complications on hospital stay and survival analysis using the Kaplan-Meier estimate were performed to estimate the cumulative probability of hospital stay.

Results: The mean hospital stay was 45.84 ± 31.16. Of these patients, 4.5% had anastomotic stricture as a complication. Stepwise multiple regression analysis revealed that the occurrence of anastomotic stricture prolonged the length of hospital stay by 58.4% ($P < 0.01$). Survival analysis revealed that the cumulative probability of hospital stay for the "positive" group with anastomotic stricture was significantly higher than that for the "negative" group.

Conclusion: These findings could help the government redesign the DPC/PDPS introduced for easing medical fee payment for acute care. The results indicate the need to provide additional success rewards to improve the quality of surgery.

Key word: esophagectomy, anastomotic stricture, DPC/PDPS, survival analysis

Ⅰ. Introduction

It has been 18 years since the Diagnosis Procedure Combination/Per Diem Payment System (DPC/PDPS) was introduced in Japan as the national system of medical fee payment for acute care. This system was developed as a tool for standardizing and ensuring the transparency of medical information to provide insights into the quality of medical treatment and hospital management[1]. As a result, the introduction of the DPC/PDPS accelerated the standardization of costs and processes

related to acute care medical treatments in Japan.

However, the prognosis of medical treatments involving highly invasive surgery is often exacerbated by complications, as is the case of esophagectomies. The main complications following esophagectomy are caused by pneumonia or anastomotic leakage[2-4]. Particularly, the incidence of anastomotic stricture after esophagectomy is caused by anastomotic leakage associated with either obstruction of blood flow at the anastomotic site or inadequate anastomosis techniques[5]. Nevertheless, the DPC/PDPS system does not have a framework to incentivize acute care hospitals to improve directly the quality of surgery related to esophageal cancer. The DPC/PDPS system is merely a mechanism that indirectly improves the quality of acute care by providing incentives for patients to be discharged early.

Considering this, a system of success rewards for successful surgical outcomes will lead to improved quality of surgery because it constitutes adequate fees. Acute hospitals that can perform high-quality surgeries will aggressively perform surgical cases if they can obtain appropriate fees for successful surgical outcomes. As a result, the surgical volume will increase in such hospitals, thus increasing surgeon experience and further improving surgical quality. The phenomenon of "cream skimming" is unlikely to occur when the risk of surgical complications is inherently unavoidable, such as with esophagectomy. This retrospective study aimed to clarify the necessity of success rewards to incentivize high-quality surgery for patients who have undergone esophagectomy. Particularly, this study analyzed the effects of three related complications—pneumonia, anastomotic leakage, and anastomotic stricture—on the length of hospital stay for patients. This study suggests that the provision of additional success rewards is necessary to encourage superior surgical outcomes.

Ⅱ. Methods

1. Study design and subjects

Data on 67 in-patients (male: n = 64, female: n = 3) who claimed medical fees were reviewed. Data were analyzed for patients who had undergone surgery for esophageal malignant tumors, including gastrointestinal reconstruction surgery through operation of the neck, chest, and abdomen, as indicated by the medical fee code for a major diagnostic category of malignant tumors of the esophagus, including the neck.

The data for this study were collected from June 2004 to December 2008. This period represented the initial stage of DPC/PDPS enforcement. It shows the correspondence of medical treatment with a new national medical service fee system after introduction of the DPC/PDPS. Thereby, the impact of the system changes might have had some impact on length of hospital stay. Although the data were older, the diagnostic criteria remain fundamentally unchanged when esophagectomy is required[6-7]. The data included a full range of outcomes, from complete recovery to death. This study used data collected from 12 hospitals and was approved by the ethics review board of the International University of Health and Welfare, Japan.

2. Statistical analysis

The distribution of patients' age profiles and length of hospital stay were analyzed using the Kolmogorov-Smirnov test. Patients were divided into "positive" and "negative" groups of patients with and without complications for each variable: pneumonia, anastomotic leakage, and anastomotic stricture. Pairwise comparisons of means for groups were conducted using Levene's test when equal variance could be assumed and Welch's t-test when it could not.

Stepwise multiple regression analysis was performed to estimate the effect of the three variables on the length of hospital stay. Moreover, additional modes of treatment (central intravenous injection, radiotherapy, and chemotherapy) defined in the DPC/PDPS as the medical fee codes were included as dummy variables. Regarding the level of severity, the pathologic stage was weighted as a dummy variable because it includes the impact of patient factors on the length of hospital stay within the constraints of data. The formula used for the estimation was

$$lnD_i = \alpha + \beta_1 P + \beta_2 AL + \beta_3 AS + \beta_4 CI + \beta_5 RT + \beta_6 CT + \beta_7 S1 + \beta_8 S2 + \beta_9 S3 + \beta_{10} S4 + \varepsilon_i.$$

where the independent variable D_i was the length of hospital stay (natural logarithm), the dependent variables were as follows: P was the pneumonia dummy, AL was the anastomotic leakage dummy, AS was the anastomotic stricture dummy, CI was the central intravenous injection dummy, RT was the radiotherapy dummy, CT was the chemotherapy dummy, $S1$ was the pathologic stage I dummy, $S2$ was the stage II dummy, $S3$ was the stage III dummy, $S4$ was the stage IV dummy, and ε_i was the error term. Each dummy variable was set to one if the independent variable was applicable. Multicollinearity was not observed.

Of these variables, survival analysis by the Kaplan-Meier estimate was used to estimate the cumulative probability of hospital stay for the group of patients with and without complications, which was statistically significant. Pairwise comparisons of the respective groups of patients with and without complications for each variable were conducted using the log-rank test. The event for starting to follow the patient was defined as discharge from acute-care beds. Statistical analyses were performed using IBM SPSS Statistics for Windows, version 26.0. After stepwise multiple regression analysis, power analysis was performed.

Ⅲ. Results

Of the in-patients analyzed, 260 were diagnosed with a malignant tumor in the esophagus, including the neck that was coded as a major diagnostic category from June 2004 to December 2008. They had undergone allied surgeries as well. Of these patients, 191 (73.5%) had undergone endoscopic esophageal mucosal resection, 67 (25.8%) had undergone esophageal malignant tumor surgery with gastrointestinal reconstruction surgery through operation of the neck, chest, and abdomen, and 3 (1.2%) had undergone other operations. Esophagectomy with gastrointestinal reconstruction surgery of the neck, chest, and abdomen has a higher risk of complications due to the

highly invasive nature of the surgery. Of these patients, 11 patients underwent additional treatment through central intravenous injection (1.5%), radiotherapy (13.4%), and chemotherapy (1.5%).

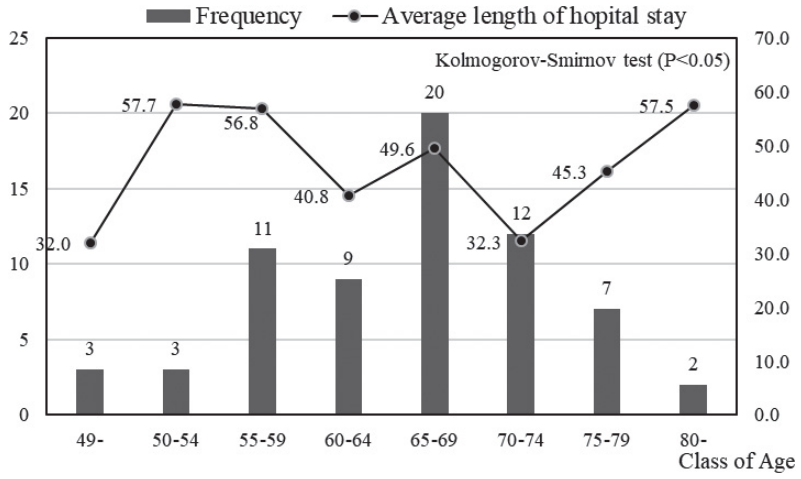
Data regarding patients' descriptive statistics as well as outcomes and pathologic stages are shown in Table 1. The average length of hospital stay tended to be inconsistent with aging (Figure 1). The peak of the length of hospital stay ranged between 22 days and 28 days, aggregated by each seventh

Table 1. Descriptive statistics of the subjects

Number of subjects	67
Age (average ± SD)	65.64±8.41
Age (range, Q1, Q3)	45-87, 60, 71.5
Male: Female ratio	64:3
Pathologic stage (n=67)	
Stage 0 (n, %)	0 (0.0%)
Stage I	16 (23.9%)
Stage II	8 (11.9%)
Stage III	19 (28.4%)
Stage IV	6 (9.0%)
Blank	18 (26.9%)
Outcome (n=67)	
Cured (n, %)	0 (0.0%)
Improvement	63 (94%)
Remission	0 (0.0%)
No change	0 (0.0%)
Worsening	0 (0.0%)
Death	2 (3.0%)
Death by other diseases	1 (1.5%)
Others	1 (1.5%)
Length of hospital stay (average ± SD)	45.84±31.16
Length of hospital stay (range, Q1, Q3)	15-214, 27, 56
Complications (n=67)	
Pneumonia (n, %)	2 (3.0%)
Anastomotic leakage	3 (4.5%)
Anastomotic stricture	13 (19.4%)
Additional treatment (n=67)	
Intravenous injection (n, %)	1 (1.5%)
Radiotherapy	9 (13.4%)
Chemotherapy	1 (1.5%)

day, while the mean and standard deviation were 45.84±31.16. According to statistics from the hospitals covered by DPC/PDPS nationwide in 2008, the mean and standard deviation were 59.15±35.23; thus, the representativeness of the data is generally secured[8].

Figure 1. Frequency (n=67) and ALS by age



Of the three complications—pneumonia, anastomotic leakage, and anastomotic stricture—the results confirmed that the average length of hospital stay of the "positive" group for anastomotic stricture was significantly longer than that of the negative group (P<0.1), while there were no significant differences in the diagnosis of pneumonia and anastomotic leakage between the groups (Table 2). The result of the test for anastomotic stricture was slightly robust, and the results of the tests for pneumonia and anastomotic leakage did not present any difficulties because the samples were small.

Table 2. Descriptive statistics of days by the occurrence group of complications

Variables of Complications	Positive		Negative			
	n	Length of Hospital Stay(1)	n	Length of Hospital Stay(1)	P	
Pneumonia	2	51.00± 4.24	65	45.68±31.62	0.81	(2)
Anastomotic leakage	3	45.00±13.08	64	45.88±31.80	0.96	(2)
Anastomotic stricture	13	70.08±51.51	54	40.00±20.72	0.06	*(3)

(1) Average ± SD, (2) Levene's test, (3) Welch's t-test, *p< .1

The effect of the three complications on the length of hospital stay was estimated using a stepwise method (Table 3). As a result, the formula to estimate the length of hospital stay is

$$lnD_i = 3.495 + 0.46AS + 0.513RT + 1.205CT + \varepsilon_i$$

The effects of anastomotic stricture, radiotherapy, and chemotherapy were found to be statistically significant, while other factors, including the pathologic stage, were excluded. In addition, exponentializing the unstandardized coefficients showed that the incidence of anastomotic stricture prolonged hospital stays by 58.4%.

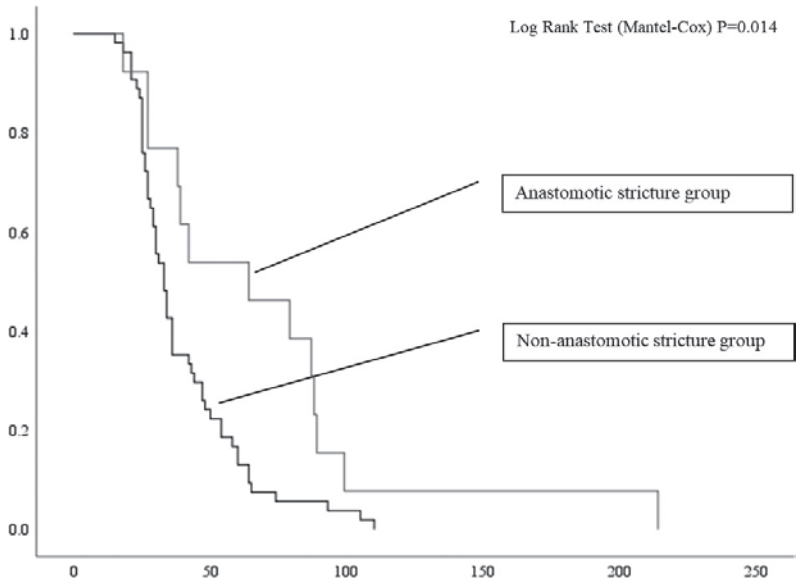
Table 3. Estimated effect of complications on the length of hospital stay, adjusted R^2: 0.30

	βCoefficient	Standard Error	t value	p value	
Intercept	3.495	0.065	53.666		
Anastomotic stricture Dummy	0.460	0.139	3.313	＜0.01	***
Radiotherapy Dummy	0.513	0.161	3.189	＜0.01	***
Chemotherapy Dummy	1.205	0.453	2.660	＜0.05	**

***p＜ .01, **p＜ .05

Finally, the cumulative probability of hospital stay for patients with and without anastomotic stricture was calculated. The results confirmed that the cumulative probability of hospital stay for the "positive" group was significantly higher than that for the "negative" group. The cumulative probability of hospital stay in the "positive" group for anastomotic stricture was 92.3% on the 21st day, in contrast to 90.7% in the "negative" group (92.3%: 64.8% on the 28th day, 76.9%: 42.6% on the 35th day, 53.8%: 33.3% on the 42nd day) (Figure 2).

Figure 2. Cumulative probability of hospital stay; Anastomotic stricture



Ⅳ. Discussion

In this study, the data on claims for medical fees for esophageal cancer in-patients following esophagectomy were retrospectively analyzed to estimate the effect of three complications—pneumonia, anastomotic leakage, and anastomotic stricture—on the length of hospital stay.

The results confirmed that the hospital stay of the "positive" group for anastomotic stricture was significantly prolonged by 58.4% compared to the "negative" group. In addition, the cumulative probability of hospital stay for the "positive" group for anastomotic stricture was significantly higher than that for the "negative" group.

Previous studies have shown that the occurrence of anastomotic stricture after esophagectomy is mainly caused by anastomotic leakage, while a high risk of anastomotic stricture does not affect survival rate. A previous study showed that anastomotic stricture was significantly associated with anastomotic leakage, while other perioperative factors, such as age, body mass index, preoperative treatment, diabetes mellitus, hemoglobin A1c before surgery, amount of bleeding under operation, pathologic stage, and pneumonia, were not[5]. Another study showed that only the occurrence of pneumonia affected survival rate, although pneumonia (22.5%), anastomotic leakage (19.4%), and recurrent nerve paralysis (15.8%) occurred in patients who had undergone esophagectomy (n＝284)[2].

Previous studies have not shown a prolonging effect of hospital stay due to the occurrence of complications. As expected, the results of this study showed that the occurrence of anastomotic stricture had a significant prolonging effect on the length of hospital stay; and radiotherapy and chemotherapy prolonged hospital stay for patients. Of these factors, the clinical features of patients following radiotherapy and chemotherapy corresponded with those in the DPC/PDPS system, because these therapies were specified in the DPC/PDPS as factors that prolonged hospital stay.

The results of this study are medically plausible because anastomotic stricture is caused by either anastomotic leakage associated with obstruction of blood flow in the anastomotic part or inadequate anastomosis techniques[5]. The incidence rate of anastomotic stricture after esophagectomy was reported to be about 5-34%, despite improvements to the suturing technique[9].

It should be noted that the occurrence of anastomotic stricture has prolonged hospital stay by 58.4% in terms of the level of treatment and quality of surgeries. A previous study reported that factors such as the number of surgeons and surgical volume are important in reducing the risks of esophagectomy[4]. However, it is not only a matter of increasing the number of surgeries. For example, some of the data included those of stage IV patients following esophagectomy. The prognoses of such patients will not always be favorable in the long run.

Whether surgery should be performed depends on clinical judgment; however, it must be premised that surgery can be performed using advanced procedures. Acute hospitals that provide high-quality surgical services will be willing to perform surgery if they can obtain the appropriate rewards for having the surgery performed. As a result, the number of surgeries will increase, and the quality of surgeries will improve, which can be expected to shorten the length of hospital stay

for patients. Therefore, by providing additional rewards for successful surgeries, the quality of surgery can be significantly improved and patients can be expected to be discharged early. Thus, it is necessary to provide an additional reward for successful surgeries to enable high-quality surgery.

Ⅴ. Limitations

This study has several limitations. First, the outcomes of esophagectomy could have been improved by introducing new suturing devices and robotic surgery. Therefore, the implications of these results are weakened. Second, anastomotic stenosis is not always caused solely by leakage of the anastomotic site. It may be caused by factors associated with patient health, such as diabetes mellitus, arteriosclerotic diseases, hepatic cirrhosis, renal dysfunction, decreased respiratory function, and the effects of consuming steroids[5]. Third, the results cannot be generalized for all population groups of Japan, therefore, it is necessary to re-examine the national data of Japan.

Ⅵ. Conclusion

This retrospective study analyzed the effects of three complications associated with esophagectomy—pneumonia, anastomotic leakage, and anastomotic stricture—on the duration of hospital stay. As a result, the hospital stay of the "positive" group pertaining to anastomotic stricture was significantly prolonged compared to that of the "negative" group, and the cumulative probability of hospital stay of the "positive" group was significantly higher than that of the "negative" group.

High-quality surgery that does not result in anastomotic stricture will improve patient prognosis. It is necessary to increase the quality of surgery by setting up a system of granting success rewards for superior quality surgery in the DPC/PDPS system. Thus, both hospitals and patients are expected to gain benefits.

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