HIP | HIP International

Primary

HIP International
2021, Vol. 31(2) 201–206

DOI: 10.1177/1120700019889308
journals.sagepub.com/home/hpi
SAGE

The association of anaemia and its severity with composite morbidity after total hip arthroplasty

Robert Frangie[1], Karim Z Masrouha[1], Racha Abi-Melhem[2], Hani Tamim[3] and Muhyeddine Al-Taki[1]

Abstract

Background: Total hip arthroplasty (THA) is a common orthopaedic procedure and is expected to increase with an increasing elderly population. Many of these patients suffer from chronic diseases which might be associated with anaemia. Anaemia, by itself, increases the risk of morbidity. We aimed to delineate relationship between preoperative anaemia and postoperative composite morbidities in patients undergoing primary THA.

Methods: A cohort study analysed the data from the American College of Surgeons National Surgical Quality Improvement Program 2008–2014 database. Adult patients who underwent unilateral primary THA were included and divided into 3 groups: no anaemia, mild anaemia, and moderate-to-severe anaemia. Thirty-day mortality and morbidity were recorded as adverse events. The associations between anaemia, baseline characteristics, and adverse events were analysed after adjusting for confounders.

Results: Moderate-to-severe anaemia patients were at increased risk for composite morbidity (adjusted odds ratio, 1.43 [1.17–1.74]) when compared to non-anaemics. The stratification revealed a significant effect of younger age, male gender, white race, obesity, general anaesthesia, and mean operative time $>$120 minutes in patients with moderate-to-severe anaemia. These patients were also at a higher risk of developing several specific morbidities.

Conclusion: Moderate-to-severe anaemia increases the risk for composite morbidities, but not mortality in patients undergoing primary THA. Further studies are needed to assess whether preoperative management of moderate-to-severe anaemia would improve outcomes in patients undergoing THA.

Keywords

ACS-NSQIP, anaemia, morbidity, risk factors, total hip arthroplasty

Date received: 06 December 2018; accepted: 27 July 2019

Introduction

Total hip arthroplasty (THA) is one of the most common orthopaedic surgeries performed in USA, and demand has significantly increased over the last 20 years.[1,2] THA greatly improves function, quality of life, and reduces the cost of arthritis treatment as compared to conservative management.[3,4] However, THA has been associated with multiple postoperative morbidities and mortality risk.

Life expectancy, particularly in patients with chronic diseases, has increased with advances in modern medicine. This spiked the number of THA patients with comorbidities. In addition, the prevalence of anaemia of chronic diseases became as high as 39%.[5] Low preoperative haemoglobin (Hb) has been associated with increased perioperative morbidity and mortality, and presented as an independent factor for cardiac complications in patients undergoing major surgeries.[5,6] In studies of patients

[1]Division of Orthopaedic Surgery, Department of Surgery, American University of Beirut Medical Centre, Beirut, Lebanon
[2]Faculty of Medicine, American University of Beirut Medical Centre, Beirut, Lebanon
[3]Biostatistics Unit in the Clinical Research Institute, Department of Internal Medicine, American University of Beirut Medical Centre, Beirut, Lebanon

Corresponding author:
Muhyeddine Al-Taki, Division of Orthopaedic Surgery, Department of Surgery, American University of Beirut Medical Centre, PO Box 11-0236, Riad El-Solh, Beirut 1107 2020, Lebanon.
Email: maltaki@aub.edu.lb

undergoing total hip or knee arthroplasty, preoperative anaemia was highly prevalent, ranging from 24–44%.[7]

The purpose of this study was to delineate any possible relationship between preoperative anaemia and postoperative composite morbidities in patients undergoing primary THA. Our main question was whether the risk of composite morbidity increases in patients with anaemia undergoing THA. Association with other secondary outcomes such as increased risk of specific morbidities and mortality was also studied.

Methods

Study design

This is a retrospective cohort study where data was gathered from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP), which prospectively collects 30-day morbidity and mortality data from more than 480 hospitals around the United States. Specialized surgical clinical reviewers (SCR) collect more than 240 variables essentially complications and readmissions for the 30-day postoperative period through medical records or patient communication. The SCRs call patients with no follow-up visit to explore complications and admission to other institutions. In accordance with our institutional guidelines (following the US Code of Federal Regulations for the Protection of Human Subjects), Institutional Review Board approval was not needed or sought for our analysis because data were de-identified and collected as part of quality assurance activity.

Patient selection and outcomes

Inclusion criteria were patients $\geqslant$18 years of age who underwent unilateral primary THA (searched by CPT code 27130) between 2008–2014. Patients undergoing revision or bilateral simultaneous surgery were excluded.

Patient demographics, comorbidities, and selected laboratory values were obtained from the ACS-NSQIP database as baseline characteristics. These included age, gender, race, anaesthesia type, American Society of Anesthesiologists (ASA) class, total operative time, duration of hospital stay, congestive heart failure, tobacco use, chronic obstructive pulmonary disease (COPD), renal disease, malignancy, body mass index (BMI), diabetes mellitus, hypertension, steroid use, prothrombin time (PTT), international normalised ratio (INR), platelet count, albumin, white blood cell count, and creatinine levels.

Patients were divided into 3 groups based on their haematocrit (Hct) level. The no-anaemia group had Hct >39 mg/dl for males and 36 mg/dl for females.[6] Mild anaemia (MA) was defined as Hct of 33–39 mg/dl for males and 33–36 mg/dl for females. Moderate-to-severe anaemia (SA) was defined as Hct <33 mg/dl.

The 30-day mortality and morbidity, including cardiac (myocardial infarction and cardiac arrest), respiratory, renal, central nervous system, wound complications, bleeding, venous thromboembolism, and readmission/reoperation related to the procedure were recorded as adverse events.

Statistical analysis

Descriptive statistics were reported as number and percentage for categorical variables and mean and standard deviation for continuous ones. Missing values of continuous variables were replaced with the mean, while that of categorical values were replaced with a negative response if dichotomous (yes/no) and/or the most frequent value. Associations between exposure (anaemia) and the different characteristics and outcomes were assessed using chi-square test, independent sample *t*-test, or ANOVA, as appropriate. To control for potentially confounding effects of patient characteristics, we carried out multivariate logistic regression analyses. Adjusted odds ratios (AdjOR) for mortality and morbidities were calculated, using logistic regression with 95% confidence intervals (CI). The level of significance for the p-value was set at <0.05.

Results

All identified patients (69,110) were included unless Hct (2907 patients) and/or > 50% of variables were missing (2565 patients). Of these, 11,435 patients had anaemia with the majority having MA. The majority of cohort was older than 50 years and white across all groups. Less than 10% of patients had open wounds, sepsis, bleeding problems, or were using steroids for a chronic condition. Around 10% of non-anaemic patients and 18% of anaemic patients were diabetic with no difference between mild and severe anaemia. Elevated creatinine levels were noted in 20% of anaemics but only 7% of non-anaemics. Hypertension was noted in 68% of anaemics and 54% of non-anaemics. However, non-anaemics had a higher percentage of obese patients versus anaemics. Additionally, the serum albumin level was less in anaemic groups as compared to non-anaemics but it was > 30g/L across all groups.

As for the procedure, >80% were performed within 24 hours of admission and >50% were done under general anaesthesia. Mean total operative time was 93.71 ± 40.91 minutes for non-anaemics versus 96.23 ± 43.16 minutes for anaemics, with no significant difference. These baseline demographics and patient characteristics are summarised in Table 1.

As for postoperative outcome, only 2.01% of non-anaemic patients experienced postoperative morbidity while this increased to 3.15% and 5.57% in the MA and SA groups, respectively.

Table 1. Baseline characteristics of patients noting frequency (%) with mean and standard deviation when appropriate.

Patients' characteristics		No anaemia (n = 57675)		Mild anaemia (n = 8634)		Moderate-to-severe anaemia (n = 2801)	
Age (years)	< 50	5281	(9.2)	651	(7.5)	271	(9.7)
	50–65	23152	(40.1)	2675	(31.0)	750	(26.8)
	65–80	23515	(40.8)	3645	(42.2)	1094	(39.1)
	⩾ 80	5727	(9.9)	1663	(19.3)	686	(24.5)
Gender, male		25249	(43.8)	4483	(51.9)	735	(26.2)
Race	White	46520	(91.5)	6668	(84.6)	2052	(81.4)
	Black	3272	(6.4)	1027	(13.0)	381	(15.1)
	Asian	739	(1.5)	135	(1.7)	67	(2.7)
	Other	340	(0.7)	52	(0.7)	20	(0.8)
Anaesthesia type	General	31369	(54.4)	5152	(59.7)	1723	(61.5)
	Regional	1698	(2.9)	243	(2.8)	68	(2.4)
	Spinal	21110	(36.6)	2757	(31.9)	868	(31.0)
	Epidural	480	(0.8)	83	(1.0)	15	(0.5)
	Other	3001	(5.2)	398	(4.6)	127	(4.5)
ASA Class	I–II	36072	(62.6)	3946	(45.7)	1033	(36.9)
	III	20762	(36.0)	4376	(50.7)	1564	(55.9)
	IV–V	770	(1.3)	308	(3.6)	200	(7.2)
Total Operation Time (min)	>120	10968	(19.0)	1830	(21.2)	689	(24.6)
Days from admission to operation	⩽1	57266	(99.3)	8358	(96.8)	2517	(89.9)
Chronic Heart Failure within 30days		118	(0.2)	43	(0.5)	36	(1.3)
Respiratory							
Tobacco use		7940	(13.8)	987	(11.4)	290	(10.4)
History of severe COPD		2124	(3.7)	466	(5.4)	197	(7.0)
Renal							
Acute renal failure		10	(0.0)	15	(0.2)	12	(0.4)
On dialysis		52	(0.1)	53	(0.6)	50	(1.8)
Haematologic-Oncologic							
Weight loss >10% in previous 6 months		130	(0.2)	41	(0.5)	28	(1.0)
Disseminated cancer		110	(0.2)	71	(0.8)	62	(2.2)
BMI ⩾30Kg/m^2		26081	(45.4)	3383	(39.5)	950	(34.6)
Diabetic (medicated)		5838	(10.1)	1543	(17.9)	495	(17.7)
Hypertension (medicated)		31338	(54.3)	5898	(68.3)	1887	(67.4)
Open wound (± infection)		247	(0.4)	74	(0.9)	56	(2.0)
Steroid use		1748	(3.0)	524	(6.1)	228	(8.1)
Systemic sepsis in previous 48 hours		171	(0.3)	65	(0.8)	41	(1.5)
White blood cells >11000 cells/uL		2297	(4.0)	408	(4.8)	220	(8.0)
Platelet ⩽ 150000cells/uL		2217	(3.9)	547	(6.4)	276	(10.0)
INR > 1.4		545	(1.4)	159	(2.6)	85	(4.2)
Blood Urine Nitrogen >40 mg/dL		271	(0.5)	234	(2.9)	167	(6.3)
Creatinine >1.2 mg/dL		3915	(7.0)	1559	(18.6)	595	(21.9)
Albumin		4.17 ± 0.39		3.99 ± 0.46		3.74 ± 0.59	

ASA, American Society of Anesthesiologists; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; BMI, body mass index; WBC, white blood cell; INR, International normalised ratio; BUN, blood urea nitrogen.

The composite morbidity AdjOR showed a significant increase in only MA group as compared to non-anaemia group (OR,1.43 [1.17–1.74], p = 0.0004). Stratification by baseline characteristics showed no significant effect in MA patients except for male gender (OR,1.31 [1.08–1.58], p = 0.006) and non-smoking patients (OR,1.17 [1.01–1.36], p = 0.04). The stratification of SA group showed significant effect (p < 0.01) for younger age (OR, 2.4 [1.29–4.48]), male (OR, 2.01 [1.46–2.76]), white race (OR,1.43 [1.15–1.77]), general anaesthesia (OR, 1.5 [1.19–1.89]), BMI > 30 kg/m^2 (OR,1.53 [1.14–2.06]), and mean operative time >120 minutes (OR, 2 [1.44–2.78]) (Table 2).

Table 2. Overall adjusted odds ratio (OR) with 95% confidence interval of postoperative composite morbidity in addition to a stratified odds ratio of this parameter.

Patients' characteristics		Overall occurrence	Mild anaemia (n = 8634)	*p*-value	Moderate-to- severe anaemia (n = 2801)	*p*-value
In all patients		1589	1.10 (0.95–1.26)	0.20	1.43 (1.17–1.74)	0.0004
Within each of category						
Age (years)	< 50 (n = 6203)	113	0.66 (0.32–1.36)	0.26	2.40 (1.29–4.48)	0.006
	50–65 (n = 26577)	465	1.23 (0.94–1.61)	0.13	1.25 (0.81–1.94)	0.31
	65–80 (n = 28254)	665	1.00 (0.79–1.25)	0.97	1.61 (1.19–2.17)	0.002
	⩾ 80 (n = 8076)	346	1.16 (0.89–1.52)	0.26	1.08 (0.75–1.56)	0.67
Gender	Male (n = 30467)	733	1.31 (1.08–1.58)	0.006	2.01 (1.46–2.76)	<0.0001
	Female (n = 38643)	856	0.89 (0.71–1.10)	0.29	1.15 (0.90–1.48)	0.26
Race	White (n = 63077)	1413	1.12 (0.96–1.30)	0.15	1.43 (1.15–1.77)	0.001
	Black (n = 4680)	153	0.97 (0.65–1.46)	0.90	1.14 (0.66–1.96)	0.65
	Asian (n = 941)	15	1.02 (0.21–4.93)	0.98	2.90 (0.72–11.70)	0.13
	Other (n = 412)	8	3.18 (0.51–19.89)	0.22	7.69 (1.10–53.59)	0.04
Anaesthesia type	General (n = 38262)	1017	1.11 (0.93–1.32)	0.23	1.50 (1.19–1.89)	0.0007
	Regional (n = 2009)	31	0.36 (0.08–1.58)	0.18	1.11 (0.24–5.11)	0.89
	Spinal (n = 24735)	468	1.28 (0.99–1.65)	0.06	1.22 (0.81–1.82)	0.34
	Epidural (n = 578)	8	0.70 (0.08–6.16)	0.75	3.05 (0.26–35.91)	0.38
	Other (n = 3526)	65	0.46 (0.18–1.22)	0.12	1.25 (0.45–3.47)	0.66
ASA Class	I–II (n = 41130)	573	1.06 (0.81–1.39)	0.65	1.75 (1.18–2.61)	0.006
	III (n = 26702)	904	1.14 (0.96–1.36)	0.14	1.38 (1.08–1.76)	0.009
	IV–V (n = 1278)	112	1.03 (0.63–1.71)	0.90	1.30 (0.76–2.24)	0.34
Days from admission to operation	⩽ 1 (n = 68143)	1503	1.12 (0.97–1.30)	0.13	1.46 (1.18–1.79)	0.0004
Tobacco use	No (n = 59893)	1326	1.17 (1.01–1.36)	0.04	1.38 (1.12–1.71)	0.003
	Yes (n = 9217)	263	0.68 (0.44–1.06)	0.09	1.55 (0.94–2.57)	0.09
Disseminated cancer	No (n = 68867)	1572	1.09 (0.95–1.26)	0.21	1.41 (1.16–1.72)	0.0007
	Yes (n = 243)	17	0.46 (0.10–2.04)	0.31	0.62 (0.15–2.56)	0.51
BMI ⩾30Kg/m^2	No (n = 38299)	769	1.04 (0.86–1.27)	0.67	1.26 (0.97–1.63)	0.09
	Yes (n = 30811)	820	1.15 (0.94–1.41)	0.17	1.53 (1.14–2.06)	0.004
Steroid use	No (n = 66610)	1490	1.13 (0.98–1.31)	0.1	1.42 (1.15–1.74)	0.0009
	Yes (n = 2500)	99	0.78 (0.45–1.36)	0.38	1.54 (0.86–2.76)	0.14
White blood cells	> 11000cells/uL (n = 2925)	144	1.28 (0.81–2.02)	0.29	1.06 (0.58–1.91)	0.86
Platelet	⩽ 150000cells/uL (n = 3040)	124	1.30 (0.83–2.03)	0.25	0.97 (0.52–1.80)	0.93
INR	> 1.4 (n = 789)	36	0.74 (0.28–1.97)	0.54	2.36 (1.02–5.46)	0.04
Blood Urine Nitrogen	> 40mg/dL (n = 672)	49	1.33 (0.65–2.74)	0.44	1.95 (0.94–4.04)	0.07
Creatinine	> 1.2mg/dL (n = 6069)	275	1.26 (0.94–1.68)	0.12	1.67 (1.16–2.40)	0.005
Albumin	< 30g/L (n = 383)	45	0.65 (0.24–1.71)	0.38	0.71 (0.31–1.59)	0.40
	⩾ 30g/L (n = 68727)	1544	1.09 (0.94–1.26)	0.24	1.47 (1.20–1.79)	0.0002
Total operative time	> 120 (n = 13487)	426	1.16 (0.89–1.53)	0.27	2.00 (1.44–2.78)	<0.0001

ASA, American Society of Anesthesiologists; BMI, body mass index; WBC, white blood cell; INR, International normalised ratio; BUN, blood urea nitrogen.
A *p*-value of <0.05 indicates statistical significance.

The OR of composite morbidity in age groups were further divided based on ASA class which revealed highest OR (OR, 12.76 [1.81–89.77]) in IV-V class for <50 years old patients with moderate-to-severe anaemia (Table 3).

In addition, the risk of specific complications was assessed. SA patients were at higher risk for developing cardiac arrest, respiratory complications, renal and neurologic problems, wound complications and developing sepsis. They were also at higher risk of re-operation related to the principle surgery (Table 4).

Discussion

We analysed association between the severity of anemia and postoperative complications, primarily composite morbidity and secondarily specific morbidities in 69,110 THA patients.

Table 3. The composite morbidity was calculated for the different ASA classes in each age group of patients who underwent THA.

ASA class	Overall occurrence	Mild anaemia (n = 8634)	p-value	Moderate-to-severe anaemia (n = 2801)	p-value
< 50 years old (n = 6203)					
I–II (n = 4548)	52	0.82 (0.28–2.40)	0.72	2.35 (0.70–7.85)	0.17
III (n = 1587)	51	0.46 (0.15–1.39)	0.17	1.98 (0.83–4.73)	0.12
IV–V (n = 61)	9	2.63 (0.17–39.82)	0.49	12.76 (1.81–89.77)	0.01
50–65 years old (n = 26577)					
I–II (n = 17821)	213	1.17 (0.74–1.85)	0.50	1.22 (0.54–2.75)	0.63
III (n = 8441)	229	1.31 (0.93–1.86)	0.13	1.43 (0.83–2.45)	0.20
IV–V (n = 292)	23	1.46 (0.44–4.82)	0.53	0.61 (0.15–2.48)	0.49
65–80 years old (n = 28254)					
I–II (n = 15594)	225	1.15 (0.76–1.74)	0.50	2.03 (1.09–3.78)	0.03
III (n = 12033)	402	0.92 (0.70–1.22)	0.57	1.37 (0.94–1.98)	0.10
IV–V (n = 587)	38	1.08 (0.46–2.51)	0.86	2.42 (1.05–5.55)	0.04
⩾ 80 years old (n = 8076)					
I–II (n = 3088)	82	0.81 (0.43–1.53)	0.52	1.32 (0.58–3.01)	0.51
III (n = 4641)	221	1.45 (1.06–1.98)	0.02	1.18 (0.75–1.85)	0.47
IV–V (n = 338)	42	0.76 (0.33–1.76)	0.52	0.40 (0.14–1.14)	0.09

ASA, American Society of Anesthesiologists; THA, total hip arthroplasty.

Table 4. The adjusted odds ratio (OR_{adj}) and 95% confidence interval of specific morbidities and mortality in anaemic patients.

Postoperative outcomes	Overall occurrence (n = 69110)	Mild anaemia (n = 8634)	p-value	Moderate-to-severe anaemia (n = 2801)	p-value
Cardiac	62	1.09 (0.55–2.17)	0.23	2.21 (1.06–4.60)	0.03
Respiratory	361	1.12 (0.84–1.48)	0.44	1.71 (1.21–2.41)	0.003
Renal	100	1.53 (0.95–2.47)	0.082	2.70 (1.48–4.90)	0.001
Return to operating room*	1370	1.26 (1.08–1.46)	0.003	1.56 (1.26–1.94)	<0.0001
Unplanned arthroplasty-related reoperation*	875	1.13 (0.93–1.38)	0.21	1.40 (1.05–1.85)	0.02
Central Nervous System*	100	0.85 (0.49–1.47)	0.56	0.40 (0.12–1.28)	0.12
Wound	388	1.12 (0.84–1.50)	0.45	1.68 (1.14–2.49)	0.009
Thromboembolism	452	0.83 (0.62–1.11)	0.20	1.09 (0.73–1.64)	0.68
Sepsis	265	1.42 (1.03–1.95)	0.03	2.03 (1.36–3.03)	0.0005
Bleeding	9050	2.90 (2.73–3.08)	<0.0001	5.58 (5.12–6.07)	<0.0001
Mortality	133	1.25 (0.80–1.96)	0.33	1.52 (0.88–2.63)	0.13

*>20% of cases missing.

Higher composite morbidity rate was associated with anemia and influenced by its severity. Similarly, Spahn et al.[7] found poorer physical functioning, poorer recovery, and increased length of hospital stay in THA patients with anaemia.[7]

Younger age affected the composite morbidity negatively in SA patients. Patients >50 years had 2.4-fold higher risk of developing morbidities, whereas no statistically significant increase was found in elderly patients. The younger population presenting for surgery might have had other medical conditions predisposing them to early hip arthritis, such as sickle cell disease, cancer, drug abuse, etc. which can lead to avascular necrosis of the femoral head. In addition, younger patients presenting for THA, might have required THA post trauma of the hip. That same trauma might have affected other body parts, putting those patients at increased risk of complications and composite morbidity. Further assessment of age groups divided by ASA class showed that that SA patients younger than 50 years had an enormous increase in OR in patients with higher ASA class (Table 3). This finding might have increased the overall score of composite morbidity in younger patients. More studies are needed to better analyse and explain this finding.

Immediate surgery was found to be associated with higher risk of composite morbidity in SA patients (Table 2). This increase can be attributed to the fact that these patients may not have been optimized enough for surgery. In addition, obesity was associated with an increased risk of composite morbidity in SA. Hence, the proportionally higher ratio of composite morbidities in moderate-severe anaemics might be due to younger patients, obese patients, and a shorter duration from admission to surgery.

Most specific morbidities were also increased in SA patients undergoing THA. The increase in cardiac, respiratory and neurologic complications in this group corresponds to previous findings from the ACS-NSQIP database on SA patients who underwent major surgery.[6] Renal complications, particularly acute kidney injury, occur in the perioperative period due to multiple factors such as ischemia, nephrotoxic drugs, hypovolaemic state, and inflammation.[8] Moreover, anaemia decreases oxygen-carrying capacity, consequently augmenting these effects on kidney function.

Wound complications were increased for SA patients. This corresponds to the results of a meta-analysis, which found a similarly increased risk of surgical site infections (OR, 1.71) in THA patients who received perioperative allogenic blood transfusions.[9]

As for MA, it only increased the risk of sepsis, bleeding, and return to the operating room, which was proportionally increased in SA patients. Anaemic patients undergoing hip replacement are at an increased risk of requiring transfusions. These patients are also at increased risk of postoperative morbidities.[5,10] The increased sepsis risk may be transfusion-related, as serious infections were reduced with a restrictive transfusion strategy.[11,12]

We found that anaemia does not increase the risk of mortality in patients undergoing THA. This finding is similar to our previous finding in patients undergoing total knee replacement[13] and previous studies on total hip and knee replacement.[14,15] However, this finding differs from a previous ACS-NSQIP study of patients with anaemia who underwent major non-cardiac surgery.[6]

The main weakness of this study was the retrospective design. In addition, the small number of patients in SA group may increase the chance of type B error. Also, the definition of anaemia was based solely on the haematocrit level with no indication of aetiology and/or chronicity which were not available in the ACS-NSQIP database. Despite these limitations, this study has several strengths. It incorporates a large sample size of 69,100 patients while previous studies had small samples. Data was collected by specialists using a rigid and straightforward definition for each variable and outcome. In addition, this study includes only primary THA cases while other studies included primary and revision THA and TKA.

Conclusion

Moderate-to-severe anaemia increased the composite morbidities risk but did not increase mortality following THA. Risks for morbidity were increased in younger, white, obese, male patients who underwent THA under general anaesthesia, with an operative time of >120 minutes. With regards to specific outcomes, SA patients were at higher risk of developing cardiac arrest, respiratory, renal and neurologic problems, wound complications, sepsis, and undergoing reoperation. Thus, SA patients might need preoperative management. Further studies are needed to assess if the preoperative management would improve outcomes in SA patients undergoing primary THA.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship and/or publication of this article.

References

1. Kim S. Changes in surgical loads and economic burden of hip and knee replacements in the US: 1997-2004. *Arthritis Rheum* 2008; 59: 481–488.
2. Kurtz SM, Ong KL, Schmier J, et al. Future clinical and economic impact of revision total hip and knee arthroplasty. *J Bone Joint Surg Am* 2007; 89(Suppl. 3): 144–151.
3. Ethgen O, Bruyère O, Richy F, et al. Health-related quality of life in total hip and total knee arthroplasty. A qualitative and systematic review of the literature. *J Bone Joint Surg Am* 2004; 86: 963–974.
4. Hawker GA, Badley EM, Croxford R, et al. A population-based nested case-control study of the costs of hip and knee replacement surgery. *Med Care* 2009; 47: 732–741.
5. Jans Ø, Jorgensen C, Kehlet H, et al. Role of preoperative anemia for risk of transfusion and postoperative morbidity in fast-track hip and knee arthroplasty. *Transfusion* 2014; 54: 717–726.
6. Musallam KM, Tamim HM, Richards T, et al. Preoperative anaemia and postoperative outcomes in non-cardiac surgery: a retrospective cohort study. *Lancet* 2011; 378: 1396–1407.
7. Spahn DR. Anemia and patient blood management in hip and knee surgery: a systematic review of the literature. *Anesthesiology* 2010; 113: 482–495.
8. Sear JW. Kidney dysfunction in the postoperative period. *Br J Anaesth* 2005; 95: 20–32.
9. Kim JL, Park JH, Han SB, et al. Allogeneic blood transfusion is a significant risk factor for surgical-site infection following total hip and knee arthroplasty: a meta-analysis. *J Arthroplasty* 2017; 32: 320–325.
10. Myers E, O'Grady P and Dolan AM. The influence of preclinical anaemia on outcome following total hip replacement. *Arch Orthop Trauma Surg* 2004; 124: 699–701.
11. Rohde JM, Dimcheff DE, Blumberg N, et al. Health care-associated infection after red blood cell transfusion: a systematic review and meta-analysis. *JAMA* 2014; 311: 1317–1326.
12. Reading FC and Brecher ME. Transfusion-related bacterial sepsis. *Curr Opin Hematol* 2001; 8: 380–386.
13. Chamieh JS, Tamim HM, Masrouha KZ, et al. The association of anemia and its severity with cardiac outcomes and mortality after total knee arthroplasty in noncardiac patients. *J Arthroplasty* 2016; 31: 766–770.
14. Mantilla CB, Wass CT, Goodrich KA, et al. Risk for perioperative myocardial infarction and mortality in patients undergoing hip or knee arthroplasty: the role of anemia. *Transfusion* 2011; 51: 82–91.
15. Pulido L, Parvizi J, Macgibeny M, et al. In hospital complications after total joint arthroplasty. *J Arthroplasty* 2008; 23: 139–145.