Low Urine Output during the First Twenty-Four Hours after Total Knee Arthroplasty

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Background: *Low urine output (LUO) for six hours is defined as the stage that is at risk of acute renal failure. Major surgeries with a bloodless field, such as total knee arthroplasty (TKA), may be associated with LUO; however, there has been no study addressing this point. The present study evaluated the incidence of LUO and the effect of fluid balance on LUO in TKA patients during the first 24 hours after surgery.*

Material and Method: *The authors retrospectively evaluated 257 uncomplicated patients undergoing unilateral TKA during the first 24 hours after surgery. Patients' demographic data, intra-operative intravenous (IV) fluid replacement, postoperative IV fluid replacement, oral fluid intake, total fluid intake, postoperative urine output, blood collected from the drain, and the total visible fluid output during the first 24 hours after surgery were collected and evaluated.*

Results: *The incidence of LUO was 19.1% (49/257) in the studied group. There were no significant differences in patients' demographic data between the LUO and normal urine output (NUO) groups. Comparing the LUO and NUO groups, the LUO group had a lower volume of intra-operative fluid replacement, with statistical significance. There were no differences in postoperative IV fluid replacement and postoperative oral fluid intake between groups. Although 80.5% of the studied group had IV fluid replacement at a less than ideal level, at discharge there was no patient suffering from renal complications related to LUO.*

Discussion and Conclusion: *Urine output is one of the common monitoring parameters of fluid balance in the perioperative period; it should be $\geq$0.5 mL/kg/h. Prolonged low urine output for six hours and for 12 hours are categorized as causing risk and injury to the kidney, respectively. The incidence of LUO at our institution during the first 24 hours after TKA is not uncommon and is significantly related to intra-operative fluid replacement. Fortunately, all LUO patients had further fluid replacement, resulting in no renal complications at discharge. As eighty percent of patients had less than ideal fluid replacement, and patients having LUO during the first 24 hours had a significantly lower volume of intra-operative fluid replacement, the authors propose reconsidering perioperative fluid replacement in TKA patients, especially intra-operative IV fluid to avoid LUO.*

Keywords: *Urine, Total knee arthroplasty, TKA, Fluid, Intravenous, Intake, Output*

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Total knee arthroplasty (TKA) has been accepted as an effective procedure for late stage knee arthritis[1]. Typical candidates for TKA are the elderly with a variety of medical co-morbidities[2]. Patients who have more medical co-morbidities tend to be at greater risk for postoperative complications than those who do not[3]. Strict perioperative intravenous (IV) fluid replacement is commonly prescribed for major surgeries in the elderly, including TKA, in order to avoid fluid overload. However, the TKA procedure is usually performed in a bloodless field, which may lead the anesthesiologist to relax concern for intra-operative IV fluid replacement. Furthermore, large areas of bone and soft tissue exposure may cause an unexpected volume of postoperative blood loss[4,5]. Studies have shown that proper perioperative fluid intake and output in patients undergoing TKA minimize the incidence of oliguria and further renal complications[6,7].

Urine output is one of the parameters used for monitoring fluid balance, especially during the first 24 hours following a major surgery. As prolonged oliguria or low urine output (LUO) can aggravate hemodynamic complications[8], the RIFLE (risk, injury, failure, loss and end-stage renal failure) criteria have

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been developed to evaluate renal function and to standardize the definition and severity of acute kidney injury[9]. A urine output of <0.5 mL/kg/h for six hours is defined as the stage that is at risk for acute kidney injury[10]. A new Kidney Disease Improving Global Outcomes (KDIGO) also defined urine output status of <0.5 mL/kg/h for six to 12 hours as acute kidney injury (AKI) stage I[11]. To the best of our knowledge, there has been no study investigating on LUO related to TKA patients.

The purpose of the present study was to evaluate the incidence of LUO during the first 24 hours after surgery, as well as causes of fluid imbalance in LUO patients.

Material and Method

From January 2009 to December 2009, the medical records of 302 patients (314 admissions) who underwent unilateral primary TKA at King Chulalongkorn Memorial Hospital were retrospectively reviewed with institutional review board (IRB) approval. Forty-five patients were excluded due to having special fluid intake management for certain medical problems (renal diseases, complicated cardiovascular diseases or complex medical co-morbidities). Twelve patients who had a second admission for contralateral TKA were also excluded in order to avoid repetition of medical comorbidities in the same patient. Thus, the studied group had a total number of 257 patients (257 admissions).

Patients' demographic data, intraoperative IV fluid replacement, postoperative IV fluid replacement, oral fluid intake, total fluid intake, postoperative urine output, blood collected from the drain, and the total visible fluid output during the first 24 hours after surgery were collected and evaluated.

Pre-, intra- and postoperative patient care

Routinely, all patients had a physical check-up at the pre-admission unit with a three-month validation; otherwise, a second physical check-up was re-evaluated. At admission, patients had nil per os (NPO) for a minimum of six hours prior to the surgery. Following NPO, the IV fluid was not started until a few minutes before initiation of anesthesia. The primary anesthetic method for all patients was spinal analgesia with morphine. General anesthesia was chosen for those who had previous lower back surgery or refused the lumbar puncture. The actual volume of intra-operative IV fluid replacement, which was varied according to the individual judgment of the anesthesiologist, was compared to the ideal intra-operative IV fluid replacement. The ideal intra-operative IV fluid replacement was calculated according to Morgan and Mikhail[12]. It consisted of compensatory intravascular volume expansion, replacement of deficit volume, maintenance, third space loss and intra-operative blood loss. The Holliday-Segar method[13] was used to assess the maintenance fluid volume.

All surgeries were performed by one of eight senior orthopedic surgeons in a bloodless surgical field with 300-350 mmHg tourniquet pressure. Mid-vastus or medial parapatellar approaches were used with a skin incision ranging from mini-incision (<10 cm) to standard incision (10-15 cm). After the surgery, the tourniquet was left inflated for bleeding control in all cases, and vacuum drainage was used in all knees.

All patients had IV fluid administration at a fixed or adjustable rate according to the surgeon's preference, ranging from 100-140 mL/h with immediate allowance for oral fluid intake. The primary post-operative pain control during the first 24 hours included patient controlled analgesia (PCA), continuous low-dose IV morphine, and bolus IV morphine around the clock. Oral pain medications, including acetaminophen, cyclooxygenase II (COX II) inhibitors (for those who had no allergy to nonsteroidal anti-inflammatory drugs) were started from the day of surgery if patients could tolerate them. Oral narcotics (codeine or tramadol) were prescribed as needed from the postoperative day one.

Determining the type of IV fluid replacement, fluid intake and LUO (Fig. 1)

A) The intra-operative IV fluid replacement was the IV fluid administration starting from a few minutes before anesthesia to the time when the patient was moved away from the recovery room.

B) The ideal intra-operative IV fluid

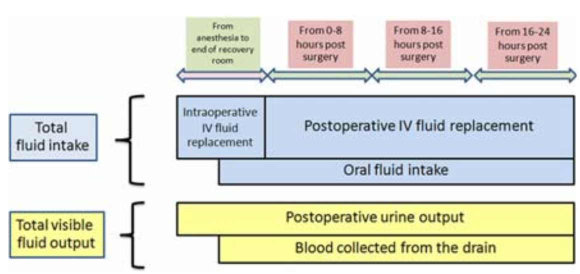

Fig. 1 Demonstrating the time frame of fluid balance monitoring for patients.

replacement is the calculated IV fluid amount according to Morgan and Mikhail[11], starting from a few minutes before anesthesia to the time when the patient was moved from the recovery room.

C) The postoperative IV fluid replacement was the IV fluid administration starting from the time the patient arrived at the ward to the end of the first 24 hours after surgery.

D) The oral fluid intake was the oral fluid that the patient had taken from the end of surgery to the end of the first 24 hours after surgery.

E) The total fluid intake was the combined volume of the intra-operative IV fluid replacement, the postoperative IV fluid replacement and the oral fluid intake.

F) The postoperative urine output was the volume of urine that was recorded from the beginning of anesthesia to the end of the first 24 hours after surgery.

G) The blood collected from the drain was the volume of blood in the drain that was recorded from the end of surgery to the end of the first 24 hours after surgery.

H) The total visible fluid output was the combined volume of the postoperative urine output and the blood collected from the drain.

I) The LUO was defined based on the RIFLE urine output monitoring criteria, with a urine volume of <0.5 mL/kg/h.

Statistical analysis

Statistical analysis was performed using GraphPad Prism version 5.01 for Windows (GraphPad Software, San Diego, California, USA). Descriptive statistics were expressed by mean, standard deviation and range. The student t-test and the Chi-square test were used to compare quantitative and qualitative data between groups. Statistical significance was considered when the *p*-value was <0.05.

Results

Of 257 patients, the average patient's age at the index for surgery was 69.6±7.5 years (range; 41-89 years). The average body weight was 63.7±9.4 kg (range; 40-96 kg), and the average body mass index (BMI) was 26.6±3.9 kg/m^2 (range; 17.9-41.3 kg/m^2). Female patients were dominant with the female/male ratio of 8.8/1 (231/26). There were no significant differences in patient's demographic data between LUO and normal urine output (NUO) groups (Table 1).

The occurrence of LUO during the first 24 hours after TKA was found in 19.1% (49/257) of patients. Patients in the LUO group had significantly lower intra-operative IV fluid replacement and total fluid intake than that of the NUO group (Table 2). Although there was no difference in postoperative IV fluid replacement between groups, the subgroup of postoperative IV fluid replacement in the second eight hours in the LUO group was significantly higher than that of the subgroup of the NUO group. There was no difference in postoperative oral fluid intake between groups.

Regarding the visible fluid output, the postoperative blood collected from the drain of both groups was similar. However, the volume of urine in LUO group was significantly lower than that of the NUO group during the first eight hours ($p<0.01$) and the second eight hours after surgery ($p<0.01$) (Table 3). Regarding the difference in volume between the actual and ideal intra-operative IV fluid replacement of both groups, the LUO group had a significantly greater difference in volume than that of the NUO group (Table 4). Furthermore, 80.5% (207/257) of the studied cohort had significantly less than ideal intra-operative IV fluid replacement ($p<0.01$).

Discussion

The RIFLE criteria[9] and a new KDIGO guideline[11] have been widely used to evaluate renal

Table 1. Demographic data of patients with NUO and LUO

Demographic data	Normal urine output (NUO)	Low urine output (LUO)	*p*-value
Number	208	49	
Age (year)	69.4±7.5	70.2±7.2	0.21
Sex (F/M)	188/20	43/6	0.61
BMI (kg/$m^{2)}$	26.8±4.2	25.7±4.3	0.15

BMI = body mass index; F = female; M = male

Table 2. Fluid intake in the first 24 hours after TKA of the studied group

Fluid intake	Normal urine output (NUO) (n = 208)	Low urine output (LUO) (n = 49)	*p*-value
Intra-operative IV fluid replacement (mL)	1,406.7±392.6	879.6±308.7	<0.01*
Postoperative IV fluid replacement (mL)	1,957.4±460.3	1,809.4±537.5	0.11
First 8 hours	921.5±269.1	881.2±274.3	0.16
Second 8 hours	668.0±253.4	705.5±266.8	0.04*
Third 8 hours	388.2±260.3	337.9±237.4	0.29
Postoperative oral fluid intake (mL)	376.5±135.4	302.5±141.5	0.10
First 8 hours	21.5±28.5	26.5±33.1	0.61
Second 8 hours	132.5±110.5	137.0±114.8	0.90
Third 8 hours	222.5±111.7	206.5±140.9	0.12
Total fluid intake	3,860.2±201.7	2,800.4±187.8	0.01*

IV = intravenous; * = statistical significance

Table 3. Fluid output in the first 24 hours after TKA of the studied group

Fluid output	Normal urine output (NUO) (n = 208)	Low urine output (LUO) (n = 49)	*p*-value
Postoperative blood collected in the drain (mL)	445.6±158.8	440.5±136.6	0.92
First 8 hours	98.5±62.3	73.4±61.7	0.20
Second 8 hours	184.5±81.9	184.5±67.1	1.00
Third 8 hours	162.2±158.8	183.6±142.4	0.65
Urine output (mL)	1,857.3±508.2	1,101.7±280.6	0.05*
First 8 hours	556.5±203.4	128.8±46.6	<0.01*
Second 8 hours	607.6±157.2	289.5±145.6	<0.01*
Third 8 hours	729.1±161.6	655.4±128.7	0.24
Total visible fluid output	2,337.6±390.7	1,613.4±297.1	<0.01*

* = statistical significance

Table 4. Actual and ideal volume of intraoperative intravenous fluid replacement

	Normal urine output (NUO) (n = 208)	Low urine output (LUO) (n = 49)	*p*-value
Actual intra-operative IV fluid replacement (mL)	1,406.7±392.6	879.6±308.7	<0.01*
Ideal intra-operative IV fluid replacement (mL)	1,762.7±488.8	1,757.2±388.9	0.93
Difference (mL)	355.9±469.9	877.6±467.3	<0.01*

* = statistical significance

function and to standardize the definition and severity of acute kidney injury. Usually, urine output is one of the common monitoring parameters of fluid balance in the perioperative period, and should be ≥0.5 mL/kg/h. Prolonged LUO for six hours is categorized as having risk to the kidney by RIFLE criteria[9] and are classified as AKI stage I if the LUO is continuing from 6 to 12 hours[11]. Early detection of this status and prompt proper management can prevent late serious complication. A systematic literature review by Brienza et al has shown that surgical patients receiving perioperative hemodynamic optimization were at decreased risk of renal dysfunction[6]. Thus, a study on urine output during the perioperative period in major orthopedic surgeries should be addressed.

In the present study, the distribution of female/male ratio was similar to those of our previous studies[14-16], which was also similar to other studies done in Asia[17,18]. This represents the fact that the female/male ratio of TKA patients in Asia is much higher than those studies done in Caucasian population[19,20].

Regarding the method of study, the authors performed a retrospective cohort in order to reflect the routine practice in daily service and to determine the actual incidence of LUO of this cohort group. The authors found that one-fifth of the studied group had LUO during the first 24 hours after TKA, which was determined to be common. Interestingly, there was significantly less volume of intra-operative IV fluid replacement in the LUO group than that of the NUO group. This finding reflected inadequate replacement of deficit volume and maintenance volume from the onset of NPO, as well as inadequate replacement of third space loss and potential intra-operative blood loss, all of which was directly related to the decision-making of the anesthesiologist on IV fluid replacement during this period. In addition, it appeared that impaired fluid replacement (from the beginning of the NPO period to the time when the patient was moved away from the recovery room) resulted in LUO condition as early as the first eight hours after surgery.

Regarding the volume of IV fluid replacement, the postoperative IV fluid replacement during the second eight hours subgroup in the LUO group had significantly more volume than that of the NUO group, with similar volume of overall postoperative IV fluid replacement and postoperative oral fluid intake. It could be assumed that as soon as the LUO condition was reported, the rate of IV fluid replacement was immediately increased in order to maintain the regular urine flow, which was usually measured during the second eight hours after surgery.

The present study demonstrated that perioperative fluid management by the orthopedic surgeon seems to be reliable, while intra-operative IV fluid replacement, adjusted by the anesthesiologist, was varied and played an important role in the LUO condition. However, in 80.5% of patients in the studied cohort, the actual overall IV fluid replacement was significantly less than that of the ideal overall IV fluid replacement. As prevention of prolonged LUO before renal biochemical changes is very important for operative patients, especially those who have multiple medical comorbidities or those who have poor tolerance of prolonged impaired fluid balance[20], the authors would call on both anesthesiologists and orthopedic surgeons to pay more attention to perioperative IV fluid replacement in TKA patients.

The limitation of the present study was that it was a retrospective study with a variable of confounding factors. However, the present study reflected routine fluid management as related to LUO during the perioperative period at our institution.

Conclusion

LUO during the first 24 hours after TKA was found in one-fifth of patients with significantly decreasing urine volume from the time of patient transfer from recovery room to ward until 16 hours after surgery. Of 49 patients with LUO, impaired intra-operative fluid replacement from the time the patient had NPO, according to anesthesiologist's adjustment, was the factor significantly relating to LUO. Other parameters of fluid intake and output were not different. However, 80.5% of all patients had less than ideal perioperative IV fluid replacement. Thus, in TKA patients, replacement of IV fluid following NPO and adequate intra-operative fluid replacement should be reconsidered by both the anesthesiologist and the orthopedic surgeon.

Potential conflicts of interest

None.

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ภาวะปัสสาวะออกน้อยใน 24 ชั่วโมงแรกหลังจากการผ่าตัดเปลี่ยนข้อเข่าเทียม

ยุทธนา คณาสุข, อารี ตนาวลี

ภูมิหลัง: *ภาวะปัสสาวะออกน้อยเป็นระยะเวลาต่อเนื่องเกิน 6 ชั่วโมงถือเป็นความเสี่ยงที่จะกลายเป็นภาวะไตวายเฉียบพลันได้ ซึ่งภาวะปัสสาวะออกน้อยภายหลังจากการผ่าตัดเปลี่ยนข้อเข่าเทียมเป็นเรื่องที่ยังไม่มีการศึกษามาก่อน*

วัตถุประสงค์: *เพื่อศึกษาอุบัติการณ์ของภาวะปัสสาวะออกน้อยใน 24 ชั่วโมงแรกภายหลังจากการผ่าตัดเปลี่ยนข้อเข่าเทียมรวมถึงปัจจัยที่เกี่ยวข้อง*

วัสดุและวิธีการ: *ศึกษาย้อนหลังในผู้ป่วยที่เข้ารับการผ่าตัดข้อเข่าเทียมข้างเดียว 257 รายที่ไม่มีโรคทางอายุรกรรม ซึ่งจำเป็นต้องควบคุมหรือดูแลการให้สารน้ำเป็นพิเศษ โดยเปรียบเทียบกลุ่มผู้ป่วยที่มีปัสสาวะออกน้อยและกลุ่มที่มีปัสสาวะออกปกติตามคำนิยามของการเกิดภาวะปัสสาวะออกน้อย ศึกษาในเรื่องข้อมูลทั่วไปของผู้ป่วย ข้อมูลการได้รับสารน้ำตั้งแต่ระหว่างการผ่าตัดและหลังจากการผ่าตัดในระยะ 24 ชั่วโมงแรก*

ผลการศึกษา: *ไม่พบความแตกต่างในเรื่องข้อมูลทั่วไปของผู้ป่วยทั้ง 2 กลุ่ม พบภาวะปัสสาวะออกน้อยร้อยละ 19.1 ของจำนวนผู้ป่วยที่ศึกษา โดยในกลุ่มผู้ป่วยที่ปัสสาวะออกน้อยได้สารน้ำที่ได้รับระหว่างการผ่าตัดในปริมาณที่น้อยกว่ากลุ่มที่ปัสสาวะปกติอย่างมีนัยสำคัญทางสถิติ ทั้งนี้ปริมาณสารน้ำที่ได้รับในช่วงเวลาอื่นไม่แตกต่างกัน แม้ว่าไม่มีผู้ป่วยรายใดเกิดข้อแทรกซ้อนทางไตในการศึกษานี้พบว่าร้อยละ 80.5 ของผู้ที่ได้รับการผ่าตัดเปลี่ยนข้อเข่าเทียมในสถาบันของผู้นิพนธ์ได้รับปริมาณสารน้ำทั้งหมดที่ผู้ป่วยได้รับจริงน้อยกว่าที่ค่าที่คำนวนในอุดมคติ*

สรุป: *อัตราการเกิดภาวะปัสสาวะออกน้อยใน 24 ชั่วโมงแรกภายหลังจากการผ่าตัดเปลี่ยนข้อเข่าเทียมสูงถึงเกือบร้อยละ 20 ของจำนวนผู้ป่วยที่ศึกษา และร้อยละ 80.5 ของผู้ป่วยได้รับปริมาณสารน้ำทั้งหมดน้อยกว่าที่ค่าที่คำนวนในอุดมคติ ดังนั้นการบริหารปริมาณสารน้ำในผู้ป่วยเข้ารับการผ่าตัดเปลี่ยนข้อเข่าเทียมควรได้รับการพิจารณาใหม่ โดยเฉพาะอย่างยิ่งการให้สารน้ำชดเชยระหว่างที่ผู้ป่วยได้รับการผ่าตัด*