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Original Article

High-surgical-volume hospitals associated with better quality and lower cost of kidney transplantation in Taiwan

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Abstract

Background: Only a small proportion of patients with end-stage renal disease can receive kidney transplants because of insufficiency of kidney donors in Taiwan. Hospitals compete with each other for kidney transplant surgeries. This study examined the association between hospital surgical volume of kidney transplants and patients' outcomes and utilizations.

Methods: Claims data of all kidney transplants between 1996 and 2003 were retrieved from the National Health Insurance Research Database for analysis. Every kidney recipient was followed up for 3 years until the end of 2006. Hospitals were classified as high-surgical-volume hospitals (HSVHs) if their total number of kidney transplants was 72 or more between 1996 and 2003; otherwise, they were grouped into the low-surgical-volume hospitals (LSVHs). The differences in quality (infection rate, graft rejection rate, readmission rate, mortality, and survival rates of patients and transplanted grafts at 1, 2, and 3 years after surgery) and cost (length of stay, total transplant cost, and annual medical cost for 3 years) of kidney transplants were examined between the two groups.

Results: Totally, 1,060 kidney transplants were analyzed, 77% of which were conducted at 6 of 29 qualified hospitals. Compared with those performed at LSVHs, transplant surgeries at HSVHs were associated with lower bacteria (35.1% *vs.* 48.8%, $p < 0.001$), fungus (0.2% *vs.* 1.3%, $p = 0.008$), and cytomegalovirus (1.2% *vs.* 4.6%, $p = 0.003$) infection; lower mortality (1.1% *vs.* 5.0%, $p < 0.001$); and higher 1-, 2-, and 3-year survival rates for patients (96.3%, 94.1%, 93.5% *vs.* 91.2%, 87.1%, 85.4%, respectively, $p < 0.01$) and for transplanted grafts (89.5%, 81.0%, 80.5% *vs.* 85.8%, 74.6%, 73.3%, respectively, $p < 0.015$). The transplant cost was lower for HSVHs than for LSVHs (New Taiwan $221,977 *vs.* New Taiwan $257,992, $p = 0.018$).

Conclusion: Seventy-seven percent of kidney transplant surgeries were concentrated at six hospitals in Taiwan. There were significant differences in quality and cost between HSVHs and LSVHs. We suggest adopting volume-based strategies for nonurgent kidney transplants.
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Keywords: End-stage renal disease; Kidney transplant; Quality; Surgical volume; Taiwan

1. Introduction

End-stage renal disease (ESRD) is a severe medical and public health issue in Taiwan, with the highest incidence and prevalence rates in the world.[1] The medical cost of ESRD and its complications was about New Taiwan (NT) $32.8

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billion (about United States $910 million) in 2008, comprising roughly 7.6% of the total National Health Insurance budget and incurring the highest cost for a single disease.[2]

Kidney transplant is widely believed to be the best therapeutic option for patients with ESRD among all kidney replacement therapies.[3] Patients who receive kidney transplants have higher satisfaction rates, better quality of life, and lower long-term utilization and costs than those who receive dialysis therapy.[4] There were approximately 59,000 patients with ESRD in Taiwan in 2008, but the number of organ donors was around 200 a year.[2] As a result, hospitals compete with each other for the limited donors.

Twenty-nine hospitals are qualified by the Department of Health (DOH) to perform kidney transplant surgeries in Taiwan. There is no volume threshold for kidney transplant at the hospital level, so any qualified hospital can perform transplant surgeries as long as matched donors are found. The Taiwan Organ Registry and Sharing Center was established in 2003 with the aims to develop a nationwide and comprehensive registry of patients waiting for organ transplant and improving the efficiency and equality of donated organ sharing among hospitals. Nevertheless, large-scale hospitals are used to having more trauma patients and invest more effort in activities promoting organ donations and thus have more opportunities to get matched organs than small-scale hospitals. The limited number of donors and uneven distribution of kidney transplant surgeries among hospitals have raised public concern regarding whether recipients can obtain the same quality of care at high- and low-volume hospitals.

The differences in quality and cost of kidney transplants between high- and low-volume hospitals have not been examined in Taiwan. Although many studies in other countries have demonstrated that patients who receive surgery at higher volume hospitals are more likely to have better outcomes,[5–13] an increasing number of studies have obtained contradictory findings.[14,15] Because the transplant volume of Taiwan's hospitals is smaller than that of other countries, the "higher volume and better outcomes" association may not exist for kidney transplant surgeries in Taiwan. Therefore, the aim of this study was to examine the association between hospital surgical volume of kidney transplants and patients' outcomes and costs.

2. Methods

2.1. Study design and data sources

We conducted a retrospective analysis using claims data for kidney transplants on a national basis in Taiwan. These data were reported to the National Health Insurance by hospitals after kidney transplants for claim purposes. Patients with a confirmed diagnosis of ESRD who received a kidney transplant between January 1, 1996 and December 31, 2003 were included in this study. Every patient's condition was followed up for a maximum of 3 years after transplant or until December 31, 2006 to confirm whether they died during the transplant itself or from its complications during the 3-year observation period. Patients younger than 18 years and those receiving a second transplant were not included in the study.

The source of the analytic data was a longitudinal data set prepared by Taiwan's National Healthcare Research Institute (NHRI), which is available to researchers interested in observing longitudinal changes in medical outcomes and cost. The application of the claims data of patients with renal transplant followed the National Healthcare Research Institute's regulations. The applied files contained individual subscription information and demographic factors, including gender, date of birth, and location of the transplant hospital. The claims files contained comprehensive records of inpatient care, ambulatory care, and the pharmacies. The files also included the date of transplant surgery, International Classification of Diseases, version 9 diagnosis codes for ESRD, and claimed medical expenses for each encounter. Individuals' identifiers in this data set were encrypted to protect their privacy.

2.2. High- and low-volume hospitals

This study was designed to compare the differences in quality and utilization of kidney transplantation surgeries at the hospital level. The total surgical volume of kidney transplants for every qualified hospital between 1996 and 2003 was counted and plotted (Fig. 1). Six hospitals performed considerably more transplant surgeries than the other 23 hospitals. Therefore, we divided the hospitals into two volume groups, namely, high-surgical-volume hospitals (HSVHs) and low-surgical-volume hospitals (LSVHs) using the cutoff value of 72 cases.

2.3. Quality and cost measures

Two groups of outcome variables were used to measure the quality of kidney transplant at the hospital level. First, the complications of surgeries, including bacterial infection, fungal infection, cytomegalovirus (CMV) infection, rejection

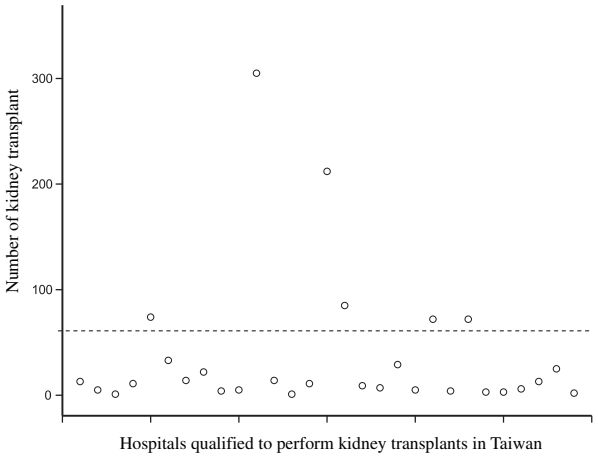

Fig. 1. Distribution of surgical volume for kidney transplants of 29 qualified hospitals in Taiwan from 1996 to 2003.

Table 1
The comparison of patients' characteristics between LSVHs and HSVHs in Taiwan from 1996 to 2003

Characteristics	LSVHs	HSVHs	*p*
Number of hospitals	23	6	
Total number of kidney transplants	240	820	
Number of kidney transplants per hospital (mean ± SD)	10.4 ± 9.1	136.7 ± 99.0	<0.001
Patient characteristics			
Male/female	113/127	398/422	0.692
Age (mean ± SD)	37.7 ± 10.1	39.6 ± 10.1	0.010
Dialysis time before transplant (mo)	28.9 ± 22.8	28.4 ± 20.2	0.756
Comorbidity burdens (Charlson score)	0.6 ± 1.0	0.6 ± 1.1	0.871

HSVH = high-surgical-volume hospital; LSVH = low-surgical-volume hospital; SD = standard deviation.

rate of the transplanted graft, hospital readmission within 14 days after discharge, and mortality. Second, the survival rates, including the survival rates for patients and transplanted grafts at 1, 2, and 3 years after surgery, respectively. Utilization variables included the length-of-hospital stay for the transplant surgery, total medical cost for the transplant, and annual medical cost for 3 years after the transplant. All necessary information for the aforementioned measures was retrieved from the claims data set.

2.4. Statistical analysis

The first step was to describe and compare the demographic information and disease characteristics of patients who received kidney transplants between the HSVHs and LSVHs, including gender, age, duration of dialysis therapy before transplant, and comorbidity burden as measured by the Charlson Comorbidity Index scores.[16] The second step was to compare the quality and utilization variables between the two volume groups using an independent *t*-test. Accumulative patient and graft survival rates for each year were calculated and plotted using the Kaplan-Meier survival analysis. The log-rank analysis was used to examine the differences in survival between hospital groups. All of these calculations were performed using SPSS software version 15.0 (SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Demographic and comorbidity analysis

A total of 1,060 kidney transplant surgeries were included in this analysis. The average dialysis time before transplant was 28.5 months, and the comorbidity burden was 0.6 by the Charlson score. The HSVHs were all large-scale medical centers: three in northern, one in middle, and two in southern Taiwan. About 77% of the kidney transplants were performed at the six HSVHs; the other 23% were performed at the 23

Table 2
The comparison of quality and utilizations of kidney transplantation surgeries between LSVHs and HSVHs

Parameters	LSVHs	HSVHs	*p*
Complications			
Bacterial infection (%)	117 (48.8)	288 (35.1)	<0.001
Fungal infection (%)	3 (1.3)	2 (0.2)	0.008
CMV infection (%)	11 (4.6)	10 (1.2)	0.003
Graft rejection (%)	26 (10.8)	127 (15.5)	0.003
Mortality (%)	12 (5.0)	9 (1.1)	<0.001
Readmission in 14 d (%)	25 (10.4)	82 (10.0)	0.903
Patient survival			
1-yr survival (%)	219 (91.2)	790 (96.3)	0.002
2-yr survival (%)	209 (87.1)	772 (94.1)	<0.001
3-yr survival (%)	205 (85.4)	767 (93.5)	<0.002
Graft survival			
1-yr survival (%)	206 (85.8)	734 (89.5)	0.132
2-yr survival (%)	179 (74.6)	664 (81.0)	0.036
3-yr survival (%)	176 (73.3)	660 (80.5)	0.019
Utilizations and cost			
Length of stay (d)	21.9 ± 15.3	19.9 ± 14.0	0.069
Transplant cost (NT$)	257,992 ± 203,865	221,977 ± 207,260	0.018
1-yr cost (NT$)	425,981 ± 425,980	410,765 ± 263,406	0.431
2-yr cost (NT$)	318,998 ± 241,959	317,056 ± 194,142	0.898
3-yr cost (NT$)	302,101 ± 212,593	303,200 ± 199,122	0.941

HSVH = high-surgical-volume hospital; LSVH = low-surgical-volume hospital; CMV = cytomegalovirus; NT = New Taiwan.

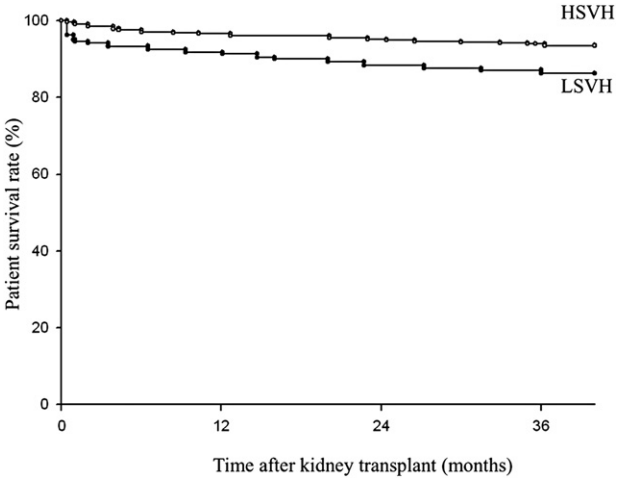

Fig. 2. The survival curve of patients who received kidney transplant at the HSVHs and LSVHs. There was significant difference between the two groups ($p < 0.001$ by log-rank test). HSVH = high-surgical-volume hospital; LSVH = low-surgical-volume hospital.

LSVHs. The average surgical volume was 136.7 ± 99.0 for HSVHs and 10.4 ± 9.1 for LSVHs during 8 years. Table 1 lists the differences between HSVHs and LSVHs in terms of patients' demographic and disease characteristics. The mean age of the recipients was higher for HSVHs than for LSVHs (39.6 *vs.* 37.7, $p = 0.01$). Otherwise, there was no statistical difference in recipients' gender, duration of dialysis before transplant, and comorbidity burdens between groups.

3.2. Transplant surgery complications analysis

Table 2 lists the differences in quality and utilization between HSVHs and LSVHs. Patients who received kidney transplants at the LSVHs were more likely to get bacterial, fungal, and cytomegalovirus infections than those at the HSVHs ($p < 0.01$ for all). The immediate graft rejection rate was higher for HSVHs than for LSVHs (15.5% *vs.* 10.8%, $p = 0.003$), but the mortality rate at the LSVHs was 4.5 times higher than that at the HSVHs (5.0% *vs.* 1.2%, $p = 0.001$).

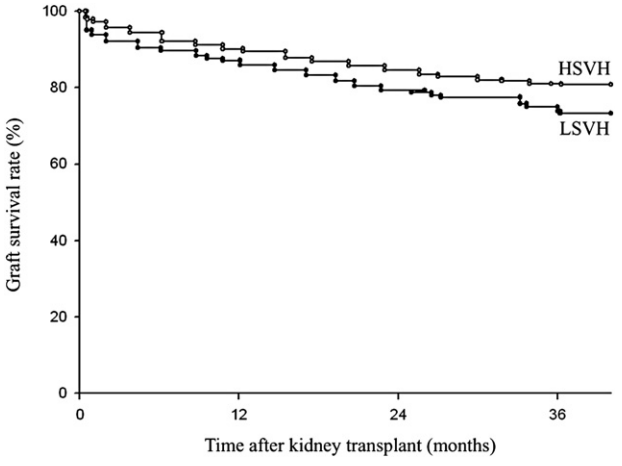

Fig. 3. The survival curves of transplanted kidney grafts at the HSVHs and LSVHs. There was significant difference between the two groups ($p = 0.016$ by log-rank test). HSVH = high-surgical-volume hospital; LSVH = low-surgical-volume hospital.

3.3. Survival analysis

The average survival rate of all patients was 95.2% at 1 year, 92.5% at 2 years, and 91.7% at 3 years after transplantation. Patients at HSVHs displayed higher 1-, 2-, and 3-year survival rates than those at LSVHs, and the difference reached statistical significance (Table 2). The survival rate of the transplanted grafts was 88.7% at 1 year, 79.5% at 2 years, and 91.7% at 3 years, and HSVHs also displayed higher survival patient rates than LSVHs except in the first year (Table 2). The Kaplan-Meier survival curves illustrate that HSVHs exhibited a higher patient (Fig. 2, $p < 0.001$) and graft (Fig. 3, $p = 0.016$) survival rate than LSVHs at every time interval.

3.4. Utilization analysis

The average length-of-hospital stay at HSVHs was 2 days less than that at LSVHs (19.9 *vs.* 21.9 days, $p = 0.069$). The medical cost for kidney transplant surgery was significantly lower at the HSVHs than the LSVHs (NT$ 221,977 *vs.* NT$ 257,992, $p = 0.018$), but the difference in posttransplant cost did not reach statistical significance (Table 2).

4. Discussion

ESRD has significant influence on patients' quality of life, and related utilization of medical resources creates a considerable financial burden on health care systems, whether in Taiwan or elsewhere.[2,17] Around 58,000 patients were on dialysis therapy in 2008 but only about 3% of them had the opportunity to receive transplantation surgery. Because hospital's surgical quality information for kidney transplantation has not been released to the public, a hospital's surgical volume of kidney transplants has become a convenient proxy quality indicator for patients and donors. This study revealed that kidney transplants performed at high-volume hospitals were more likely to result in fewer surgical complications, lower mortality, and higher survival for patients and transplanted grafts than those performed at low-volume hospitals. Transplant surgery costs were also lower at high- than low-volume hospitals.

These findings are similar to those of other volume-outcome studies for transplantation [5–8] and high-risk surgeries[11,13] in other countries. Kidney transplant outcome is determined by a recipient's health status, surgical techniques, competency of the surgeons and staff, multidisciplinary care, infection control, and the ability to manage graft rejection after surgery. Although the mean age of the kidney recipients was older and the initial graft rejection rate was higher for patients at HSVHs than at LSVHs, the survival rates for recipients and grafts were significantly better at HSVHs than LSVHs.

Many studies support the "practice makes perfect" hypothesis, in that higher volume providers develop more effective skills and treatments that result in better outcomes.[18,19] It is plausible that lower volume providers are at a disadvantage because they have fewer opportunities to develop the necessary skills for successful transplants.[20] In this study, the surgeons and the transplant team at the high-volume hospitals likely had the necessary facilities, equipment, surgical techniques, and experience in managing transplant risks and complications, such as old age, graft rejections, and all kinds of infections. Given fewer complications and better infection control, kidney transplants at the HSVHs resulted in shorter lengths of stay and lower costs than those at the LSVHs.

The "higher volume, better outcome" relationship has also been explained in part by the ''selective referral" hypothesis, in that volume could be higher in hospitals with better outcomes because patients seek care at facilities with reputations for better performance.[21] Many large-scale hospitals have the resources to promote organ donation; and thus patients with ESRD, register and wait for kidney transplants at hospitals renowned for kidney transplantation. Cadaver donors are the main organ sources in Taiwan. Thus, many people are willing to donate organs to hospitals with strong reputations in kidney transplants. Sometimes, the donors are at other hospitals, and a quick response transplant team is usually readily available from the HSVHs to get the donated organs. Because it costs a lot to develop and maintain an experienced transplant team, LSVHs gradually lose the edge and cannot compete for the limited numbers of donated organs. The "selective referral" hypothesis can partially explain the concentration of kidney transplants in six hospitals, although other hospitals have the techniques and facilities to perform them as well.

The study results have high reliability and external validity because the analysis was based on nationwide claim data from the single-payer insurance system in Taiwan. However, interpretation of these study findings should be cautious because patient and kidney graft survival is associated with many factors beyond the scope of secondary data analysis. First, the quality of donated kidneys significantly affects transplant prognosis, as do other relevant factors, including donor age, gender, species, cause of brain death, HLA typing, cadaver or living kidney, and cold ischemic time during transplant.[22] This study could not clarify these factors using the claim data. Second, the volume threshold used in this study was not based on scientific evidence but a convenient cutoff value (Fig. 1). The collected number of kidney transplants was inadequate to study the learning curve of the surgery for hospitals across time. Therefore, the minimum number of accumulated kidney transplant surgeries at the hospital level above which the quality of transplant, according to survival of patients and grafts, can attain a certain high standard has yet to be clarified.

A hospital's kidney transplant success rate is usually considered a quality landmark in risky surgery and multidisciplinary care, and it is also the first step toward other organ transplantation surgeries in Taiwan. The capability of hospital facilities, equipment, and personnel for kidney transplant are inspected and accredited to ensure quality and patient safety in Taiwan. Nevertheless, the appropriate number of hospitals allowed to perform kidney transplants is still under debate. Several volume-based selective referral or regionalization policies have been implemented for certain risky surgeries in the United States.[23] Accumulating evidence has shown that volume-based referral can save more patient lives.[11,13] Further observational studies show that the beneficial effects of high-volume hospitals are particularly concentrated in a subgroup of moderate- to high-risk patients.[24,25]

This study highlights the fact that nearly 80% of the surgeries were performed at six HSVHs, which provided better quality of care than LSVHs. If all kidney transplants were performed at these HSVHs, more patients and transplanted grafts would be saved and costs could be contained. Therefore, we suggest that policy makers consider the following volume-based strategies to improve the quality of kidney transplants. First, the DOH can consider adopting a "center of excellence" policy, that is, regionalizing nonurgent kidney transplant surgeries to hospitals that have performed kidney transplant surgeries above a certain volume threshold. This volume threshold can be decided by health care authorities, transplant expert groups, hospitals, and patient representatives. Urgent transplant surgeries and those in the rural areas are waived for the volume standard. Second, the "center of excellence" hospital should be accountable for regional kidney transplant quality and outcomes. All high-risk patients shall be referred to high-volume hospitals for intensive care. If kidney transplants for high-risk patients are allowed to be performed at low-volume hospitals, they shall be supervised by the "center of excellence" hospitals. Third, the DOH can use a "certificate of need" policy to review proposals for new construction and expand services in an effort to control costs and to improve kidney transplant quality. Such policies have been proved to be beneficial to high-risk patients receiving heart transplantation,[26] pancreas cancer,[27] and cardiac surgeries.[28]

In conclusion, this study highlights the fact that 77% of all kidney transplant surgeries were concentrated at only six hospitals in Taiwan. Patients who received kidney transplants at high-volume hospitals were more likely to have fewer surgical complications, lower mortality, higher survival rates, and lower costs than those at the low-volume hospitals. We suggest adopting volume-based strategies to ensure the quality of nonurgent kidney transplant surgeries and to facilitate the highest utilization of limited kidney donors. Nevertheless, hospital kidney transplant volume is just a proxy quality indicator on the population basis. The ultimate goal is for recipients and donors to have access to comprehensive and transparent quality information of kidney transplants.

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