# The Incidence And Risk Factors of Serum Hypokalemia After Primary Total Joint Arthroplasty

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# Abstract

**Background**: Regular monitoring of serum potassium after total joint arthroplasty (TJA) is a routine examination, which can detect abnormal serum potassium and reduce adverse events timely caused by postoperative hypokalemia. In this study, we aimed to investigate the incidence and risk factors of hypokalemia after primary total hip and knee replacement.

**Methods**: This study included patients who underwent unilateral total knee or hip arthroplasty in our department from April 2017 to March 2018. The serum potassium level before and after operation was collected and retrospectively analyzed. The differences in age, BMI and other factors between hypokalemia patients and non-hypokalemia patients at different time points after surgery were compared, and then the risk factors of postoperative hypokalemia were analyzed based on multiple logistic regression.

**Results:** The total incidence of postoperative hypokalemia was 53.1%, while the respective rate on the first, third and fifth postoperative day was 12.5%, 40.7% and 9.6%. The serum potassium level on the first, third and fifth postoperative day was 3.84±0.32mmol/l, 3.59±0.34mmol/l and 3.80±0.32mmol/l, while among which, the level on the third day was the lowest (p=0.015). The independent risk factors for hypokalemia after total hip and knee replacement were the level of preoperative serum potassium (p=0.011), preoperative red blood cells (p=0.027), and a history of diabetes (p=0.007).

**Conclusion:** Regular monitoring of serum potassium should be performed after TJA due to hypokalemia was a very common complication. We need to pay more attention to patients' preoperative potassium and red blood cells, especially patients with diabetes.


# Introduction

Total joint arthroplasty (TJA) is a mature surgical technique. In America, by 2030, there will be 572,000-635,000 primary hip replacements and 1.26-3.48 million primary knee replacements [1] [2] [3]. However, there are still some complications, including postoperative anemia [4], infection [5], deep venous thrombosis(DVT)[6], dislocation [7], electrolyte disturbance [8] [9] [10], vascular and nerve damage and so on [11]. Serum potassium is one of the important electrolytes in blood. Patients with moderate hypokalemia often develop general weakness, fatigue, and constipation. When serum concentration is less than 2.0 mmol/L, paralysis will occur, which ultimately may impair respiratory function. In patients with myocardial ischemia, heart failure, or left ventricular hypertrophy, even mild to moderate hypokalemia can increase the risk of arrhythmia [12, 13]. In addition, hypokalemia can also cause longer hospital stay and recovery time and more medical costs [14] [15] [16].

Previous studies have shown that hypokalemia is a common clinical postoperative complication. General surgery, neurosurgery, obstetrics and gynecology and other departments have reported that the hypokalemia rate is 25%, and will cause many adverse symptoms of patients [15]. There are only a few

reports on the level of potassium after orthopedic surgery, about 25% resulting in hypokalemia in joint surgery, and also can bring some low potassium symptoms.

The age, sex, anesthesia method and other factors in the surgical departments such as general surgery was reported to be the risk factors for postoperative hypokalemia [15]. Previous reports have suggested that possible factors for the occurrence of hypokalemia after joint replacement include the patient's preoperative blood potassium level, whether they have diabetes, etc [8] [9] [10]. However, the studies are not enough, and the attitudes to the prevention and detection of hypokalemia are different.

Therefore, this study aims to investigate the incidence, tendency and risk factors of hypokalemia after total hip and knee arthroplasty in order to make an early diagnosis and fast potassium supplement.

# Patients And Methods

This study was approved by the Institutional Review Board. Patients who underwent primary TJA in our department were screened from April 1, 2017, to March 31, 2018. Those who received staged TJA during the research period, only the first procedure was included. We excluded patients with serum hypokalemia before surgery (normal laboratory potassium value is defined as (3.5-5.5 mmol/L) [13]). Eventually, 160 patients met these criteria and were enrolled in the study.

Patients' demographic and clinical data was collected from medical records including age, sex, body mass index (BMI), comorbidities, history of surgery and anticoagulant drug use, heart ejection fraction, intraoperative blood loss, blood transfusion amount, operation duration and the amount of postoperative drainage. Laboratory values were collected such as blood type, preoperative blood glucose, creatinine, glomerular filtration rate, hemoglobin, hematocrit and serum potassium (K) before surgery and the first, third and fifth day after surgery.

Patients in the two groups were compared: (1) patients with normal postoperative serum potassium and (2) patients with abnormal postoperative serum potassium.

Descriptive statistics, including mean and standard deviations, as well as frequency and proportion, were calculated to characterize the study group. The independent t-test was used to examine differences in continuous variables between groups. The chi-square or fisher precision test is used to compare differences in categorical variables. The multivariate logic model is suitable for identifying the related risk factors of abnormal potassium value after the operation. All baseline differences between the two groups were entered into the logistic regression model. The alpha level for all analyses was set to $P < 0.05$. All statistical analyses were carried out using Statistical Package for the Social Sciences, version 20.0 (SPSS Inc, Chicago, IL).

# Results

The basic information of the 160 enrolled subjects was shown in Table 1. There were 37 men and 123 women with the age of 66.02±10.11 years old. Fifty-two patients had primary hip arthroplasty and 108 patients had primary knee arthroplasty. Preoperative potassium was 3.99±0.29 mmol /L.

Table 1
Patient's demographic and clinical characteristics

| Variables | No. of patients(N=160) |
|---|---|
| Age (years) (mean±SD) | 66.02±10.11 |
| Gender (female) (%) | 123(76.8%) |
| BMI (kg/m2) (mean±SD) | 25.5±4.16 |
| Hypertension(%) | 84(52.5%) |
| Diabetes mellitus(%) | 26(16.2%) |
| Heart disease(%) | 28(17.5%) |
| Smoking history(%) | 7(4.4%) |
| Surgery type (TKA) (%) | 108(67.5%) |
| Preoperative potassium(mmol/L) | 3.99±0.29 |
| RBC,10^9/L | 4.37±0.52 |
| Hb, g/L (mean±SD) | 128.48±19.83 |
| HCT(%) | 41.00±26.22 |
| Blood glucose(mmol/L) | 5.86±1.70 |
| Urine creatinine(umol/L) | 56.08±14.73 |
| Urea nitrogen(mmol/L) | 5.78±1.32 |
| eGFR(ml/min/1.73m^2) | 113.54±28.94 |
| EF(%) | 60.11±2.94 |
| Intraoperative blood loss, ml | 234.78±193.84 |
| Operation time, min (mean±SD) | 60.11±2.94 |
| Drainage(ml) | 237.66±193.84 |
| BMI ,body mass index; SD ,standard deviation ;TKA, total knee arthroplasty ; RBC ,red blood cell; Hb, hemoglobin; HCT, hematocrit; eGFR, glomerular filtration rate; EF ,ejection fraction. | |

The lowest level of serum potassium after TJA was 3.59±0.34mmol/L on the third day after surgery (Table 2). There was a significant difference in serum potassium among on the third day and on the first or fifth day after operation (p=0.027). But no statistical difference was found between the level on the

first day and the fifth day. The new occurrence of postoperative hypokalemia was 12.5%, 40.7% and 9.6% on the first, third and fifth day respectively. Most of the patients suffered mild hypokalemia after the operation. Less than 10% patients with moderate and severe hypokalemia (Table 3).

Table 2
The number and proportion of new hypokalemia in the first, third and fifth day after the operation

| | First day | Third day | Fifth day | Total |
|---|---|---|---|---|
| Mean± SD(mmol/L) | 3.84±0.32 | 3.59±0.34 | 3.80±0.32 | 3.74±0.35 |
| New hypokalemia(total) | 20(160) | 57(140) | 8(83) | 85(160) |
| Percentage | 12.5% | 40.7% | 9.6% | 53.1% |
| SD, standard deviation | | | | |

Table 3
The number and incidence of different degree hypokalemia after the operation

| Degree of hypokalemia | hypokalemia | Percentage of total(%) | Percentage Of hypokalemia(%) |
|---|---|---|---|
| Mild | 78 | 48.75 | 91.76 |
| Moderate | 5 | 3.13 | 5.88 |
| Severe | 2 | 1.25 | 2.35 |

Univariate logistic regression analysis showed that five factors were associated with postoperative hypokalemia including age(p=0.010), diabetes mellitus(p=0.013), preoperative red blood cell count(p=0.024), preoperative serum potassium level(p=0.008), preoperative cardiac ejection fraction(p=0.033) (Table 4).

Table 4
Univariate analysis of the risk factors for hypokalemia after operation

| Variable | No hypokalemia (n=75) | hypokalemia (n=85) | P value |
|---|---|---|---|
| Age, years (mean±SD) | 68.2 ±8.7 | 64.1 ±11.0 | **0.010** |
| Female gender (%) | 59 (47.9) | 64 (52.1) | 0.614 |
| BMI, kg/m2 (mean±SD) | 25.3 ±4.0 | 25.7 ±4.3 | 0.577 |
| Diabetes (%) | 36 (42.9) | 48 (57.1) | **0.013** |
| Hypertension (%) | 108 (46.2) | 14 (36.8) | 0.284 |
| Heart disease (%) | 16(57.1) | 12(42.9) | 0.231 |
| Smoking history (%) | 2(28.6) | 5(21.4) | 0.321 |
| History of thrombosis | 10(13.3) | 13(15.3) | 0.724 |
| History of anticoagulant | 10(13.3) | 7(8.2) | 0.296 |
| History of other medication | 20(26.6) | 14(16.5) | 0.116 |
| Surgical history | 19(25.3) | 13(15.3) | 0.113 |
| Surgery type (TKA) (%) | 53(49.1) | 55(50.1) | 0.422 |
| Preoperative potassium(mmol/L) | 4.1±0.24 | 3.9±0.27 | **0.008** |
| RBC, 10^9/L | 4.3±0.46 | 4.4±0.56 | **0.024** |
| Hb, g/L (mean±SD) | 129.48±12.83 | 127.60±24.44 | 0.551 |
| HCT(%) | 38.7±4.4 | 43.1±3.6 | 0.290 |
| Blood glucose(mmol/L) | 5.48±1.13 | 5.18±1.29 | 0.122 |
| Urine creatinine(umol/L) | 56.98±15.52 | 55.29±13.67 | 0.467 |
| Urea nitrogen(mmol/L) | 6.08±1.56 | 5,68±1.76 | 0.134 |
| eGFR(ml/min/1.73m^2) | 110.34±26.24 | 116.36±30.35 | 0.184 |
| EF(%) | 59.6±2.7 | 60.6±3.0 | **0.033** |
| Operation time, min (mean±SD) | 99.1 ± 26.1 | 103.6 ± 21.8 | 0.245 |
| Drainage(%) | 60(80) | 66(77.6) | 0.717 |
| Blood transfusion | 7(9.3) | 7(8.2) | 0.816 |

BMI ,body mass index; SD ,standard deviation ;TKA, total knee arthroplasty ; RBC ,red blood cell; Hb, hemoglobin; HCT, hematocrit; eGFR, glomerular filtration rate; EF ,ejection fraction.

*P<0.05 was considered statistically significant.

Combined with multivariate logistic regression analysis, age and cardiac ejection fraction were not independent risk factors for postoperative hypokalemia (p=0.778 and 0.069, respectively). Preoperative serum potassium value was an independent factor affecting hypokalemia after TJA (p=0.011). Patients with low preoperative serum potassium were 5.9 times more likely to postoperative develop hypokalemia than those with higher preoperative serum potassium. Diabetes was also an independent factor of influencing postoperative hypokalemia (p=0.007). Patients without diabetes were 25.5% less likely to develop postoperative hypokalemia than those with diabetes, suggesting that diabetes was an effective independent risk factor. Preoperative erythrocytes were also the independent influencing factor of hypokalemia after TJA (P=0.027, Table 5)

Table 5
Logistic regression analysis to identify the independent risk factors for hypokalemia

| **Variables** | **P-value** | **OR** | **95% CI** |
|---|---|---|---|
| potassium | **0.011** | 5.997 | 1.502-23.934 |
| Diabetes | **0.007** | 0.255 | 0.095-0.688 |
| RBC | **0.027** | 0.417 | 0.193-0.903 |
| Constant | 0.412 | 107.674 | - |
| RBC, red blood cell; OR, odds ratio; 95% CI, confidence interval. | | | |
| *P<0.05 was considered statistically significant. | | | |

In the receiver operating characteristics (ROC) analysis for the risks of postoperative hypokalemia, the area under curve (AUC) was 0.62 ((95% CI 0.7-0.9), P=0.008) and when the cut-off value of preoperative potassium was set at 4.0mmol/L, the sensitivity and specificity of postoperative hypokalemia were 78.8% and 48.0%, respectively (figure 2, Table 6)

Table 6
The area under the ROC curve (AUC)

| Preoperative potassium | | | | |
|---|---|---|---|---|
| Area | Std. Error[a] | Asymptotic Sig.[b] | Asymptotic 95% Confidence Interval | |
| | | | Lower Bound | Upper Bound |
| 0.621 | 0.044 | 0.008 | 0.534 | 0.708 |

[a] Under the nonparametric assumption

[b] Null hypothesis: true area = 0.5

*P<0.05 was considered statistically significant.

# Discussion

In this retrospective study, eighty-five of 160 enrolled patients developed postoperative hypokalemia within 5 days, and the rate of postoperative hypokalemia on the third day was the highest. Multivariate analysis showed that preoperative potassium, red blood cell count and diabetes were independent risk factors for hypokalemia. In the ROC analysis, the cut-off value of preoperative potassium was set at 4.0mmol/L, the sensitivity and specificity of postoperative hypokalemia were 78.8% and 48.0%, respectively.

Hypokalemia is not uncommon after surgery, accounting for 25% [15], but few studies have reported serum potassium abnormalities after TJA. Only one recent retrospective study reported the incidence of postoperative abnormalities of potassium, which was about 25.2% [10]. However, the risk factors were not mentioned. Based on our study, 53.1% of patients developed serum hypokalemia within five days after surgery, with slight, moderate and severe hypokalemia accounting for 48.75%, 3.13% and 1.25%, respectively.

The level of serum potassium displayed a remarkable drop from pre-operational to the third day after surgery and then showed a slight increase. Thus, we proposed that the serum potassium should be checked on the third day after TJA for avoiding severe hypokalemia. However, the previous study has thought postoperative basic metabolic panel should not be routinely tested in patients unless they have medical comorbidities, and their potassium is below 4 mmol/L[9]. Halawi et al.[8] provided evidence that routine postoperative laboratory testing is not necessary in modern-day primary unilateral THA. Therefore, whether and when to detect serum potassium after joint replacement still needs further study. In addition, our study showed that there were two patients got severe hypokalemia after the operation. If we did not carry out serum potassium monitoring, serious complications may occur, and the previous study has thought early potassium monitoring can be helpful to correct hypokalemia, effective to recover trauma operation [17].

It is believed that the occurrence of postoperative hypokalemia is related to a variety of factors, including insufficient intake, excessive potassium loss and impaired potassium distribution mechanism [18]. By multivariate regression analysis, we found that the independent risk factors for hypokalemia after TJA were diabetes, preoperative serum potassium level, which was similar to the report of Mohamad J et al. [10].

Kildow BJ [10] also regarded Diabetes as an important predictor. the feedback system regulates potassium and insulin levels. The increase of extracellular potassium concentration stimulates the release of insulin and causes cells to absorb potassium [13] [19]. Normally, high extracellular potassium levels increase the release of endogenous insulin by inhibiting ATP-sensitive potassium channels in pancreatic B cells [20]. In diabetics, however, low insulin levels lead to the elimination of glucose in the kidneys, which increases the delivery of sodium to the distal nephron and increases potassium excretion [21]. Diabetes often requires oral glucose-lowering drugs or subcutaneous injections of insulin, compared with normal patients, diabetes tend to have larger fluctuation, which can cause abnormal potassium ion distribution, likely the cause of postoperative low potassium [18]. Our study, patients with diabetes mellitus, also showed a significant increase in postoperative hypokalemia, confirming previous findings.

Our study also first found that preoperative red blood count is also a risk factor for postoperative hypokalemia, which may be related to intraoperative and postoperative loss of red blood cells and fluid in patients, and further prospective studies are needed to confirm this.

In addition, another study in a single institution with hip or knee primary total joint replacement showed that preoperative potassium levels below 4 mmol/L in 72% of patients had hypokalemia after surgery, while about 28% of the patients had anemia, heart disease, cardiovascular disease, or a history of chronic kidney disease [9]. Similarly, In our study, patients with preoperative serum potassium lower than 4mmol/L should be treated with preoperative oral potassium supplementation, but a larger sample study is needed.

# Limitations

This study has some limitations. First, this is a single-center study with a relatively small sample size. Second, because this was a retrospective study, case selection could not comply with the principle of randomization.

# Conclusion

Routine monitoring of serum potassium should be performed because of patients with the highest risk of hypokalemia on the third day after joint replacement. We need to pay more attention to patients' preoperative potassium and red blood cells, especially patients with diabetes.

# Abbreviations

BMI: body mass index; SD: standard deviation ;TKA: total knee arthroplasty ; RBC: red blood cell; Hb: hemoglobin; HCT: hematocrit; eGFR: glomerular filtration rate; EF: ejection fraction.

# Declarations


### Acknowledgements

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### Authors' contributions

ZHX contributed substantially to the conception and design of the study. PP, ZTZ, XFZ, and QJ collected and analyzed the data. ZTZ wrote the manuscript with support from PP. All authors read and approved the final manuscript.


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### Availability of data and materials

The data used to support the findings of this study are available from the corresponding author upon request.

### Ethics approval and consent to participate

This study was approved by the institutional review board (IRB) of Nanjing Drum Tower Hospital.

### Consent for publication

Not applicable

### Competing interests

The authors declare that they have no competing interests.

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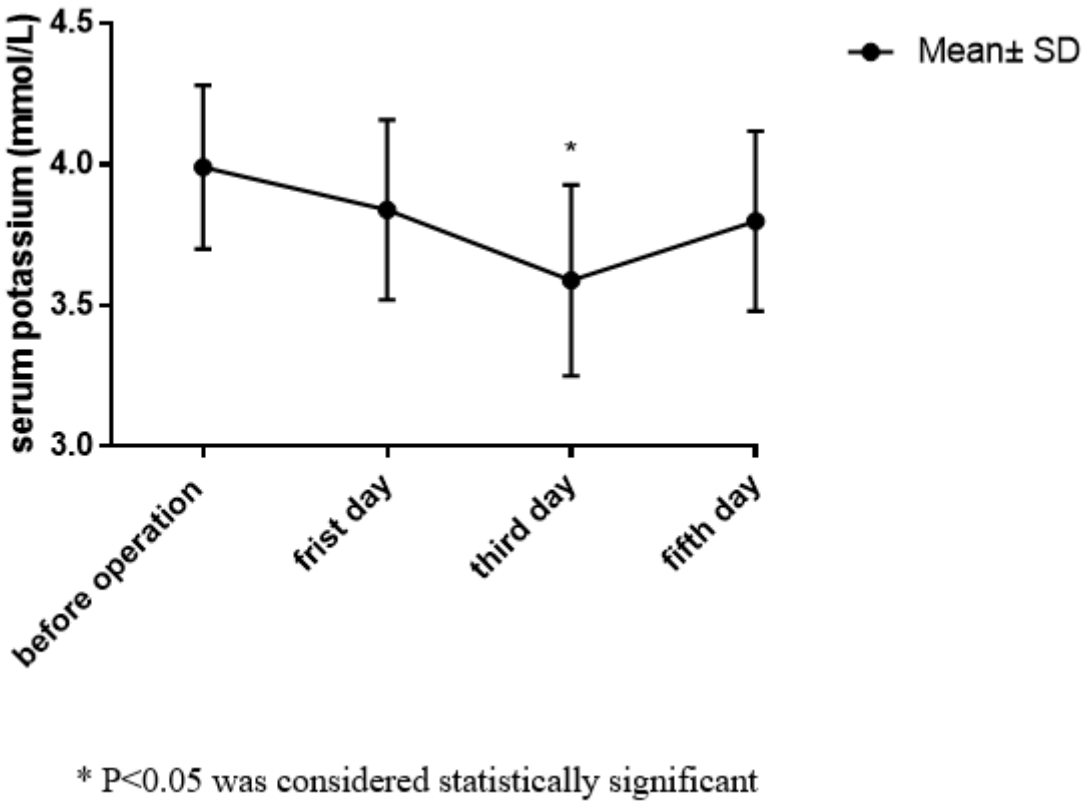
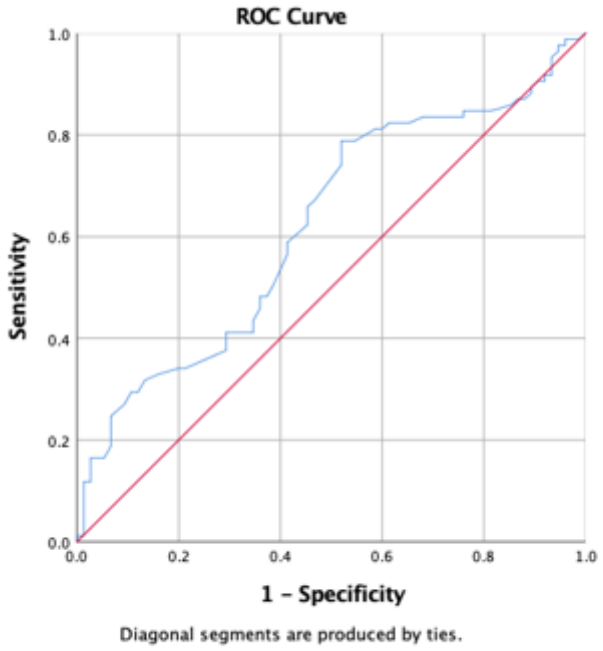
# Figures




## Figure 1

The change of serum potassium during the perioperative period




## Figure 2

Receiver-operating characteristic (ROC) curve analysis of the sensitivity and specificity with which preoperative potassium detects hypokalemia after the operation