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Original Article

Unplanned hospital readmissions after kidney transplantation among patients in Hefei, China: Incidence, causes and risk factors

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ABSTRACT

Objectives: Unplanned readmissions severely affect a patient's physical and mental well-being after kidney transplantation (KT), which is also independently associated with morbidity. A retrospective study was conducted to identify the incidence, causes and risk factors for unplanned readmission after KT among Chinese patients.

Methods: Patients who underwent KT were admitted to the organ transplant center of the Affiliated Hospital of University of Science and Technology of China (2017–2018). Medical records for these patients were obtained through the hospital information system (HIS).

Results: In 518 patients, the incidence of unplanned readmissions within 30 days ($n = 9$) was 1.74%, and 90 days ($n = 64$) was 12.35%. The one-year unplanned readmission rate was 22.59% ($n = 122$). Overall, 122 patients were readmitted because of infection, renal events, metabolic disturbances, surgical complications, etc. Hemodialysis ($OR = 10.462$, 95% CI: 1.355–80.748), peritoneal dialysis ($OR = 8.746$, 95% CI: 1.074–71.238) and length of stay ($OR = 1.023$, 95% CI: 1.006–1.040) were independent risk factors for unplanned readmissions.

Conclusion: Unplanned readmission rates increased with time after KT. Certain risk factors related to unplanned readmissions should be deeply excavated. Targeted interventions for controllable factors to alleviate the rate of unplanned readmissions should be identified.

What is known?

- The number of patients receiving Kidney Transplantation (KT) has steadily increased over the years, which is associated with a concomitant increase in post-adverse events that often result in unplanned readmissions.
- Unplanned readmissions have become a critical issue for health care, which is also a meaningful quality measurement for transplant centers.

What is new?

- The incidence of unplanned readmissions among Chinese patients increases with time after KT.
- The causes of unplanned readmissions among Chinese patients after KT were multi-factorial, and involved infection, renal events, metabolic disturbances and so on.
- The risk factors of unplanned readmission among Chinese patients after KT included hemodialysis, peritoneal dialysis and length of stay.

1. Introduction

Kidney transplantation (KT) is the preferred treatment for patients with end-stage kidney disease [1,2]. According to the Global Observatory on Donation and Transplantation (GODT), 69,500 kidney transplants were performed worldwide in 2016, accounting for 64.43% of all organ transplants [3]. In China, around 63,842 KTs were performed from 2007 to 2016 [4]. Although the survival rate after KT is more than 90% within one year, many complications such as infection, acute rejection and chronic renal failure often lead to poor outcomes and increased return to the hospital [5]. Repeated readmission in patients after organ transplantation is the highest

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risk period for allograft loss and death [6].

Unplanned readmissions refer to readmissions that are unpredictable after discharge [7]. Patients who experience an unplanned readmission after KT have a 50% higher mortality rate than those without an unplanned readmission [8]. Unplanned readmissions not only negatively affect a patient's physical and mental well-being, but also increase the financial burden and limits healthcare resources [9]. Therefore, reducing the unplanned readmission rate after KT is beneficial for both the patients and institutions.

Nationally, the incidence rate of unplanned readmissions after KT within 30 days ranges from 20.6% to 45% [10–12], a substantially higher rate than for patients undergoing other surgeries (4%–15%) [13]. Prior studies have identified several risk factors for the 30-day readmission rate, such as recipient age, comorbid diabetes mellitus, length of stay, cytomegalovirus (CMV) serology negative, deceased kidney donation, delayed graft functioning and low glomerular filtration rate at discharge [9,14,15]. However, these studies focused on the short term [16–19], with a lack of long-term follow-up data.

In general, the first year after organ transplantation is associated with a higher risk of readmission [15]. Among liver transplantation patients, Peixian et al. [20] found that unplanned readmissions within the first year were unavoidable and affected the morbidity and quality of care. Additionally, infection or rejection was the most frequent causes of unplanned readmissions within one year for heart transplant patients [21]. For KT patients, Naylor et al. [22] also reported graft survival, rejection, acute renal failure and urinary tract abnormalities as key risk factors. Furthermore, most of the existing literature has been collected from the USA, which lacks data on Asian populations, especially in China. More effort needs to be taken to investigate the incidence, causes and risk factors associated with first-year unplanned readmissions after KT to better inform the coordination of care in high-risk populations. Thus, this study aimed to investigate the incidence, causes and risk factors of unplanned hospital readmissions after KT within one year in China.

Based on previous literature, we hypothesized that recipient age, comorbidity, length of stay, dialysis method, type of surgery, anti-rejection drug type and blood biochemical results at discharge from the initial hospitalization would be associated with increased odds of first-year unplanned hospital readmission after KT.

2. Methods

2.1. Study design

A single-center retrospective study was performed.

2.2. Setting and participants

Patients (≥18 years of age) who underwent KT were admitted to the organ transplant center of the Affiliated Hospital of University of Science and Technology of China, which serves as a comprehensive hospital integrating medical, teaching and scientific research from January 2017 to December 2018. We excluded multi-organ transplant patients, patients who had incomplete medical records and patients who died prior to discharge from KT. The subjects were divided into a readmission group and a non-readmission group.

2.3. Data extraction

This study was approved by the Hospital Medical Ethics Committee (No.2019-N H-177). Informed consent was waived due to the retrospective study design. Data collection were performed by three nurses with graduate degrees and two years of experience, who completed the checklist by referring to the electronic medical records of the Hospital Information System (HIS). The collected data were re-examined by the researcher in order to confirm the accuracy of the data. The components of the checklists were developed based on related references [15,17]. The final checklists were established by a clinical kidney transplant specialist, a transplant unit nurse manager and a nursing researcher, and included: (1) basic characteristics, such as gender, age, marital status, education, residence, occupation, body mass index (BMI), comorbidity and length of stay; (2) transplant-related information, such as dialysis method, type of surgery and anti-rejection drug type; and (3) laboratory test results, such as leukocyte, neutrophil, hemoglobin, prealbumin, total protein, albumin, globulin, alanine aminotransferase, aspartate aminotransferase, blood urea nitrogen, serum creatinine, uric acid, blood glucose, K^+, Ca^{2+}, P and Mg^{2+}.

2.4. Statistical analysis

Statistical analyses were performed using SPSS version 23.0 (SPSS Inc., Chicago, Illinois, USA). Data were presented as mean and standard deviation or frequency and percentages for all the demographic, clinical and outcome measures. Student's *t*-test, Mann–Whitney *U* test and Chi-square test were utilized to compare the differences between patients with or without unplanned readmission after KT. To find the potential risk factors for unplanned readmissions, binary logistic regression analysis was applied. Statistical significance was set at $P < 0.05$, two tails.

3. Results

3.1. Population

During the study period, a total of 549 consecutive KTs were performed. Thirty-one patients were excluded from our study: 15 patients had planned readmissions, two patients were younger than 18 years, three patients died prior to discharge from their KT and 11 patients had incomplete medical records. Finally, a total of 518 patients were included in our analysis.

Of the 518 enrolled patients (*Mean age* = 33.75 years), 368 were male. The majority of the participants were married (66.60%), and most of the participants were from the countryside (81.27%). With regard to education level, 309 patients (59.65%) were educated to a junior high school level. Overall, 488 patients (94.21%) had experienced hemodialysis or peritoneal dialysis before KT. In addition, KT mainly involved living donor kidneys (82.05%). Other socio-demographic characteristics and clinical data for the patients are presented in Table 1. Among the patients who were readmitted, most were married, female, unemployed, junior high school educated and from urban areas. Hemodialysis was the main dialysis method.

3.2. Incidence of unplanned readmission

Of all the rehospitalizations, the incidence of unplanned readmissions within one year was 23.75% ($n = 122$), of which, the 30-day readmission rate was 1.74% ($n = 9$) and the 90-day readmission rate was 12.35% ($n = 64$). Unplanned readmissions occurred at a median time of 89.5 days after post-transplant discharge. The median hospital readmission duration was 10 days.

3.3. Causes for unplanned readmission

The reasons for unplanned readmissions were categorized based on the medical records. Fig. 1 shows the distribution of primary reasons among the 122 patients with unplanned

Table 1
Comparison of clinical data among KT patients in the readmission group and non- readmission group ($n = 518$).

Variables	Readmission group ($n = 122$)	Non-readmission group ($n = 396$)	$t/Z/\chi^2$	P
	***n* (%)**	***n* (%)**		
Gender			0.372	0.542
Male	84 (68.85)	284 (71.72)		
Female	38 (31.15)	112 (28.28)		
Age			/	0.651
18–35	72 (59.02)	243 (61.36)		
36–59	49 (40.16)	151 (38.13)		
≥60	1 (0.82)	2 (0.51)		
Marital status			0.175	0.916
Unmarried	35 (28.69)	119 (30.05)		
Married	83 (68.03)	262 (66.16)		
Widowed/divorced	4 (3.28)	15 (3.79)		
Education			4.159	0.125
Junior high school	82 (67.21)	227 (57.32)		
Senior high school	21 (17.21)	79 (19.95)		
College or above	19 (15.57)	90 (22.73)		
Residence			0.303	0.582
Countryside	101 (82.79)	319 (80.56)		
Urban	21 (17.21)	77 (19.44)		
Occupation			1.022	0.312
Unemployed	82 (67.21)	285 (71.97)		
Employed	40 (32.79)	111 (28.03)		
BMI			2.650	0.449
<18.5	22 (18.03)	80 (20.21)		
18.5–23.9	73 (59.84)	247 (62.37)		
24.0–28.0	25 (20.49)	60 (15.15)		
>28	2 (1.34)	9 (2.27)		
Comorbidity			0.082	0.774
Yes	16 (13.11)	56 (14.14)		
No	106 (86.89)	340 (85.86)		
Dialysis method			10.562	0.014
Hemodialysis	102 (83.61)	302 (76.26)		
Peritoneal dialysis	18 (14.75)	63 (15.91)		
Both	1 (0.82)	2 (0.51)		
Non-dialysis	1 (0.82)	29 (7.32)		
Type of surgery			0.264	0.608
Living donor kidney	102 (83.61)	323 (81.57)		
Corpse donor kidney	20 (16.39)	73 (18.43)		
Anti-rejection drug type			0.552	0.457
Tacrolimus	56 (45.90)	197 (49.75)		
Cyclosporine	66 (54.10)	199 (50.25)		
	Mean* ± *SD	***Mean* ± *SD***		
Hemoglobin	90.91 ± 21.32	93.85 ± 19.77	1.404	0.161
Total protein	64.13 ± 6.76	62.51 ± 6.83	2.289	0.022
Albumin	40.29 ± 4.16	39.28 ± 4.24	2.300	0.022
	***Median*(P_{25}, P_{75})**	***Median*(P_{25}, P_{75})**		
Length of stay	26.00 (20.75, 33.00)	22.00 (19.00, 28.00)	3.739	<0.001
Leukocyte	8.88 (6.93,11.46)	8.73 (6.72, 10.97)	0.157	0.875
Neutrophil	69.85 (7.68,77.7)	62.35 (6.81, 74.30)	2.356	0.018
Prealbumin	314.50 (290.00,360.75)	298.50 (255.75, 347.00)	2.472	0.013
Globulin	23.45 (21.50, 26.13)	23.00 (20.73, 25.40)	1.534	0.125
Alanine aminotransferase	21.00 (13.00, 29.50)	21.00 (13.00, 36.00)	0.887	0.375
Aspartate aminotransferase	16.00 (13.00, 22.00)	17.00 (14.00, 22.00)	0.426	0.670
Blood urea nitrogen	8.80 (7.00, 11.84)	8.34 (6.70, 10.81)	1.892	0.058
Serum creatinine	102.50 (72.00, 135.50)	90.00 (72.00, 113.75)	2.148	0.032
Uric acid	271.50 (220.63, 338.45)	271.00 (227.00, 326.75)	0.150	0.881
Blood glucose	4.44 (4.04, 5.02)	4.43 (4.10, 4.96)	0.179	0.858
K^+	4.32 (3.99, 4.74)	4.17 (3.81, 4.54)	2.179	0.013
Ca^{2+}	2.32 (2.19, 2.43)	2.28 (2.17, 2.40)	1.313	0.189
P	0.73 (0.57, 0.96)	0.73 (0.56, 0.95)	0.199	0.842
Mg^{2+}	0.73 (0.66, 0.82)	0.73 (0.67, 0.79)	0.395	0.693

readmissions within one year. Specifically, 72.1% of all unplanned readmissions were for infection, including pneumonia, urinary system infection, incision infection and skin infection; 10.7% were metabolic disturbances, including electrolyte abnormalities, anemia and gastrointestinal disturbances; renal issues accounted for 7.4% including acute kidney injury and acute renal rejection; 4.1% were cardiovascular events, including arrhythmia, thrombus and hypertension; 2.5% were surgical complications, including hernia, infected incision site and hematoma; and 3.3% were miscellaneous and included renal space occupying lesions, phthisis, canceration and so on.

3.4. Risk factors for unplanned readmission

The results (Table 1) showed that there were significant differences between the patients with or without unplanned readmissions among such variables as the dialysis method, length of stay, neutrophil, prealbumin, total protein, serum creatinine and K^+

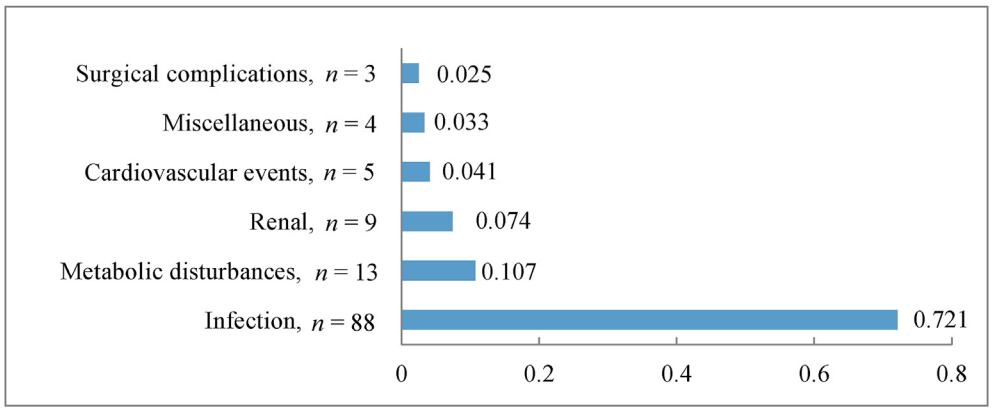

Fig. 1. Reasons for unplanned admission.

levels (all *P* values < 0.05).

Logistic regression analysis indicated that those who had experienced hemodialysis (*OR* = 10.462, 95% CI: 1.355–80.748), peritoneal dialysis (*OR* = 8.746, 95% CI: 1.074–71.238) and longer length of stays (*OR* = 1.023, 95% CI: 1.006–1.040) were at increased risk of unplanned readmissions (Table 2).

4. Discussion

The number of patients receiving KTs has steadily increased over the years, and this has been associated with a concomitant increase in post-adverse events that have often resulted in unplanned readmissions. Unplanned readmissions have become a critical issue for health care, and is also a meaningful quality measurement for transplant centers. The aim of this study was to identify the incidence, causes and risk factors of unplanned readmissions within one year at a transplant center in China.

The incidence of unplanned readmissions within one year was 22.59%. Previous studies have shown that the readmission rates after other organ transplantations [20,23,24] have ranged from 19.3% to 45.5%. In comparison, the one-year readmission rate was comparatively low at our center. On the one hand, some patients may have been readmitted to other hospitals, potentially leading to a different prediction of the readmission rate in this study. Additionally, it is also imperative to acknowledge that there are differences in the environments and resources available at different transplant centers, which could lead to changes in the transplant rate. However, these differences are not necessarily reflected by variations in patient volume or population characteristics in the different transplant centers [25]. Variability could be explained by the patient care processes as well as interactions between patient characteristics and patient care.

The causes of readmissions after KT were multi-factorial. The most common cause for readmission was fever, with infection as the most common diagnosis (70.90%). Previous studies have declared that infection has been cited as a frequent complication following KT and other organ transplantations that involve immunosuppressive therapies [26,27]. A report found that pulmonary complications after KT were responsible for 65% of readmissions [28]. In the study by Paterno et al. [29], infections were the most common reason for hospital readmission among liver transplant recipients (19.5%). In our study, the most common sources of infections were reported to be pulmonary, urinary and incision infections. Similarly, renal events, metabolic disturbances, surgical complications and cardiovascular events have been reported to be associated with an increased risk of readmission among recipients who have undergone KT [30–32].

Compared with other studies, we did not find any of the already identified significant factors from literature, including gender, age, BMI and immunosuppressive induction in the prediction of unplanned readmissions in the first year following KT [15]. First, it is unclear whether this represents differences in the KT patients or the post-KT care. Secondly, we cautiously selected a recipient cohort that could have resulted in selection bias of our results. Thirdly, this is a single institution study as compared to studies based on national databases that allow for larger cohorts.

However, it is surprising that we found that dialysis modality was a risk factor for readmission. This may be because of infection-related hospitalizations (IRH) produced by dialysis. Studies have shown that IRHs could contribute to significant mortality and

Table 2
Logistic regression analysis of risk factors for unplanned readmission (n = 518).

Variables	*B*	*SE*	Wald χ^2	*P*	*OR* (95%CI)
Dialysis method					
Hemodialysis	2.348	1.043	5.070	0.024	10.462 (1.355, 80.748)
Peritoneal dialysis	2.169	1.070	4.106	0.043	8.746 (1.074, 71.238)
Both	2.591	1.615	2.573	0.109	13.349 (0.56, 316.63)
Non-dialysis					1
Length of stay	0.022	0.009	6.786	0.009	1.023 (1.006, 1.040)
Neutrophil	0.006	0.003	3.827	0.050	1.007 (1.000, 1.013)
Total protein	0.244	0.748	0.106	0.744	1.276 (0.295, 5.526)
Albumin	−0.196	0.748	0.069	0.793	0.822 (0.190, 3.564)
Globulin	−0.249	0.747	0.112	0.738	0.779 (0.180, 3.367)
Serum creatinine	0.001	0.001	0.344	0.558	1.001 (0.999, 1.003)
K^+	−0.008	−0.020	0.163	0.686	0.992 (0.953, 1.032)
Constant	−6.107	1.500	16.583	˂0.001	–

readmission [33]. Other studies have also confirmed that peritoneal dialysis and hemodialysis were associated with a higher risk of death from infection [34].

Not surprisingly, the initial length of stay for the transplant hospitalization was another risk factor for unplanned readmissions. In our study, re-hospitalized patients had a longer mean length of stay for the transplant hospitalization when compared with the non-readmission group (26 vs. 22 days, $P < 0.001$). Based on a national study, McAdams-DeMarco had a longer mean length of stay for transplant hospitalization (9.8 vs. 8.1 days, $P < 0.001$) [25]. Nonetheless, there are differences in the median time for length of stay among different studies. This could reflect differences in transplant center practices. Additionally, Harhay and colleagues also reported that re-hospitalized patients were more likely to have had a longer length of stay (median, 4.8 vs. 4.0 days; $P = 0.03$) [11]. The median time of length of stay after readmission was described as 10 days in this study. There was no association between the unplanned readmission duration and the time to readmission.

There are several limitations of the present study. First, the presented data were extracted from a single center, which limits its generalizability and cohort size. Compared with studies based on national databases that allow for larger cohorts, our retrospective chart review allowed us to evaluate data not documented in clinical registry databases. Second, data were obtained through retrospective chart reviews. As such, our data relied on accurate documentation and some comorbidities or specific patient factors may have been missed because of documentation errors or omissions. Third, not all significant risk factors that were reported in previous publications were included in this chart review.

5. Conclusions

In conclusion, unplanned readmission rates have become an important measure of quality and value. Dialysis modality and the length of stay for the transplant hospitalization result in a higher risk of unplanned readmission following KT, both for infection, renal events and surgical reasons. Many of the one-year readmission cases are unavoidable. A thorough understanding of incidence, causes and risk factors for readmission are essential for patient risk stratification and follow-up strategies. Importantly, there has been little research on the association between readmission and the recipients' self-management, as well as quality of life. Further studies may consider focus on these aspects. More targeted guidelines should be provided to reduce the unplanned readmission rate.

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CRediT authorship contribution statement

Aiqin Chu: Methodology, Writing - original draft. **Tian Zhang:** Methodology, Writing - original draft. **Yueyan Fang:** Data curation. **Li Yuan:** Data curation. **Xiaohong Guan:** Data curation. **Hailing Zhang:** Conceptualization, Writing - review & editing.

Declaration of competing interest

None.

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