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Which Patients Are at Risk for Kidney Dysfunction After Hip Fracture Surgery?

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Abstract

Background Kidney dysfunction (KD) after hip fracture surgery is a major complication. However, the incidence and risk factors of KD in this population are unclear.

Questions/purposes We therefore (1) determined the incidence of KD in a large cohort of fracture patients, (2) identified preoperative risk factors predisposing to KD, and (3) determined the effect of KD on length of stay and subsequent function.

Methods Between April 2011 and June 2012, 450 patients (263 women) with a mean age of 73 years (range, 67–96 years) underwent surgery for hip fracture in our institution. We calculated incidence and retrospectively reviewed suspected predisposing risk factors. We report followup at 6 months.

Results The overall incidence of KD was 11% (n = 52). Forty-five patients (86%) developed acute KD and seven patients developed acute-on-chronic KD. Three of the 52 patients died during the followup time. Thirty-eight of the 52 patients (73%) regained their prior kidney function after treatment. An increased risk of KD was found in those with diabetes, shock during or after surgery, age, and preexisting KD. Mean length of stay was higher for patients with KD compared to those without: 9.6 versus 7.4, respectively. At 6 months, 39 of the 49 surviving patients (80%) were fully weightbearing.

Conclusions Many patients at risk for postoperative KD can be identified and treated. Most patients recover from their KD and the majority return to full weightbearing.

Level of Evidence Level III, prognostic study. See Instructions for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.
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Introduction

Orthopaedic surgeons operate on a diverse group of patients, many of whom have comorbidities including kidney dysfunction (KD) [24]. Important recognized risk factors for developing KD in patients with orthopaedic disorders include blood loss, sepsis, pulmonary embolism, heart failure, electrolyte disturbances, infection, systemic diseases, specific medication, perioperative analgesia, and

emergency surgery [24, 34]. Postoperative KD predisposes to acute renal failure (ARF) and cardiovascular compromise, leading to increased mortality [11, 29].

Carmichael and Carmichael [8] reported an overall estimated risk for developing postoperative KD of 1%. The incidence of perioperative KD in patients with hip fractures in particular was reportedly 16% [5] and 36% [34] in two series.

Recognition of patients at risk potentially reduces the incidence of postoperative KD and its concomitant complications [12]. Several factors may contribute to the marked increase of KD after hip fractures, including low mobility, impaired cognition, poor nutritional status, and "frailty syndrome," as described in a meta-analysis by Haentjens et al. [10].

To confirm the reported incidence of KD in patients with hip fractures, we (1) determined the incidence of KD in a large cohort of patients with fractures, (2) identified preoperative risk factors predisposing to KD, and (3) determined the effect of KD on length of stay and subsequent function.

Patients and Methods

We retrospectively reviewed the medical records of 450 patients who were operated on for hip fractures between April 2011 and June 2012. We found 263 (58%) women and 187 (42%) men with a mean age of 73 years (range, 67–96 years). The mean time from fracture to admission was 9.5 hours (range, 1–48 hours) and the mean time from admission to surgery was 2 days (range, 0–5 days). We report the followup at 6 months for surviving patients.

Demographics, ICD-10 diagnosis for admission, history of preexisting KD, comorbidities, nephrotoxic medication, time from injury to admission, time from admission to surgery, length of hospital stay, American Society of Anesthesiologists classification, type of surgery, and overall mortality were recorded in an electronic database. Dehydration at the time of admission was noted in 36 patients as diagnosed clinically by sternal skin turgor and tongue dryness and confirmed by reduced urine output (< 0.5 mL/kg/hour) and an increase of electrolytes and urea from baseline values due to hemoconcentration. Twenty-one patients developed shock during or after surgery with tachycardia of more than 100 pulses per minute, tachypnea of more than 20 breaths per minute, and low mean blood pressure (< 100 mm Hg) and were treated accordingly (Table 1).

All patients received a battery of tests according to a predetermined protocol, including CBC, urine analysis, glucose, renal function tests, liver function tests, electrolytes, ECG, chest radiographs, and other radiographs as required. Potential risk factors for developing postoperative KD included age, dehydration, diabetes, shock, heart failure, nephrotoxic medication, and preexisting KD (Table 2).

Table 1. Demographics and clinical data

Variable	Value
Sex (female/male)	263 (58%)/187 (42%)
Age (years)*	73 (67–96)
History of kidney disease	
Yes	22 (4.8%)
No	428 (95%)
Comorbidities	
Diabetes mellitus	73 (16%)
Heart failure	62 (14%)
Hypertension	45 (10%)
Coronary disease	17 (3.7%)
COPD	28 (6%)
Shock	21 (4.6%)
Dehydration	36 (8%)
ASA classification	
Class 1	178 (40%)
Class 2	195 (43%)
Class 3	77 (17%)
Type of surgery	
DHS	35 (8%)
Intramedullary nailing	225 (0.5%)
Cannulated screws	10 (2.2%)
Hemiarrthoplasty	180 (0.4%)

* Values are expressed as mean, with range in parentheses; the remaining values are expressed as number of patients, with percentage in parentheses; COPD = chronic obstructive pulmonary disease; ASA = American Society of Anesthesiologists; DHS = dynamic hip screw.

The Acute Kidney Injury Network criteria were used to identify and stage patients with KD postoperatively [20–22]. According to these criteria, three stages are recognized: Stage 1, serum creatinine increase of 26.5 μmol/L or more (≥ 0.3 mg/dL) or serum creatinine increase of 1.5- to 2.0-fold from baseline and urine output of 0.5 mL/kg/hour for 6 hours; Stage 2, serum creatinine increase of greater than 2.0- to 3.0-fold from baseline and urine output of less than 0.5 mL/kg/hour for 12 hours; and Stage 3, serum creatinine increase of greater than 3.0-fold from baseline or serum creatinine of 354 μmol/L or more (≥ 4.0 mg/dL) with an acute increase of at least 44 μmol/L (0.5 mg/dL) or need for renal replacement therapy and urine output of less than 0.3 mL/kg/hour for 24 hours or anuria for 12 hours or need for renal replacement therapy.

The patients treated for KD postoperatively were evaluated by a senior nephrologist and the outcome was classified as (1) complete resolution, (2) failure to return to prior kidney function, (3) end-stage renal disease, and (4) death. The orthopaedic outcome was evaluated by the senior authors as unassisted or assisted pain-free walking, with no evidence of radiographic nonunion or implant failure.

Table 2. Potential risk factors for developing postoperative KD (n = 52)

Variable	Value
Sex (female/male)	32 (62%)/20 (39%)
Age (years)*	79 (71–95)
Type of KD	
Acute	45 (87%)
Acute on chronic	7 (13%)
Risk factors for developing KD	
Dehydration	9 (17%)
Diabetes	7 (13%)
Shock	6 (12%)
Heart failure	5 (10%)
Medications	
NSAIDs	5 (10%)
Antibiotics	4 (9%)
ACE-I	2 (3.8%)
Diuretics	2 (3.8%)
AT-II	2 (3.8%)
Opiates	2 (3.8%)
Iodinated contrast agents	1 (1.9%)
Preexisting KD	7 (13%)

* Values are expressed as mean, with range in parentheses; the remaining values are expressed as number of patients, with percentage in parentheses; KD = kidney dysfunction; ACE-I = angiotensin converting enzyme inhibitors; AT-II = angiotensin-II receptor antagonists.

Table 3. Bivariate association analysis of qualitative and quantitative data and KD

Variable	Value		$OR_{bivariate}$ (95% CI)	p value
	No KD (n = 398)	KD (n = 52)		
Age (years)*	71 ± 12.2	79 ± 15.3	1.35 (1.15–2.20)	< 0.001
Sex				0.657
Male	167 (89%)	20 (11%)	1	
Female	231 (88%)	32 (12%)	1.16 (0.64–2.10)	
Dehydration				0.025
No	371 (90%)	43 (10.4%)	1	
Yes	27 (75%)	9 (25%)	2.88 (1.27–6.53)	
Diabetes				0.008
No	332 (91%)	35 (10%)	1	
Yes	66 (80%)	17 (21%)	2.44 (1.29–4.62)	
Shock				0.025
No	383 (89%)	46 (11%)	1	
Yes	15 (71%)	6 (29%)	3.33 (1.23–9.10)	
Heart failure				0.520
No	341 (88%)	47 (12%)	1	
Yes	57 (92%)	5 (8%)	0.64 (0.24–1.67)	
Nephrotoxic medication				0.296
No	343 (89%)	42 (11%)	1	
Yes	55 (85%)	10 (15%)	1.48 (0.71–3.13)	
Preexisting KD				0.008
No	383 (90%)	45 (11%)	1	
Yes	15 (68%)	7 (32%)	3.97 (1.53–10.26)	

* Values are expressed as mean ± SD; the remaining values are expressed as number of patients, with percentage in parentheses; KD = kidney dysfunction; OR = odds ratio.

Data were expressed as mean ± SD for continuous variable (age) and as percentages for categorical data. The Kolmogorov-Smirnov test was utilized to assess normality of the continuous parameters. We determined the association between all binary qualitative variables (dehydration, diabetes mellitus, shock, heart failure, nephrotoxic medications, and preexisting KD) and KD status (no-yes) using the chi-square test or Fisher's exact test; Student's t-test was used to examine whether the mean age differed in patients with and without KD. The variables exhibiting a difference ($p < 0.1$) in the bivariable analysis were selected for the multivariable analysis. These variables were subjected to logistic regression analysis, establishing presence of KD as the outcome variable, and the odds ratios with 95% CIs were presented. The Wald forward elimination method was used to arrive at the final model. Goodness of fit was evaluated using the Hosmer-Lemeshow statistics. All tests were two-sided. All analyses were carried out using the statistical package SPSS® v 16.00 (SPSS Inc, Chicago, IL, USA).

Results

Of 450 patients reviewed, 52 (11%) developed postoperative KD: 32 (62%) women and 20 (39%) men with a mean age of 79 years (range, 71–95 years); 45 developed acute KD and seven developed acute-on-chronic KD (Table 2).

Bivariable analysis showed patients with diabetes, dehydration, perioperative shock, and preexisting KD were at higher risk for developing postoperative KD (Table 3). The mean glomerular filtration rate of the 52 patients who developed postoperative KD was 79.5 mL/minute (range, 28–314 mL/minute). Thirty-eight (73%) of them showed full recovery of their renal function, 10 (19%) showed incomplete recovery, four (8.8%) developed end-stage renal disease, and three (5.7%) died. Multivariable analysis (Table 4) confirmed that patients with diabetes had an 8.64 times higher risk (95% CI, 4.3–15.6; $p < 0.001$), those with perioperative shock had a 5.35 times greater risk (95% CI, 2.1–7.4; $p = 0.017$), and those with preexisting KD had a 2.4 times higher risk (95% CI, 1.2–8.2; $p = 0.043$) for developing postoperative KD (Fig. 1). There was also a 12% higher risk (95% CI, 1.1–2.0; $p = 0.034$) of postoperative KD with each increasing year of age.

Table 4. Multivariable analysis of significant variables and KD

Variable	Reference category	$OR_{multivariable}$ (95% CI)	p value
Age		1.12 (1.08–2.03)	0.034
Diabetes mellitus	No	8.64 (4.29–15.62)	< 0.001
Shock	No	5.35 (2.13–7.44)	0.017
Preexisting KD	No	2.40 (1.15–8.21)	0.043

KD = kidney dysfunction; OR = odds ratio.

The mean length of hospital stay for those who developed postoperative KD increased compared to patients without KD (9.6 days versus 7.4 days) ($p < 0.001$). Three of the 52 patients died from their KD at times ranging from 1 to 4 weeks postoperatively. At last followup 6 months after surgery, of the 49 patients who recovered from KD, 39 (80%) were fully weightbearing and recovered their preinjury activity levels, seven (14%) walked with a single walking aid, and three (6%) with a double walking aid.

Discussion

While the overall reported incidence of postoperative KD in surgical patients is approximately 1% [8], the incidence appears to be higher in patients undergoing surgery for hip fractures [12]. To confirm the reported incidence of KD in patients with hip fractures, we (1) determined the incidence of KD in a large cohort of patients with fractures, (2) identified preoperative risk factors predisposing to KD, and (3) determined the effect of KD on length of stay and subsequent function.

Several limitations affect our study. First, the relatively small size of our cohort and the multiple comorbidities affecting our patient cohort limit our analysis to only those clearly related to postoperative KD. The effect of combined morbidities however was impossible to determine. Second, we were also unable to identify associations between nephrotoxic medications and postoperative KD that could exist; these would need to be identified in larger cohort studies. Finally, dehydration remains a difficult clinical diagnosis that may contribute to the development of perioperative shock, which was more easily defined and therefore studied in our analysis.

The overall incidence of KD after elective or emergency orthopaedic surgical procedures has widely ranged from 9% to 36% in the literature (Table 5), while KD after hip fracture surgery is reportedly as high as 36% [3, 5, 6, 26, 27, 34]. Our incidence of 12%, although lower than other reported data, clearly highlights that postoperative KD is a major and not uncommon complication in this patient group that treating physicians should recognize to reduce morbidity and mortality rates. A recent analysis by White et al. [34] showed approximately ⅓ of patients presenting for surgical fixation of femoral neck fracture had at least moderate KD on admission to hospital, a prevalence that increases with age. We found that seven of the 52 patients who developed postoperative KD (13%) (Table 2) had preexisting KD. It is well recognized that postoperative KD is dependent on preexisting renal function [6, 12, 26] and is a risk factor for concomitant complications, including ARF and cardiac compromise [18], leading to prolonged hospital stay [11] and increased morbidity and mortality [29].

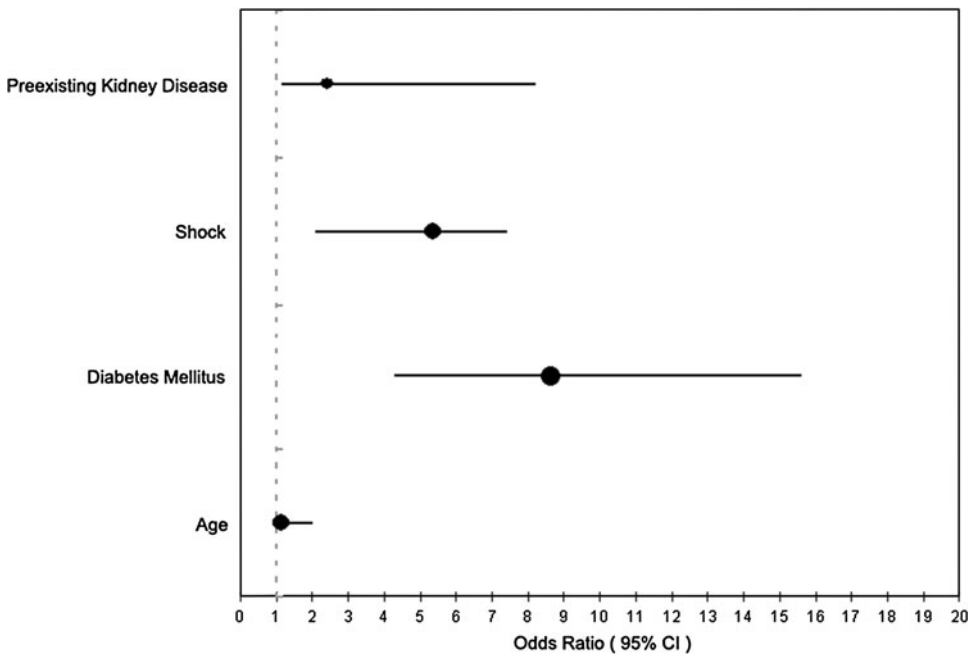

Fig. 1 A graph shows the odds ratios with 95% CIs for the key risk factors in the multivariable analysis.

Table 5. Key comparisons of the current study to the literature

Study	Purpose of the study	Number of patients	Type of study	Period	Results	Recommendations/conclusions
Kheterpal et al. [15]	Investigation of the incidence and risk factors for postoperative ARF after major surgery among patients with previously normal renal function	15,102	Prospective, observational	4 years	Preoperative predictors: age, urgent surgery, liver disease, BMI, high-risk surgery, peripheral vascular occlusive disease, and COPD Intraoperative predictors: total vasopressor dose administered, use of a vasopressor infusion, and diuretic administration	Several preoperative predictors previously reported to be associated with ARF after cardiac surgery were found to be associated with ARF after noncardiac surgery; use of vasopressor and diuretics was also associated with ARF
Chertow et al. [9]	Examination of the effects of AKI on in-hospital mortality, length of stay, and costs	19,982	Consecutive	8 months	AKI is associated with increased mortality, length of stay, and costs; outcomes are related directly to the severity of AKI	Prevention and effective treatment of hospital-acquired AKI should be a national priority
Ackland et al. [2]	Association of CKD with postoperative morbidity after elective, moderate-risk orthopaedic procedures	526	Prospective	13 months	Postoperative morbidity occurred more frequently in patients with CKD: more pulmonary, infectious, cardiovascular, renal, neurologic, and pain morbidities	Preoperative estimated GFR may enhance perioperative risk stratification beyond traditional risk factors
Abelha et al. [1]	Outcome and quality of life evaluation after major surgery with AKI development	1200	Retrospective	12 months	Patients with AKI were more severely ill, stayed longer in the PACU, and had worse SF-36 scores	Patients developing AKI had worse scores than PACU patients who did not develop AKI
Jafari et al. [12]	Identification of the risk factors for renal impairment after total joint arthroplasty	17,938	Retrospective	7 years	0.55% either ARF or AKI Independent risk factors: elevated BMI; elevated preoperative serum creatinine; and history of COPD, liver disease, congestive heart failure, hypertension, and underlying heart disease Renal impairment was associated with increased duration of hospital stay	In high-risk patients, preoperative optimization might be considered in an attempt to reduce the incidence of such a complication
Bennet et al. [5]	Investigation of the incidence, risk factors, and outcome of ARD in patients with a fractured femoral neck	170	Retrospective	10 weeks	27 patients (16%) developed ARD Risk factors were male sex, vascular disease, hypertension, diabetes, CKD, and premorbid use of nephrotoxic medications	Awareness of risk factors and serial measurements of renal function allow early identification and focused monitoring of these patients
White et al. [34]	Estimation of the serum urea and electrolyte concentrations in patients requiring surgery for proximal femoral fracture and calculation of their GFRs	1511	Retrospective	3 years	Approximately ⅓ of patients had at least moderate KD on admission, associated with an increased likelihood of death during hospital admission and within 30 days of surgery	Renal impairment is common in patients admitted for fixation of fractured femoral neck consequently at risk of opioid toxicity

Table 5. continued

Study	Purpose of the study	Number of patients	Type of study	Period	Results	Recommendations/conclusions
Current study	Investigation of which patients are at risk for KD after hip fracture surgery	450	Retrospective	14 months	52 (11.5%) suffered from postoperative KD; diabetes, preoperative shock, and increased age were associated with the development of KD	Hip fractures are associated with increased prevalence of a preventable morbidity; several risk factors were identified; vigilant evaluation and monitoring with emphasis on fluid balance and diabetes control are urged

ARF = acute renal failure; AKI = acute kidney injury; CKD = chronic kidney disease; ARD = acute renal dysfunction; GFR = glomerular filtration rate; KD = kidney dysfunction; COPD = chronic obstructive pulmonary disease; PACU = postanesthesia care unit.

Numerous reports [2, 14, 19, 23, 33] have assessed various factors contributing to postoperative KD and described the consequences of KD on surgical and anesthetic management [1, 5, 13, 16, 19]. Reported risk factors are dehydration, increased age, diabetes, shock, heart failure, nephrotoxic medications (NSAIDs, aminoglycosides, angiotensin-converting enzyme inhibitors, diuretics, angiotensin II receptor antagonists, opiates), iodinated contrast agents, and preexisting KD [5]. The most important risk factors for postoperative KD in our series were diabetes, perioperative shock, preexisting KD, and increased age. Shock is not a homogeneous condition in an elderly population sustaining hip fractures and does not manifest in a single form; thus, difficulties exist in its assessment [30]. Clinical evaluation combined with laboratory data can help the diagnosis, especially of those suffering from preoperative dehydration, which predisposes to shock in the elderly with hip fractures [7, 32]. White et al. [34] indicated a higher perioperative risk due to opioid-induced respiratory depression, necessitating consideration of opioid-reducing strategies such as early fracture fixation, regular simple analgesia, and regional nerve blockade. Similarly, Bennet et al. [5] mentioned that reduced glomerular blood flow leads to an increased incidence of adverse drug reactions and clinicians should evaluate the risk versus benefit of continuing long-term prescription medications on admission in this group of patients. We were unable to identify opiates as a risk factor for developing postoperative KD mainly due to the small sample size. Jafari et al. [12] found age was not an independent risk factor for developing KD after elective primary or revision hip and knee surgery. Hip fracture however is an acute traumatic event that may affect renal function differently from elective orthopaedic surgery. We found a 12% higher risk of postoperative KD with an increase in age of 1 year. Circulatory and cardiac compromise consistent with advanced age is predictive of KD in surgical patients in accordance with our findings [2, 5, 25, 34]. White et al. [34] suggested KD before surgery should alert the anesthetist to the importance of both suitable perioperative analgesic administration and adequate intraoperative intravenous fluid management to reduce the risk of postoperative KD. Moreover, patients frequently present dehydrated due to the mechanism of injury and ensuing immobility. Absolute or relative hypovolemia is a risk factor for acute KD [4], and several studies suggest invasive monitoring of fluid balance and oxygen delivery perioperatively is of paramount importance to reduce mortality [28, 31, 35]. In hip fracture surgery, diminished physiologic response to trauma, coupled with enforced fasting, anesthetic agents, and blood loss caused by the injury and surgery exacerbate additional stresses on an already frail patient [5, 17, 19].

In conclusion, we found a 12% rate of postoperative KD in patients with hip fractures, which highlights an increased

prevalence of a preventable morbidity. We identified several risk factors and we urge vigilant evaluation and monitoring with emphasis on diabetes, shock, preexisting KD, and advanced age. Further prospective studies are required to evaluate algorithms of diagnosis and treatment to reduce the risk of postoperative KD in the elderly with hip fractures.

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