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ARTHROPLASTY

The incidence and risk factors for abnormal postoperative blood tests following primary total joint replacement

A SINGLE-CENTRE RETROSPECTIVE COHORT STUDY

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Aims

We aim to evaluate the usefulness of postoperative blood tests by investigating the incidence of abnormal results following total joint replacement (TJR), as well as identifying preoperative risk factors for abnormal blood test results postoperatively, especially pertaining to anaemia and acute kidney injury (AKI).

Methods

This is a retrospective cohort study of patients who had elective TJR between January and December 2019 at a tertiary centre. Data gathered included age at time of surgery, sex, BMI, American Society of Anesthesiologists (ASA) grade, preoperative and postoperative laboratory test results, haemoglobin (Hgb), white blood count (WBC), haematocrit (Hct), platelets (Plts), sodium (Na^+), potassium (K^+), creatinine (Cr), estimated glomerular filtration rate (eGFR), and Ferritin (ug/l). Abnormal blood tests, AKI, electrolyte imbalance, anaemia, transfusion, reoperation, and readmission within one year were reported.

Results

The study included 2,721 patients with a mean age of 69 years, of whom 1,266 (46.6%) were male. Abnormal postoperative bloods were identified in 444 (16.3%) patients. We identified age (≥ 65 years), female sex, and ASA grade ≥ III as risk factors for developing abnormal postoperative blood tests. Preoperative haemoglobin (≤ 127 g/dl) and packed cell volume (≤ 0.395 l/l) were noted to be significant risk factors for postoperative anaemia, and potassium (≤ 3.7 mmol/l) was noted to be a significant risk factor for AKI.

Conclusion

The costs outweigh the benefits of ordering routine postoperative blood tests in TJR patients. Clinicians should risk-stratify their patients and have a lower threshold for ordering blood tests in patients with abnormal preoperative haemoglobin (≤ 127 g/l), blood loss > 300 ml, chronic kidney disease, ASA grade ≥ III, and clinical concern.

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Introduction

In 2017 the worldwide prevalence of hip and knee osteoarthritis was approximately 40 million and 263 million people, respectively.[1,2] End-stage osteoarthritis in weight-bearing joints remains a leading cause of disability with no current cure. Treatments such as total hip arthroplasty (THA) and total knee arthroplasty (TKA) have been proven to be effective and safe in symptomatically managing these patients.[2-5] As health services across the world deal with ageing, comorbid,

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Table I. Patient characteristics between normal and abnormal blood test groups.

Variable	Normal postoperative	Abnormal postoperative	Total	p-value
Total, n (%)	2,277 (83.7)	444 (16.3)	2,721	
Mean age, yrs (SD; range)	68.4 (10.4; 27.0 to 98.0)	72.3 (9.1; 29.0 to 92.0)	69.0 (10.3; 27.0 to 98.0)	< 0.001
Mean BMI, kg/m^2 (SD; range)	30.0 (5.4; 14.9 to 50.9)	28.5 (5.2; 17.7 to 46.7)	29.8 (5.4; 14.9 to 50.9)	< 0.001
Sex, n (M:F)	1,108:1,169	158:286	1,266:1,455	< 0.001
THA:TKA, n	1,213:1,064	239:205	1,452:1,269	0.830
Mean ASA grade (SD; range)	2.0 (0.5; 1.0 to 3.0)	2.0 (0.5; 1.0 to 4.0)	2.0 (0.5; 1.0 to 4.0)	0.003
ASA grade, n (%)				
I	236 (10.4)	33 (7.2)	268 (9.8)	
II	1,713 (75.2)	321 (72.3)	2,034 (74.8)	
III	327 (14.4)	90 (20.3)	417 (15.3)	
IV	1 (0.03)	1 (0.2)	2 (0.1)	

ASA, American Society of Anesthesiologists; SD, standard deviation; THA, total hip arthroplasty; TKA, total knee arthroplasty.

and obese populations with an increasing demand for arthroplasties, it is pivotal that clinicians evaluate their practice to ensure service is delivered cost-effectively without any detrimental consequences to safety.[1]

It is widely accepted that elective total joint replacements (TJRs) for hips and knees are successful procedures with a predictable postoperative course.[4,6,7] However, on occasions these procedures can result in significant blood loss, among other complications.[3,8-14] This explains the historical actions of clinicians who err on the side of caution by routinely performing preoperative 'group and save' (G&S) as well as postoperative blood tests prior to discharge. Recently, there has been debate questioning the usefulness of these tests and the 'one size fits all' approach towards requesting them in routine elective settings.[8,12,13] It has been reported that by necessitating pre- and postoperative blood tests, provision of care and even discharge can often be delayed. Given the rise of enhanced recovery pathway after surgery (ERAS) and multimodal strategies to identify and treat patients at risk of biochemical or haematological derangement perioperatively, some argue that these routine tests may be rendered redundant.[3,15-18]

The National Institute for Health and Care Excellence (NICE) has published guidelines on preoperative blood tests based on the type of elective surgery and the patient's American Society of Anesthesiologists (ASA) grade.[19,20] However, these guidelines do not include primary elective arthroplasties. The responsibility inevitably falls on the clinician to decide on the need for such blood tests, weighing any risks against benefits, while considering the financial impact of the investigation. We hypothesize that following uncomplicated elective THA or TKA, blood tests add little value to the management of most patients.

This study aims to 1) establish the incidence of abnormal postoperative blood test results following elective primary THA and TKA; 2) identify risk factors for abnormal postoperative blood results; 3) determine thresholds that could predict abnormal laboratory tests necessitating medical intervention such as anaemia or acute kidney injury (AKI); and 4) investigate any association between abnormal postoperative blood test results and risk of readmission, reoperation, or longer hospitalization.

Methods

Study design. Following institutional approval (2122_014) from our trust's Clinical Audit Registration and Management Systems (CARMS), we conducted a retrospective, single (tertiary) centre and multi surgeon cohort study, which we report in accordance to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) criteria.[21]

Participants and eligibility criteria. All patients at our trust who had undergone elective primary THA or TKA between January and December 2019 were identified on our electronic database, and case notes were reviewed up to one year post surgery. We excluded patients that had bilateral joint arthroplasty, resurfacing arthroplasty, traumatic cases, hemiarthroplasty, revision surgery, arthroplasties with oncological indications, patients with bleeding disorders, and cases with concurrent major procedures (e.g. femoral osteotomies femoral osteotomies, removal of metalwork). Procedures that had a prolonged operating time (> 240 minutes) as to limit the influence of extreme outliers.[22,23] Cases with missing data, or no postoperative blood results at the request of the operating surgeon, were also excluded.

At our centre, the use of intravenous (IV) tranexamic acid and antibiotics is routine during elective TJR. The posterior approach was performed for all THAs, and the medial parapatellar approach for the majority of TKAs, as some surgeons prefer a lateral approach for fixed valgus knees. Hence, heterogeneity was largely limited by standardization of practice.

Variables and outcomes. We extracted individual demographic data such as age at time of surgery, sex, BMI, and American Society of Anesthesiologists (ASA) grade.[20] Preoperative and postoperative laboratory test results were extracted, including haemoglobin (Hgb), white blood count (WBC), haematocrit (Hct), platelets (Plts), sodium

Table II. Patient preoperative blood tests between normal and abnormal blood test groups.

Variable	Normal postoperative	Abnormal postoperative	Total	p-value
Mean preoperative bloods (SD; range)				
Haemoglobin, g/dl	137.7 (12.5; 96.0 to 183.0)	131.5 (13.8; 85.0 to 177.0)	136.7 (12.9; 85.0 to 183.0)	< 0.001
Packed cell volume, l/l	0.417 (0.033; 0.307 to 0.537)	0.398 (0.038; 0.276 to 0.519)	0.414 (0.035; 0.276 to 0.537)	< 0.001
Platelets, 10*9 /l (SD, range)	266.3 (68.2; 112.0 to 742.0)	286.4 (72.2; 114.0 to 856.0)	269.5 (69.2; 112.0 to 856.0)	< 0.001
White blood cells, 10*9 /l (SD, range)	6.9 (2.3; 2.4 to 69.7)	7.1 (2.3; 2.5 to 19.6)	7.0 (2.3; 2.4 to 69.7)	0.252
Sodium, mmol/l (SD, range)	140.5 (2.2; 131.0 to 148.0)	137.5 (3.7; 124.0 to 144.0)	140.1 (2.7; 124.0 to 148.0)	< 0.001
Potassium, mmol/l (SD, range)	4.4 (0.3; 3.1 to 5.8)	4.4 (0.5; 3.0 to 5.8)	4.4 (0.4; 3.0 to 5.8)	0.937
Creatinine, umol/l (SD, range)	78.4 (19.6; 38.0 to 221.0)	75.9 (27.7; 36.0 to 436.0)	78.0 (21.2; 36.0 to 436.0)	0.025
eGFR, 1.73 m^2 (SD, range)	77.0 (13.7; 21.0 to 90.0)	75.8 (15.4; 10.0 to 90.0)	76.8 (13.9; 10.0 to 90.0)	0.100
Ferritin, ug/l (SD, range)	174.3 (167.1; 7.0 to 2,521.0)	166.9 (142.6; 15.0 to 1,230.0)	173.1 (163.3; 7.0 to 2,521.0)	0.404
Postoperative variables				
Mean length of stay, days (SD, range)	3.6 (2.5; 1.0 to 43.0)	5.1 (9.1; 1.0 to 184.0)	3.8 (4.4; 1.0 to 184.0)	< 0.001
Readmission, n (%)				0.820
Yes	34 (1.5)	6 (1.4)	40 (1.5)	
No	2,243 (98.5)	438 (98.6)	2,681 (98.5)	
Mean days to readmission (SD; range)	77.6 (103.8, 1.0 to 363.0)	46.5 (72.6, 9.0 to 194.0)	72.9 (99.6, 1.0 to 363.0)	0.488
Reoperation, n (%)				0.734
Yes	17 (0.7)	4 (0.9)	21 (0.8)	
No	2,260 (99.3)	440 (99.1)	2,700 (99.2)	
AKI, n (%)				< 0.001
Yes	0 (0)	20 (4.5)	20 (0.7)	
No	2,277 (100)	424 (95.5)	2,701 (99.3)	
Transfused, n (%)				< 0.001
Yes	0 (0)	67 (15.1)	67 (2.5)	
No	2,277 (100)	377 (84.9)	2,654 (97.5)	
Mean units transfused (SD; range)		1.7 (0.5; 1.0 to 3.0)	1.7 (0.5; 1.0 to 3.0)	
Mean estimated blood loss, ml (SD; range)		94.3 (27.2; 43.6 to 189.5)	94.3 (27.2; 43.6 to 189.5)	
Mean change in blood test values following surgery (SD; range)				
Haemoglobin, g/dl	16.6 (8.3; -12.0 to 49.0)	19.4 (9.7; -9.0 to 56.0)	17.1 (8.6; -12.0 to 56.0)	< 0.001
Packed cell volume, l/l	0.05 (0.03; -0.370 to 0.150)	0.06 (0.03; -0.300 to 0.170)	0.05 (0.03; -0.370 to 0.170)	< 0.001
Platelets, 10*9 /l	24.4 (34.6; -230.0 to 259.0)	32.5 (38.9; -138.0 to 184.0)	25.7 (35.5; -230.0 to 259.0)	< 0.001
White blood cells, 10*9 /l	5.7 (3.2; -19.8 to 4.4)	5.2 (3.5; -18.5 to 4.1)	5.6 (3.2; -19.8 to 4.4)	0.003
Sodium, mmol/l	3.5 (2.5; -5.0 to 11.0)	6.2 (3.8; -5.0 to 20.0)	3.9 (2.9; -5.0 to 20.0)	< 0.001
Potassium, mmol/l	0.1 (0.4; -4.9 to 1.5)	0.1 (0.5; -1.5 to 1.6)	0.1 (0.4; -4.9 to 1.6)	0.691
Creatinine, umol/l	0.6 (10.8; -55.0 to 68.0)	1.5 (19.3; -223.0 to 46.0)	0.3 (12.6; -223.0 to 68.0)	0.002
eGFR, 1.73 m^2	0.3 (8.6; -45.0 to 32.0)	0.9 (12.1; -36.0 to 72.0)	0.1 (9.3; -45.0 to 72.0)	0.017

AKI, acute kidney injury; eGFR, estimated glomerular filtration rate; SD, standard deviation.

(Na^+), potassium (K^+), creatinine (Cr), estimated glomerular filtration rate (eGFR), and Ferritin (ug/l). Normal ranges at our trust were defined as Hgb (130 to 180 g/l), WBC (4.0 to 11.0 10*9 /l), Hct (0.400 to 0.520 l/l), Plts (150 to 450 10*9 /l), Na^+ (133 to 146 mmol/l), K^+ (3.5 to 5.3 mmol/l), Cr (60 to 110 umol/l), and eGFR/1.73 m^2 (> 90 ml/min). Results outside their normal range, or that required medical intervention such as a transfusion or IV fluids, were defined as abnormal.

Demographics. A total of 2,758 patients had a primary joint arthroplasty (53.4% THA, 46.6% TKA) at our institution in the study period, of whom 2,721 met the inclusion criteria. The mean age of the study population was 69.0 years (SD 10.3; 27.0 to 98.0), mean BMI 29.8 kg/m^2 (SD 5.4; 14.9 to 50.9), and 46.5% (n = 1,266) were male.

Outcomes. The postoperative blood results were used to divide the study population into abnormal and normal postoperative blood results groups (Table I). The presence of a postoperative acute kidney injury (AKI), electrolyte derangement, anaemia, need for transfusion, reoperation, and readmission within one year were recorded. Length of stay was also extracted. Patients who required blood transfusion had an individual analysis of estimated blood loss volume using a validated formula.[24]

An AKI was defined as an increase in baseline serum creatinine by at least 0.3 mg/dl or 26.4 mmol/l, and

Table III. Receiver operating characteristic analysis for anaemia and acute kidney injury.

Preoperative blood test	Cut-off point	Sensitivity, %	Specificity, %	AUC (95% CI)	p-value
Anaemia					
Haemoglobin	127 g/l	100	79	0.932 (0.825 to 1.000)	0.010
Packed cell volume	0.395 l/l	100	72	0.906 (0.760 to 0.912)	0.015
Platelets	308 (10*9 /l)	100	25	0.516 (0.304 to 0.728)	0.923
White cell count	14.0 (10*9 /l)	100	99	0.318 (0.0 to 0.804)	0.276
AKI					
Sodium	144 mmol/l	100	6	0.586 (0.457 to 0.715)	0.206
Potassium	3.7 mmol/l	100	23	0.356 (0.223 to 0.489)	0.035
Creatinine	130 umol/l	100	3	0.530 (0.397 to 0.662)	0.663
eGFR	47 ml/min	100	4	0.503 (0.376 to 0.629)	0.970

AKI, acute kidney injury; AUC, area under the curve; CI, confidence interval; eGFR, estimated glomerular filtration rate.

clinically significant anaemia as a Hgb value of 80 g/l or less.[8,25,26]

Statistical analysis. The statistical software SPSS version 23 (IBM, USA) was used to perform all analysis. Independent-samples *t*-test was used for analyzing mean values between groups with normal and abnormal laboratory test results for continuous variables. The chi-squared test or Fisher's exact test was used to compare categorical variables. An analysis of variance (ANOVA) was performed to identify factors that may have influenced the outcomes reported. Welch and Brown-Forsythe tests were used to evaluate the equality of the means. Bonferroni's correction was used in the case of multiple comparisons, to avoid α error. A logistic regression analysis was performed to generate a receiver operating characteristic (ROC) curve with the 95% confidence intervals (CIs) to assess abnormal postoperative blood tests. This was performed for each preoperative value with respect to parameters that measure for anaemia and AKI. The ROC curve focused on sensitivity, rather than specificity. The area under the curve was interpreted as the probability to correctly identify the majority of the cohort. A p-value of less than 0.05 was considered significant.

Results

Abnormal postoperative blood tests. Only 16.3% of patients (n = 444) were identified with abnormal postoperative blood test results. There were three (0.1%) patients with a haemoglobin of 80 or less, 20 (0.7%) patients with an AKI, 333 (12.2%) patients with an abnormal sodium, and 72 (2.6%) with an abnormal potassium. The transfusion rate was 2.5% (n = 67).

Risk factors for abnormal postoperative blood results. Our analysis showed that an age of ≥ 65 years (p < 0.001, independent-samples *t*-test), lower BMI (p < 0.001 independent-samples *t*-test), ASA grade ≥ III (p = 0.003, chi-squared test), and female sex (p < 0.001, chi-squared test) are significantly more prevalent in the abnormal postoperative blood test result group (Table I). Preoperative values of haemoglobin (p < 0.001, independent-samples *t*-test), packed cell volume (p < 0.001, independent-samples *t*-test), platelets (p < 0.001, independent-samples *t*-test), sodium (p < 0.001, independent-samples *t*-test), and creatinine (p = 0.025, independent-samples *t*-test) were significant factors in the abnormal postoperative results group compared to the normal group, and can also be deemed as risk factors for abnormal blood results necessitating an intervention (Table II).

Acute kidney injury. Only 0.7% (n = 20) of the study population were diagnosed with AKI. Age (p = 0.013, ANOVA) and low preoperative potassium (p = 0.044, ANOVA) were identified as significant risk factors. ROC analysis was performed for each preoperative blood test in the context of AKI. A preoperative potassium of < 3.7 mmol/l was found to be a significant predictor of postoperative AKI (p = 0.035, ANOVA) (Table III).

Anaemia. ROC analysis was performed for each preoperative blood test in the context of anaemia. A set cut-off point of preoperative haemoglobin level of < 127 g/l (p = 0.010) or haematocrit < 0.395 l/l (p = 0.015) were significant predictors of postoperative anaemia (Table III).

Transfusion. Of those requiring transfusion, the mean number of units required was 1.7 (SD 0.5; 1.0 to 3.0) and the overall estimated mean blood loss was 94.3 ml (SD 27.2 ml, 43.6 to 189.5 ml). During the perioperative period 2.5% (n = 67) patients received a blood transfusion. Only 0.1% (n = 3) had a haemoglobin of 80 or less. THA (p = 0.006, chi-squared test), female (p < 0.001, ANOVA), ASA grade ≥ III (p < 0.001, ANOVA), age ≥ 65 years (p < 0.001, ANOVA), and low BMI (p < 0.001, ANOVA) have been found to be significant risk factors for patients requiring a transfusion. Preoperative blood results of low haemoglobin (p < 0.001, ANOVA), packed cell volume (p < 0.001, ANOVA), sodium (p < 0.001, ANOVA), and eGFR (p < 0.001, ANOVA) were also noted as significant factors predicting a need for transfusion postoperatively.

Length of stay, readmission, and reoperation. At one year, readmission (p = 0.820, ANOVA) and reoperation (p = 0.734, ANOVA) were not found to be significant between

groups, but length of stay ($p < 0.001$, ANOVA) was significant between groups postoperatively (Table II).

ROC analysis. A further ROC analysis was performed for the age of the patient. The cut off was set at 65 years with a sensitivity of 100% and specificity of 23%. The area under the curve (AUC) was 0.661 (95% CI 0.572 to 0.750), which was deemed significant ($p = 0.013$). Similar ROC analysis was performed for age and anaemia ($p = 0.0629$), BMI and anaemia ($p = 0.620$), preoperative ferritin and anaemia ($p = 0.837$), units transfused and anaemia ($p = 0.388$), estimated blood loss and anaemia ($p = 0.317$), BMI and AKI ($p = 0.098$), units transfused and AKI ($p = 0.623$), and estimated blood loss and AKI ($p = 0.326$); all were deemed as insignificant (Table III).

Discussion

Only 444 (16.3%) patients of the cohort had abnormal postoperative blood tests. This highlights that the incidence of postoperative blood test abnormalities following elective TJR is low. Patients who were aged ≥ 65 years, female, had a low BMI, or had an ASA grade of ≥ III were more likely to have abnormal test results. These risk factors should be interpreted along with the clinical context of each individual case to decide on the need for postoperative blood tests. Preoperative haemoglobin values of ≤ 127 g/l and haematocrit ≤ 0.395 l/l are predictive of postoperative anaemia. Meanwhile, a hypokalaemia of ≤ 3.7 mmol/l is predictive of postoperative AKI.

This study sample comprised a wider range of patients in terms of age and complexity, and had comparable incidences of abnormal test results to other studies, which reported figures that ranged from 11.6% to 27.9%.[27,28] The majority of patients were reported to have had test results within the normal range, which explains why the utility of such tests is heavily debated.[3,12,27-34] The data did not allow for subgroup analysis of individual comorbidities. However, we found that a significantly higher number of patients in the abnormal postoperative blood test group were of an ASA grade of ≥ III ($p = 0.003$) and were aged ≥ 65 years ($p < 0.001$).[20] Our findings were concordant with Garg et al,[3] who reported that patients who had an ASA grade ≤ IIand were aged ≤ 70 years were more likely to have uneventful blood test results. Multiple studies have proven that the female sex is a significant predictor of abnormal postoperative blood results, and this was further supported by our data ($p < 0.001$).[34-38] However, Howell et al[35] argue that the females who required transfusion in their study had other contributing risk factors and therefore, in otherwise fit female patients, routine ordering of blood tests may not be necessary.

Patients with chronic kidney disease (CKD) are thought to be at greater risk of developing an AKI during the perioperative period.[32,39,40] Greco et al[34] further support that hypokalaemia is a risk factor for AKI. Our data, surprisingly, did not show an association between preoperative creatinine and the risk of an AKI. The clinical significance of a given drop in renal function, however, is likely to be higher if the starting point is already low. The need for postoperative blood tests in these patients should be guided by clinical judgement and the severity of CKD.

Only 67 (2.5%) patients in our study group required a transfusion, which was similar to other studies.[27,28,35] However, only three of these 67 patients had a haemoglobin of 80 or less. In addition to low haemoglobin and haematocrit contributing to a higher risk of transfusion, Wu et al[28] report that hypoalbuminemia and a longer operating time could also be predictive risk factors. Our routine practice does not include liver function testing and albumin, unless risk factors exist, ergo these were not analyzed. It is widely accepted that a low preoperative haemoglobin leads to an increased risk of needing transfusion.[3,27,28,34,35] Greco et al[34] advise that routine postoperative tests should be requested for patients with a preoperative haemoglobin of less than 130 g/l. Our analysis recommends a slightly lower threshold of 127 g/l to warrant such tests. However, using a much larger study sample of n = 8,582, Dhiman et al[8] report a risk as low as 0.1% for developing severe anaemia of Hg < 70 g/l, which suggests that these tests may not be indicated after all.

Hyponatraemia was the most common abnormal postoperative blood result with an overall incidence of 12.2%. Hyponatraemia, either in isolation or in combination with another abnormal result, contributed to 333 (75%) of the 444 (16.3%) patients with an abnormal blood result. Halawi et al[27] reported similar findings, with 78% of their abnormal test results being due to electrolyte abnormalities. Studies have shown that, although scarcely reported, hyponatraemia is as common as 20% in TJR patients.[41] Macdonald et al[42] believe that postoperative hyponatraemia is common and rarely warrants clinical intervention, as long as the patient is clinically well. It is our usual practice to discontinue routine intravenous fluids at the end of surgery. The risk of a severe iatrogenic electrolyte abnormality is likely to be higher in patients receiving prolonged postoperative intravenous fluids, and these patients should be monitored accordingly.

In our unit, we have formulated a model and implemented it in terms of postoperative blood testing. A preoperative haemoglobin value of ≤ 127 g/l, blood loss of > 300 ml, and symptomatic ischaemic heart disease should have a HemoCue test or a full blood count. If HemoCue-estimated value is < 90 g/l, then a full blood count should be performed. A second Group & Save (G&S) can be sent postoperatively, ifthere is blood loss of > 300 ml or clinical concern. In terms of postoperative urea and electrolytes (U&Es), those should be performed in ASA grades III or IV, cases of preoperative CKD (eGFR <

60), where the surgeon or anaesthetist expresses clinical concern.

Postoperative FBC and second G&S would have been unnecessary in 2,209 (81.2%) patients and postoperative U&Es would have been unnecessary in 2,265 (83.2%) patients undergoing TJRs, if we used our approach. In 2019 alone, there were 95,677 THAs and 103,617 TKAs performed in the UK.[43] This amounts to 161,827 postoperative FBCs and second G&Ss, as well as 165,813 postoperative U&Es, of which results could be reasonably predicted from our model. This could have led to a national savings of about £6,703,816.6. A change in practice in laboratory testing during the perioperative period has the potential to serve as a major cost containment measure while maintaining safe evidence-based patient care.[35] Pre-surgery optimization, ERAS and modern rehabilitation techniques allow for elective TJRs to be done as a day-case procedure, minimizing the risks of hospitalization. Our study aims to add to the body of evidence that will inform clinicians of the patient-specific risk factors for abnormal postoperative blood results, thereby guiding their decision when ordering investigations that have the potential to delay discharge unnecessarily, when normal. We hope that this leads to cost-effective care, minimal patient discomfort, and fewer delays in care or discharge.

The limitations of this study include its 1) retrospective nature; 2) the lack of a standardized algorithm in practice, i.e. non-uniform practices in response to abnormal blood results; 3) a sample size that was limited to TJRs performed in one institution; 4) the combined analysis of THAs and TKAs, as no significant difference was noted between groups, although this might not be the observed in different institutes; 5) the use of a blood loss formula that can potentially underestimate blood loss volume; and 6) the lack of generalizability of the TJR procedure itself, i.e. approach, prosthesis used. The latter was down to the operating surgeon's preference.

In conclusion, routine postoperative blood tests should not be compulsory for every patient following a unilateral, primary hip or knee arthroplasty. Clinicians should have a lower threshold for ordering routine postoperative blood tests for patients with abnormal preoperative haemoglobin (≤ 127 g/l), blood loss > 300 ml, CKD, ASA grade ≥ III, and clinical concern.

Take home message

- Routine postoperative blood tests should not be compulsory for every patient following a unilateral primary hip or knee arthroplasty.
- Clinicians should risk-stratify their patients using preoperative blood tests, blood loss, and clinical concern.

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- This was a retrospective study and only anonymised data previously acquired as part of the patient workup or for service evaluation purposes were used. Ethics approval was not required as data gathering is performed routinely as part of our service. Hence, an institutional approval (2122_014) was obtained from our centre's Clinical Audit Registration and Management Systems (CARMS).

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