Renal function after elective total hip replacement

Incidence of acute kidney injury and prevalence of chronic kidney disease

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Background and purpose — Acute kidney injury (AKI) is associated with increased short-term and long-term mortality in intensive care populations and in several surgical specialties, but there are very few data concerning orthopedic populations. We have studied the incidence of AKI and the prevalence of chronic kidney disease (CKD) in an elective population of orthopedic patients undergoing primary total hip replacement, hypothesizing that chronic kidney disease predisposes to AKI.

Patients and methods — This was a single-center, population-based, retrospective, registry-based cohort study involving all primary elective total hip replacements performed from January 2003 through December 2012. Patient demographics and creatinine values were registered. We evaluated the presence of CKD and AKI according to the international guidelines for kidney disease (KDIGO Acute Kidney Injury Workgroup 2013).

Results — 3,416 patients were included (2,064 females (60%)). AKI (according to KDIGO criteria) was seen in 75 patients (2.2%, 95% CI: 1.7–2.7) in the course of primary total hip replacement. Of these, 26 had pre-existing CKD of class 3–5. Pre-existing CKD of class 3–5, indicating moderately to severely reduced kidney function, was seen in 374 individuals (11%).

Interpretation — Development of acute kidney injury appears to be a substantial problem compared to other complications related to elective total hip arthroplasty, i.e. luxation and infection. Patients with pre-existing chronic kidney disease may be especially vulnerable. The clinical impact of acute kidney injury in an elective orthopedic population remains to be elucidated.

Acute kidney injury (AKI) is defined as an abrupt decline in kidney function with severity ranging from mild dysfunction to complete renal failure and the need for acute dialysis (KDIGO Acute Kidney Injury Workgroup 2013). A multitude of studies concerning the association between AKI and morbidity and mortality in hospitalized patients have been published in the last decade, and AKI is now recognized as a common and serious organ dysfunction associated with increased short- and long-term mortality in intensive care populations (Gammelager et al. 2012, 2013, Nisula et al. 2013) and in several different groups of surgical patients. Most studies have been conducted in cardiothoracic surgery (see, for example, Liotta et al. 2014).

Even slight increases in plasma creatinine with no need for medical intervention have been associated with progressive loss of kidney function and increased mortality after discharge, with a higher prevalence of chronic kidney disease (CKD) in post-AKI populations (Lo et al. 2009). This association was found even if plasma creatinine had normalized before discharge (Bucaloiu et al. 2012, Lai et al. 2012).

However, the number of studies that have focused exclusively on elective surgical populations has been limited (Aveline et al. 2009, Ackland et al. 2011, Hansen et al. 2013). In addition, there have been few studies on kidney dysfunction in orthopedics, with most of them dealing with mixed populations or trauma patients (Aveline et al. 2009, Bennet et al. 2010, Jafari et al. 2010, Ackland et al. 2011).

An elective population is interesting because acute illness and concomitant risk factors associated with acute illness (e.g. dehydration and infection) are not present when surgery is performed. The impact of AKI related to the surgical procedure as such can therefore be assessed.

We report the incidence of AKI and the prevalence of CKD in a homogenous population of elective patients who underwent primary total hip replacement (THR).

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Patients and methods

Design and setting

The study was conducted in the Capital Region of Denmark (with 1.7 million inhabitants) using a cohort of all primary, elective THR surgeries carried out in Hørsholm Hospital and (when this hospital was closed) Gentofte Hospital from January 1, 2003 to December 31, 2012. The 2 hospitals were fused.

The Danish National Health Service provides tax-funded medical care for all Danish residents. Due to the unique Central Personal Registry number that is assigned to all Danish residents at birth or on immigration, it is possible to link individual patients and registries with a high degree of accuracy.

The patients and the exclusion process

Data collected included the following: date of surgery, patient sex, age at surgery, and plasma creatinine levels pre- and postoperatively. If a patient underwent bilateral THR, only the first THR was included in the study. Patients were assumed to be Caucasian. The median age of the population was 68 (26–95) years.

When Hørsholm and Gentofte hospitals were fused, laboratory data on 690 patients were not transferred to the electronic test result database resulting in plasma creatinine values not being accessible and leading to the exclusion of the patients. 7 patients did not have their plasma creatinine values measured within 7 days of surgery, and they were also excluded.

Perioperative care

Operations were conducted at Hørsholm Hospital from January 1, 2003 to December 31, 2010 when the hospital was merged with Gentofte Hospital. Standardized antibiotic prophylaxis, fluid therapy, and physiotherapy were delivered according to the local standard of care. The use of NSAIDs in the preoperative, perioperative, and postoperative analgesic regime was very limited, and was generally kept to a single dose of celecoxib given preoperatively. Patients were encouraged to resume fluid and solid intake on the first postoperative day.

Determination of acute kidney injury

Pre- and postoperative plasma creatinine (pCr) values in a cohort of 3,416 patients who underwent primary THR in Gentofte Hospital and Hørsholm Hospital between January 1, 2003 and December 31, 2012 were obtained using the databases of the hospital laboratories.

AKI was defined according to international KDIGO criteria as an increase in pCr of more than 26.5 µmol/L within 48 h of surgery (Table 1), or an increase in pCr to 1.5 times the baseline creatinine value within the first 7 postoperative days. Due to the lack of data on urine output, only pCr was used when determining AKI status. Because of this, our data may be an underestimation of the true incidence of AKI according to the KDIGO criteria.

Table 1. Assessment of AKI and classification of CKD

AKI determination		
pCr increase	≥ 26.5 µmol/L	≤ 48 h postop.
pCr increase	≥ 1.5 times the baseline value	≤ 7 days postop.
Chronic kidney disease classes		eGRF mL/min/1.73 m^2
CKD 1	Normal/high	≥ 90
CKD 2	Mildly decreased	60–89
CKD 3	Mildly to moderately decreased	30–59
CKD 4	Severly decreased	15–29
CKD 5	Kidney failure	< 15

Baseline creatinine was identified using preoperative pCr. Most tests were done between 1 and 2 months before surgery. To assign AKI status, we compared the peak postoperative creatinine measurement in the period from the start of surgery to day 7 with the baseline creatinine value.

We also identified patients whose first postoperative pCr value had dropped 5 µmol or more, presumably because of perioperative fluid therapy, as we hypothesized that this might also lead to an underestimation of the true incidence of AKI (Macedo et al. 2010).

Chronic kidney disease

Kidney function was described on the basis of estimated glomerular filtration rate (eGFR) using baseline creatinine and the CKD-EPI (Crea) formulae developed by KDIGO (KDIGO Acute Kidney Injury Work Group. 2013) .

According to the classification of chronic kidney diseases (KDIGO), patients with eGFR of 60 mL/min/1.73 m^2 or less (corresponding to class 3–5) were recorded as having mildly to moderately reduced kidney function or worse.

Statistics

To calculate 95% CIs for the incidence of AKI in the population, the following formula was used (Newcombe 1998):

$$x/n \pm 1.96 \times \sqrt{(x \times (n - x)/(n \times n))}$$

x is the number of AKI cases and n the size of the population.

Ethics

The study was approved by the Danish Data Protection Agency (February 27, 2014; record number GEH-2014-009). The Danish Ethics Committee was notified (January 8, 2014; record number H-2-2014-FSP2). All patient data were anonymized before analyses and handled with confidentiality.

Results

This study included 3,416 of the 4,113 patients who underwent primary THR between 2003 and 2012. Of these, 114 (3%) had preoperative pCr values taken more than 2 months before surgery.

AKI was present in 75 patients (2.2%, 95% CI: 1.7–2.7). Of these, 47% were female. One third of the patients who developed AKI (26/75) had pre-existing CKD of class 3–5.

When we calculated the incidence of AKI in the population, 10 patients had increases in creatinine of 27 µmol or more between 48 h and 7 days postoperatively, but without reaching more than 1.5 times the baseline creatinine value. These were not included in the total number of instances of AKI.

374 patients (11%) had moderately to severely reduced kidney function prior to surgery (CKD of class 3–5). Of these, 66% were female.

Compared to the first postoperative pCr value, 1,821 patients (53%) had a decrease in pCr of 5 µmol or more.

Discussion

We found an incidence of AKI of 2% in a homogenous, presumed healthy elective population of 3,416 THR patients. We used an updated, widely accepted definition of AKI and CKD that should allow comparison with other patient groups—both within and outside orthopedics.

Moderately to severely reduced kidney function, classified as CKD of stage 3–5, was present in 11% of the population, and this group appeared to be more susceptible to development of AKI, as they constituted one third of the instances of AKI.

To date, there have been no large studies investigating the incidence and prevalence of CKD in Denmark.

Studies from the USA and Norway have shown that 10–15% of the adult population has some degree of CKD, mainly mild. In the USA, the prevalence of CKD was on the increase until 2004 but it has stabilized since then (Hallan et al. 2006, USRDS Annual Data Report 2014).

The prevalence of CKD is comparable with (if not higher than) that of other important chronic diseases such as diabetes, chronic obstructive pulmonary disorder (COPD), and anxiety/depression.

Jafari et al. (2010) reported the incidence of kidney injury or kidney failure to be as low as 0.6% in a cohort of 17,983 arthroplasty patients. In contrast to our study, they included both primary and revision arthroplasty but they only included patients who had postoperative sCr levels documented, believing that since standard care for patients with renal impairment involves monitoring of sCr, an absence of these measurements would indicate that no acute renal injury or acute renal failure had taken place. This, together with differences in populations, might explain the higher incidence of AKI in our study (2%) than in the study described above.

In a population consisting of 527 patients undergoing either primary or revision total joint arthroplasty (hip or knee), Ackland et al. (2011) found an incidence of preoperative CKD of 27%. They did not include patients with an eGFR of less than 20 mL/min/1.73 m^2, which could mean that the total percentage of CKD (of class 3–5) was even greater. The higher incidence may have been due to differences in the patient populations, i.e. total knee replacement as opposed to THR, but it is not possible to ascertain this with the data available to us. A French study using a cohort of 755 patients undergoing primary THR found that 22% of the population had a preoperative eGFR of below 60 mL/min/1.73 m^2 (Aveline et al. 2009). The authors reported widespread use of NSAIDs in their cohort (85% of the population).

Our cohort was unique in that the quantity of uncemented prostheses was very high compared to other THR populations; the proportion of uncemented hip replacements increased from 81% in 2003 to 97% in 2012. By comparison, 70% of primary hip replacements in Denmark are uncemented (Danish Hip Register, Annual Report 2015). Furthermore, the use of NSAIDs has been limited, meaning that the likelihood of perioperative use of NSAIDs being the cause of AKI is low.

We found that both AKI and preoperative CKD are prevalent, even in preoperatively optimized and presumed healthy populations of THR patients. Compared to other complications relating to hip arthroplasty, for example luxation and infection, AKI appears to be a substantial problem. Patients with pre-existing moderately to severely reduced kidney function appear to be especially susceptible to development of AKI postoperatively. The incidence of AKI in the present study was too small for statistical analysis of differences in mortality, effects of current medication, or comorbidities.

The literature on the impact of AKI and CKD in orthopedics is limited. Ackland et al. (2011) studied the impact of CKD (defined as eGFR < 60 mL/min) in elective orthopedic surgery. Their study showed a statistically significant increase in morbidity after surgery compared to the healthy control group: CKD patients had more pulmonary, infectious, cardiovascular, renal, neurological, and pain-related complications (all with an odds ratio of 2).

Bihorac et al. (2009) studied long-term mortality and AKI during hospitalization after major surgery and found that patients who developed AKI had statistically significantly worse survival during the follow-up period. Both 1- and 5-year survival was impaired (86% survival in the AKI group at 1 year as compared to 91% in the no-AKI group, and 45% survival at 10 years in the AKI group as compared to 65% survival in the non-AKI group). This difference remained even after adjustment for age, sex, race, type of surgery, comorbidities, other postoperative complications, discharge facility, and length of stay (LOS). Thus, the current literature points to an increase in postoperative morbidity and mortality related to pre-existing CKD and to AKI following the surgical procedure.

Our findings raise questions regarding current regimens for perioperative use of medicines and fluid therapy, and they indicate that more attention should be given to AKI developing in the perioperative period around the time of larger planned surgery. Further studies are needed to investigate medicine use and patient demographics, and their association with AKI and CKD.

The main strength of the study was the use of an updated, widely accepted definition of AKI and CKD in a non-cardiac surgical population with no infection that was undergoing homogeneous, moderate-risk surgery. The Danish Arthroplasty Register states that the typical THR population consists of 58% females and 42% males with a median age of 69 years (http://www.dhr.dk/Rapporter.htm). Our population was representative with 60% females and a median age of 68 (26–95) years.

Given that the study was a retrospective analysis of prospectively collected, single-center data, it is not possible to characterize potential causes of postoperative AKI. Equally, since earlier studies have used several different definitions of—and methods for—calculating CKD, any comparison is difficult .

We believe that close perioperative monitoring of CKD patients especially (but not solely) is merited. Equally, a more vigilant approach to prevent even subclinical AKI should be obtained so as to decrease the risk of progression to clinical AKI and thus prolonged hospital stay as well as to decrease the risk of lasting kidney damage.

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