Journal of Clinical Orthopaedics and Trauma 11 (2020) S255–S259

Contents lists available at ScienceDirect

Journal of Clinical Orthopaedics and Trauma

journal homepage: www.elsevier.com/locate/jcot

Incidence and risk factors of acute kidney injury after total joint arthroplasty; a retrospective cohort study

Izziddine Ahmad Ali Vial [a, *], Tehmoor Babar [a], Ihab Boutros [b]

[a] Manchester Medical School, Stopford Building, Oxford Rd, Manchester, M13 9PT, United kingdom
[b] Department of Orthopaedic Surgery, Salford Royal Hospital, Stott Lane, Salford, M6 8HD, Manchester, United Kingdom

ARTICLE INFO

Article history:
Received 26 March 2019
Received in revised form
16 August 2019
Accepted 31 October 2019
Available online 5 November 2019

ABSTRACT

Background: Acute Kidney Injury (AKI) is a common complication post-arthroplasty, although it has not been extensively studied. We carried out a retrospective study to determine the incidence and risk factors of AKI in patients undergoing total joint arthroplasty (TJA).

Method: We reviewed the medical records of all patients who underwent elective TJA from December 2014 to January 2017 at the Salford Royal Hospital, UK. AKI was defined using the AKIN, RIFLE and KDIGO criteria in patients with worsened renal function post-arthroplasty. We analysed the association of the demographics, risk factors, medications and use of peri-operative IV fluids with AKI. A logistic regression was performed to find any correlation between these factors and incidence of AKI.

Results: 197 patients were included in our study, the mean age was 70.2 and male to female ratio was 6:5. Of these, 32(16.2%) developed an AKI. The multivariate logistic regression revealed 4 independent factors associated with the risk of AKI; age ($P = 0.0011$, OR 1.07, 95% CI 1.03–1.18), obesity ($P = 0.003$, OR 6.4, 95% CI 2.34–17.5), smoking ($P = 0.0482$, OR 3.76, 95% CI 1.01–14.0) and COPD ($P = 0.0253$, OR 3.85, 95% CI 1.18–12.5).

Conclusion: The incidence of AKI post-arthroplasty was found to be much higher than stated in other literatures. The recognition of the high incidence and multiple independent risk factors will allow a better approach to peri-operative management, limiting the risks of AKI. Our study also highlighted the importance of documenting urine output and the need to repeat the renal function test 3 months after an AKI to assess recovery.

1. Introduction

Total joint arthroplasty (TJA) is one of the most common type of orthopaedic surgical procedure performed. It is expected that the demand for primary and revision arthroplasties is going to keep growing in the coming years.[1,2] In 2016, 101, 651 hip arthroplasties and 108, 713 knee arthroplasties were performed in the United Kingdom.[3] As the number of arthroplasties keeps increasing annually, the number of complications associated with them is also on the rise. One of the most common complication is postoperative acute kidney injury (AKI).[4]

Postoperative AKI affects 0.5–14.8% of patients undergoing TJA.[4–8] The big range in the incidence of AKI may be because of some studies including both elective and trauma patients in their studies and others including only elective patients. Incidence of AKI among elective orthopaedic patients is much lower compared to incidence of AKI among both elective and trauma orthopaedic patients.[5,9] AKI patients have a higher hospital mortality than non-AKI patients.[10–12] Even after recovery of their renal functions, AKI patients have a higher degree of mortality than non-AKI patients.[13]

The aetiology of postoperative AKI is believed to be multifactorial. Previous studies identified some preoperative risk factors linked to postoperative AKI. They include elevated body mass index (BMI), vascular disease, hypertension (HTN), diabetes mellitus, congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), angiotensin converting enzymes inhibitors (ACEi), angiotensin receptor blockers (ARBs) and age.[5–8,14,15]

General anaesthesia and blood transfusion have been identified to be perioperative predictors of postoperative AKI.[5]

In majority of literatures about AKI post-arthroplasty, there is coherent evidence that some definite factors increase the risk of

* Corresponding author.
E-mail addresses: izziddine.vial@student.manchester.ac.uk (I.A. Ali Vial), tehmoor.babar@nhs.net (T. Babar), Ihab.Boutros@srft.nhs.uk (I. Boutros).

https://doi.org/10.1016/j.jcot.2019.10.012
0976-5662/

AKI. However, in a few papers there is also inconsistency regarding some predictors.

We performed an audit on patients who underwent primary and revision arthroplasties at Salford Royal Hospital, United Kingdom between December 2014 and January 2017. The aim of the study was to:

(1) Calculate the incidence of patients suffering from AKI after the changes made from the 2014 audit.
(2) Find out the major pre- and perioperative risk factors of AKI in the cohort of patients.

The 2014 audit found that 18% of arthroplasty patients suffered from renal injury. The proposed plan was to halve the dose of gentamicin given prophylactically from 2 mg to 1 mg.

2. Method

2.1. Design and subjects

The charts of 197 patients who underwent a hip or knee arthroplasty between December 2014 and January 2017 inclusive were retrospectively reviewed at our institution, a big tertiary teaching hospital in Manchester, United Kingdom. The patients had either undergone primary or revision arthroplasty. All patients had undergone an elective procedure. These patients were selected from the Electronic Patient records (EPR). Inclusion criteria was more than 18 years of age. In the UK, no approval from the ethics committee of the hospital is required for an audit.

2.2. Assessment of AKI

The main aim of the study was to find the incidence of post-operative AKI among the TJA patients. Diagnosis of AKI was made using the Risk, Injury, Failure, Loss of kidney function and End-stage criteria (RIFLE) criteria,[16] Acute Kidney Injury Network (AKIN) criteria[17] and Kidney Disease Improving Global Outcome (KDIGO) criteria.[18]

Table 1 shows the three classifications and staging of AKI according to RIFLE, AKIN and KDIGO.

The diagnosis of postoperative AKI was made by comparing the baseline and highest postoperative sCr. Usually, preoperative sCr is obtained during the pre-op appointment which happens within 3 months of surgery. Postoperative sCr is usually obtained by the surgical team during a time period of 72 h after surgery. Patients meeting any of the criteria describe above was diagnosed as having postoperative AKI. Urine output was not used as a diagnostic tool as it was not properly recorded during surgery and on postoperative wards.

2.3. Data collection

Comorbidities, age, gender, BMI > 30 (obesity), smoking status, past medical history and pre-operative renal function (measured by serum creatinine and estimated glomerular filtration rate (eGFR)) were collected and recorded. Comorbidities recorded are chronic obstructive pulmonary disease (COPD), type 2 diabetes mellitus (T2DM), chronic kidney disease (CKD)/renal dysfunction, hypertension (HTN) and hypothyroidism. Data on medication such as ACEi, ARBs, diuretics, potassium sparing, statins, beta blockers, prednisolone, PPI and NSAIDs were abstracted from the medication charts. Operative data including volume of intraoperative fluid administered was also collected.

2.4. Data analysis

Explanatory variables were identified following a systematic review of the literature. A PubMed database search was done to find previous studies, also in the Elsevier database. The search terms used were as follows: “kidney injury”, “kidney failure”, “kidney dysfunction”, “arthroplasty”, “risk factors”, “hip replacement”, “knee replacement” and “postoperative”. Thereafter, the literatures were manually reviewed to identify studies that investigated postoperative AKI following total joint arthroplasty.[4–6,8,9,19]

Mean and standard deviations were calculated for continuous variables.

Univariate comparison was performed using the univariate logistic regression. It was performed on all potential risk factors. Multivariate comparison was then done using the multivariate logistic regression. It was performed to identify risk factors causing postoperative AKI. Predictors having a P value of < 0.05 were considered to be statistically significant. The study found that age, obesity, smoking and COPD were independent risk factors of postoperative AKI. Statistical analysis was performed using Stats Direct.

3. Results

Table 2 shows factors associated with the development of AKI post-TJA 197 patients were retrospectively reviewed in the audit, including 90 males and 107 females with a mean age of 70.2 (S.D = 11.8). 32 patients (16.2%) suffered from postoperative complication of AKI. Demographic, pre-operative, intra-operative and post-operative information of patients with or without AKI can be found in Table 1.

Univariate logistic regression was performed for all the potential risk factors of AKI and the results are shown in Table 1. Obesity (OR, 4.72; P = 0.0012), COPD (OR, 3.92; P = 0.0099), NSAIDs (OR, 2.8; P = 0.0419) and statin (OR, 2.37; P = 0.0275) were significant risk factors for renal impairment after total joint arthroplasty on univariate analysis.

Generalised multivariate logistic regression was then conducted on all the potential risk factors. Intraoperative fluid administered could not be added to the multivariate logistic regression and thus, multivariate logistic regression results could not be obtained. Age (OR, 1.07; P = 0.0011), obesity (OR, 6.40; P = 0.0003), smoking (OR, 3.76; P = 0.0482) and COPD (OR, 3.85; P = 0.0253) were identified as being significant risk factors of postoperative AKI.

4. Discussion

This is to the best of my knowledge the first study to look at the incidence of AKI and the relationship between AKI, intraoperative fluid administration, urine output and significant co-morbidities in patients undergoing hip and knee arthroplasties.

The main findings of the audit in patients undergoing arthroplasties are:

- AKI is common in the early postoperative timeline.
- Age, obesity, smoking and COPD have been found to be independent risks of developing postoperative AKI.

4.1. Incidence of AKI

Overall, AKI was found to be present in 16.2% of the patients within 72 h of the surgical procedure. The incidence reported was much higher compared to other studies (2%–5%).[8]The main reason why there may be so much disparity in the rate of incidence

Table 1
Classification of AKI.

Classification	RIFLE	AKIN	KDIGO
Stage	**Risk** Increased Serum creatinine (SCr) x 1.5 or GFR decrease > 25% or urine output < 0.5 ml/kg/h for 6 h **Injury** Increased SCr × 2 or GFR decrease > 50% or urine output < 0.5 ml/kg/h for 12 h **Failure** Increased sCr × 3 or GFR decrease > 75% or sCr ≥ 4 mg/dl (acute rise of sCr ≥ 0.5 mg/dl) or urine output < 0.3 ml/kg/h for 24 h or anuria for 12 h **Loss** Persistent AKI > 4 weeks ESRD End-stage renal disease	**Stage 1** Increased sCr × 1.5 or ≥ 0.3 mg/dl from baseline or urine output < 0.5 ml/kg/h for 6 h **Stage 2** Increased sCr × 2 or urine output < 0.5 ml/kg/h for 12 h **Stage 3** Increased sCr × 3 or ≥ 4 mg/dl with acute rise of sCr ≥ 0.5 mg/dl or urine output < 0.3 ml/kg/h for 24 h or anuria for 12 h	**Stage 1** Increased sCr × 1.5 to 1.9 baseline or ≥ 0.3 mg/dl from baseline or urine output < 0.5 ml/kg/h for 6–12 h **Stage 2** Increased sCr × 2.0 to 2.9 baseline or urine output < 0.5 ml/kg/h for 12 h **Stage 3** Increased sCr × 3 baseline or ≥ 4 mg/dl or initiation of RRT, or GFR decrease < 35 ml/min/1.73 m2 for patients < 18 years of age or urine output < 0.3 ml/kg/h for 24 h or anuria for 12 h

between the studies is because of the use of different criteria used to assess kidney damage in the patients. At the moment, there is no definite meaning for acute kidney injury.[20]

Renal insufficiency, renal dysfunction and acute renal failure (ARF) are examples of different terms used in literatures which describe AKI.[21] As there is no general agreement on the definition of AKI, this prevents the comparison of clinical studies.[9] This has given rise to major restriction in clinical success. However, in order to standardise AKI, the Acute Dialysis Quality Initiative (ADQI) group in 2002 suggested the RIFLE (Risk, Injury, Failure, Loss and End-stage kidney disease) criteria to address this technical shortcoming. This was proposed as a definition and staging method for AKI.[16] Later on, the AKIN criteria was developed which came up with the acute kidney injury term. According to AKIN criteria, AKI is diagnosed if a patients has a 0.3 mg/dl or a 50% or more increase in serum creatinine (Scr) from its baseline or there is a reduction in urine output of less than 0.5 ml/kg/h over a period of 6 h, after appropriate fluid resuscitation.[17]

The higher rate of incidence of AKI among arthroplasty patients may also be due to the inclusion of patients with kidney dysfunction compared to other studies where only patients with healthy kidneys were studied.[6,8,19] AKIN and RIFLE criteria were used to diagnose patients in the study and obtained 16.2% of AKI patients in the study. A retrospective study performed by Jiang et al. revealed an incidence of 6.8% of acute kidney disease (AKD). The study consisted of patients with no prior kidney abnormality and it assessed AKD using the RIFLE criteria, more precisely, increase in Scr was used to establish the degree of renal impairment.[4]Weingarten et al. conducted a retrospective study consisting of 9171 patients who underwent elective TJA. 167 (1.82%) patients suffered from AKI within 72 h after the surgical procedure. AKI was assessed using a modified AKIN.[5] Jafari et al. had an incidence of 0.40% renal injury in a cohort of patients of 17 938. It was a retrospective study which made use of the RIFLE classification to define acute renal failure.[8] 58 cases of AKI were diagnosed in the retrospective study conducted by Jamsa et al. 18, 575 patients were included and Scr was used to categorise them into the different RIFLE grades.[19] Kimmel et al. reported an incidence of 14.8% in the retrospective study she conducted. 425 elective patients who had primary, elective total joint arthroplasty formed part of the study. RIFLE criteria was used to assess AKI in the group of patients.[6]The incidence was lower in the retrospective cohort study conducted by Hassan. He reported an incidence of 2.7% in a study comprising of 599 patients who underwent primary total hip joint replacement.[5]

Right now, prevention is the only way to lower mortality and morbidity in postoperative AKI patients. Thus, appropriate policies can only be written after identification of the risk factors of postoperative AKI.[5]

4.2. Risk factors of AKI

In the study, obesity was found to be the most notable risk factor. Obese patients are 65% more likely to develop AKI compared to non-obese patients during the first month of admission.[22] Glance et al. studied 300, 000 patients who just underwent general, vascular or orthopaedic surgery. He found that the risk of AKI was increased by 3–7 times in obese patients. Moreover, obese patients are associated with other comorbidities such as hypertension and diabetes which are also linked to postoperative AKI.[9,23,24] Jiang et al., Jafari et al., Jamsa et al., Weingarten et al. and Kimmel et al. all concluded that a high BMI was a risk factor for postoperative AKI.[5,6,8,19] Conversely, Hassan et al. did not have the same finding. His study did not find any correlation between obese patients and AKI although the BMI of patients range from 15 to 46.[7]

Numerous papers have reported age as being an independent risk factor for the development of postoperative AKI.[6,7,19,25] Yet, Mehdi et al. did not come to the same conclusion and his study analysed more patients than the one listed above.

Smoking and COPD are not known risk factors of AKI.[26] However, Jafari et al. found COPD to be linked to the incidence of AKI in postsurgical arthroplasty patients.[8] Apart from Jafari et al., no research have found COPD to be a predictor of postoperative AKI in arthroplasty patients.

Contrary to numerous studies, hypertension has not been associated with postoperative AKI in the study.[5,8,25] This may be due to the small number of patients analysed.

4.3. Study limitations

The study conducted has a few limitations. It was performed in a large tertiary care institution which covers quite a predominant white population. Generalisation is thus, limited to centres with a similar group of patients and surgical protocols. The audit is of retrospective nature which does not permit commitment to a specific anaesthetic or surgical protocol. Unfortunately, the urine output, and intraoperative blood loss could not be collected as it was not properly recorded or inexistent in the majority of documents. Similarly to other retrospective studies, unmeasured risk factors may also be linked to the incidence of AKI. 72 h postoperatively was decided to be the time period to diagnose AKI. This may have led to some AKI patients being missed as Scr may have increased after that timeframe. Finally, we did not do a follow-up of the patients who suffered from postoperative AKI. So, we do not know if they had fully or partially recovered from the disease. Yet, it

Table 2
Potential risk factors.

Normal Variable	All patients	Post operative AKI, n = 32	No post operative AKI, n = 135	Logistic Regression			
				Univariate		Multivariate	
				O.R (95%CI)	P value	O.R (95% CI)	P value
Age							
Mean	70.2	72.8	69.7	10.2(0.99–1.06)	0.166	1.07(1.03–1.18)	0.0011
Standard Deviation	11.8	10.2	12.1				
Gender							
Male	90	14	76	0.89(0.41–1.91)	0.7621	0.67(0.30–1.53)	0.3443
Female	107	18	89				
Obese*							
Yes	105	26	79	4.72(1.84–12.1)	0.0012	6.40(2.34–17.5)	0.003
No	92	6	86				
Smoking*							
Yes	22	5	17	1.61(0.55–4.74)	0.3853	3.76(1.01–14.0)	0.0482
No	175	27	148				
COPD*							
Yes	18	7	11	3.92(1.39–11.1)	0.0099	3.85(1.18–12.5)	0.0253
No	179	25	154				
T2DM							
Yes	33	9	24	2.30(0.95–5.56)	0.0649	1.19(0.42–3.33)	0.7469
No	164	23	141				
CKD/Renal dysfunction							
Yes	18	7	11	1.67(0.61–4.56)	0.3147	0.88(0.25–3.09)	0.8425
No	179	25	154				
HTN							
Yes	87	18	69	1.79(0.83–3.84)	0.1357	1.01(0.43–2.35)	0.9817
No	10	14	96				
Hypothyroidism							
Yes	24	3	21	0.71(0.20–2.54)	0.5972	0.59(0.15–2.38)	0.4593
No	173	29	144				
ACEI/ARBS							
Yes	53	13	40	2.07(0.94–4.55)	0.0708	1.67(0.56–4.98)	0.4593
No	144	19	125				
Loop diuretics							
yes	23	4	19	1.10(0.35–3.47)	0.8739	1.44(0.45–4.61)	0.3552
No	174	28	146				
Thiazide diuretics							
Yes	19	3	16	0.96(0.26–3.52)	0.955	0.53(0.14–2.11)	0.5387
No	178	29	49				
Potassium Sparing diuretics							
Yes	8	1	7	0.73(0.086–6.13)	0.7703	2.16(0.25–18.6)	0.4824
No	189	31	158				
Statin							
Yes	76	18	58	2.37(1.10–5.11)	0.0275	1.41(0.57–3.47)	0.4576
No	121	14	107				
B-blocker							
Yes	43	10	33	1.82(0.79–4.21)	0.1626	1.69(0.57–5.02)	0.3487
No							
Prednisolone							
Yes	4	2	2	5.43(0.74–40.1)	0.0969	4.52(0.54–37.6)	0.1622
No							
PPI							
Yes	82	13	69	0.95(0.44–2.06)	0.9003	0.60(0.26–1.42)	0.2485
No	15	19	96				
NSAIDs							
Yes	22	7	15	2.80(1.04–7.55)	0.0419	2.57(0.98–6.72)	0.0547
No	175	25	150				
Intraoperative fluid administered (missing = 44)		missing = 35	missing = 9				
Mean	1600	1603	1587	1.00(1.00–1.00)	0.5182		
Standard deviation	853	851	887				

has been written in papers that a high percentage of postoperative AKI patients get back to their original baseline Scr measurement. Ulucay et al. found that all patients who suffered from stage 1, 2 and 3 of AKI according to AKIN criteria, had full recovery of their renal function within a mean of 4.84 days (range 3–8 days).[27]

Another audit conducted by Courtney et al. demonstrated that patients who had AKI of stage 1, 2 and 3 under the AKIN criteria got back to 50% of their original Scr measurement within an average of 3 days.[28] Those research papers prove that postoperative AKI patients have the capacity of regaining their full renal function.

5. Conclusion

My study, along with other studies, validates the high risk of suffering from renal dysfunction after a total hip or total knee joint arthroplasty.16.2% is quite a substantial percentage and policies need to be adopted to decrease the occurrence of AKI. Postoperative AKI has greater chance of occurring in patients with significant comorbidities.

Other studies need to be conducted to look at the relationship of urine output and AKI, a larger cohort of patients need to be studied

to obtain statistically significant results and AKI patients need to be followed to know if their kidney function return to normal after three months.

Declaration of competing interest

I.Vial, T.Babar and I.Boutros declare that they have no conflict of interest.

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