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Original Research

Routine Postoperative Hemoglobin and Hematocrit Tests Are Unnecessary Following Primary Total Hip and Knee Arthroplasty

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ABSTRACT

Background: Acute blood loss and transfusion are recognized risks factors of total hip (THA) and total knee arthroplasty (TKA). This study aimed to investigate the clinical value of immediate postoperative hemoglobin and hematocrit (H&H) tests following primary elective THA and TKA.

Methods: This retrospective observational study was undertaken at a single academic hospital. Medical records were reviewed for a consecutive series of patients undergoing primary elective THA and TKA over a 12-month period. Patient demographic data; the use of preoperative anticoagulants; preoperative and postoperative blood test results; and the incidence of postoperative allogenic blood transfusion (ABT) were collected. The primary outcome measure was the incidence of postoperative ABT prescribed in response to the immediate postoperative H&H result.

Results: Overall, 367 eligible patients were included, with 167 THA (46%) and 200 TKA (54%) cases. Only 3 patients (0.8%) received a postoperative ABT; none on the day of surgery or on postoperative day 1. Immediate postoperative H&H tests were drawn in 246 patients (67%), but it did not influence clinical decision-making with regards to transfusion. No significant differences in ABT were observed in relation to patient age, sex, body mass index, operation (THA or TKA), or the use of preoperative anticoagulation medication. The incidence of ABT was significantly higher in patients with a combined preoperative hemoglobin <12.5 g/dL and hematocrit <40.0% ($P = .003$).

Conclusions: The incidence of postoperative blood transfusion following primary elective THA and TKA was low at 0.8%. Postoperative H&H tests were drawn in most patients but did not influence clinical management. Immediate postoperative hematological monitoring is unnecessary for most low-risk patients following uncomplicated primary elective THA and TKA.

Introduction

Primary total hip (THA) and total knee arthroplasty (TKA) procedures are highly successful and common operations [1,2]. In 2019, the Centers for Medicare & Medicaid Services data reported an annual volume of 480,958 TKA and 262,369 THA procedures, with combined volumes estimated to reach almost 2 million cases by 2040 in the United States [3]. Acute blood loss and transfusion are recognized risk factors when undertaking primary THA and TKA. Preoperative patient screening and optimization combined with advances in the medical management of perioperative blood loss, improvements in surgical techniques and technology, and emerging evidence for decreasing transfusion thresholds have all helped to significantly reduce the incidence of blood transfusions in patients undergoing elective THA and TKA [4-8]. However, despite these multi-faceted advances in the medical and surgical management of blood loss, routine postoperative hematological monitoring has remained common practice following primary elective THA and TKA. This may be due to the historically high incidence of blood transfusion following THA and TKA, with figures ranging from 15% to 68% [9-12]. Hemoglobin and hematocrit (H&H) blood tests are frequently used in the early postoperative period to establish a baseline estimation of blood loss and identify patients

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with acute anemia. With an ever-increasing emphasis on healthcare economics, it is important to judiciously use investigations that provide clinical value while maintaining patient safety. Previous research has challenged the practice of routinely obtaining type and screens in elective primary THA and TKA, which may ultimately lead to cost-efficiency savings [8,13–15]. The primary aim of this study was to investigate the clinical value of obtaining immediate postoperative H&H tests following primary elective THA and TKA. A secondary goal was to determine the potential cost-efficiency savings by discontinuing this practice.

Material and methods

This retrospective observational study was undertaken at a single academic center. Institutional board review approval was granted for this study. A consecutive series of patients undergoing primary elective THA and TKA performed under the supervision of 3 fellowship-trained surgeons over a 12-month period from January 1, 2023, to December 31, 2023, were included. Exclusion criteria included any surgery performed for acute or traumatic conditions (such as proximal femoral fractures), hip hemiarthroplasties, revision THA/TKA, conversion arthroplasties with removal of hardware, and patients with transfusion-dependent conditions. All patients receiving anticoagulation therapy (including coumadin, direct oral anticoagulants, and low-molecular-weight heparins) had these medications suspended and/or bridged preoperatively following recommendations from the preoperative medical evaluation and/or anticoagulation clinics. Each patient received 2 g of tranexamic acid (TXA) preoperatively, and unless contraindicated, also a periarticular cocktail containing ropivacaine, epinephrine, and ketorolac, which was injected prior to wound closure. Prior to conducting this study, H&H tests were routinely included in the postoperative order set for all patients undergoing primary elective THA and TKA. However, these orders are placed at the discretion of individual providers, and therefore, not all patients undergo these investigations. The transfusion guidelines used at this institution include a hemoglobin (Hb) threshold of $\leq$7.0 g/dL in a hemodynamically stable patient who is not actively bleeding, or $\leq$8.0 g/dL in patients with stable coronary artery disease, end-organ ischemia, or with symptomatic postoperative anemia. However, clinical judgment, shared decision-making, and informed patient consent were used for all patients who were prescribed a postoperative red blood cell transfusion.

Electronic medical records were reviewed and patient data collected for demographics (age, sex, and body mass index); operative details; the use of preoperative anticoagulation; perioperative blood test results; the incidence, timing, and quantity of postoperative allogenic red blood cell transfusions (ABT); and overall length of inpatient stay. The perioperative blood test results collected included Hb and hematocrit (HCT) levels obtained preoperatively within 30 days of surgery and postoperatively on days 0 and 1. The primary outcome measure was the incidence of postoperative ABT prescribed in response to the H&H result. The secondary outcome measure was to quantify potential cost-efficiency savings by eliminating the immediate postoperative H&H blood test for all patients who underwent this investigation in this study. Patients were grouped according to their postoperative transfusion status, and statistical analysis was performed for each metric in relation to this status. Descriptive statistics were used to report group metrics, with age, BMI, Hb, and HCT data presented in both continuous and categorical formats. Patient length of stay (LOS) was recorded in integers of single days (24-hour periods) and categorized into 3 groups: less than or equal to 1 day ($\leq$24 hours), 2-3 days ($\geq$24 to $\leq$72 hours), and greater than 3 days (>72 hours). The normality of data distribution was not assumed, and non-parametric statistical tests were used for analysis. Wilcoxon rank sum tests were used to analyze continuous data for the 2 groups, and Pearson's chi-squared test or Fisher's exact test was used to analyze categorical data. The significance threshold was set at 0.05 for all statistical analyses. Statistical analysis and graphical visualization were performed using RStudio (RStudio Team (2023): Integrated Development for R. RStudio, PBC, Boston, MA).

Results

Patient demographics and postoperative ABT requirements

Summary descriptive statistics for patient demographics results are outlined in Table 1. A total of 367 patients were eligible for inclusion in this study, with 200 TKA (54%) and 167 THA (46%) cases. There were 211 female (57%) and 156 male (43%) patients, with an overall mean average age of 67.5 years (standard deviation [SD] 9.9) and BMI of 29.8 kg/m^2 (SD 6.2). Sixty patients (16%) were prescribed regular anticoagulation medications preoperatively.

Only 3 patients received a postoperative ABT: 2 following THA (1.2%) and one following TKA (0.5%), amounting to a cumulative transfusion incidence of 0.8% (Table 2). No patients received an ABT on postoperative day (POD) 0 or 1, or specifically in response to the immediate postoperative H&H test result. Within the group of 3 patients who received an ABT, 2 were transfused on POD 2, and one on POD 3. One patient had symptomatic anemia, and 2 were clinically asymptomatic. Two patients received 1 unit of packed red blood cells, and one patient received 3 units with a mean of 1.7 units transfused per patient. A thigh tourniquet was used in the single patient who received an ABT following TKA (patient #1 in Table 2). This patient had a history of breast cancer and previous macrocytic anemia. The 2 patients who received ABT following THA underwent a procedure using the postero-lateral approach. One of these patients (patient #2 in Table 2) had a history of chronic kidney disease with associated anemia and was also receiving long-term immunosuppression (mycophenolate mofetil) for interstitial lung disease. The other (patient #3 in Table 2) underwent a simultaneous gluteus maximus transfer following THA for chronic

Table 1
Summary patient demographics and the use of anticoagulation medications.

Postoperative transfusion	Overall, N = 367[a]	No, N = 364[a]	Yes, N = 3[a]	*P*-value[b]
Operation				.6
THA	167 (46%)	165 (45%)	2 (67%)	
TKA	200 (54%)	199 (55%)	1 (33%)	
Gender				.3
Female	211 (57%)	208 (57%)	3 (100%)	
Male	156 (43%)	156 (43%)	0 (0%)	
Age	67.5 (9.9)	67.5 (10.0)	73.2 (2.6)	.3
Age category				.4
<60 y	74 (20%)	74 (20%)	0 (0%)	
60-70 y	127 (35%)	127 (35%)	0 (0%)	
70-80 y	132 (36%)	129 (35%)	3 (100%)	
>80 y	34 (9%)	34 (9%)	0 (0%)	
BMI	29.8 (6.2)	29.8 (6.2)	28.8 (4.4)	.9
BMI category				>.9
Underweight	4 (1%)	4 (1%)	0 (0%)	
Normal	77 (21%)	76 (21%)	1 (33%)	
Overweight	123 (34%)	122 (34%)	1 (33%)	
Class 1 obesity	85 (23%)	84 (23%)	1 (33%)	
Class 2 obesity	50 (14%)	50 (14%)	0 (0%)	
Class 3 obesity	28 (8%)	28 (8%)	0 (0%)	
Preoperative anticoagulation	60 (16%)	60 (16%)	0 (0%)	>.9

BMI, body mass index; THA, total hip arthroplasty; TKA, total knee arthroplasty.
[a] n (%); mean (SD).
[b] Fisher's exact test; Wilcoxon rank sum test.

Table 2
Transfused cohort perioperative data.

Patient	Age/Gender	ASA class	Preoperative Hb (g/dL)	POD 0 Hb (g/dL)	Change in Hb (g/dL)	BMI (kg/m^2)	POD transfused	Units ABT transfused	Bleeding disorder present?	Operation
1	75 F	2	12.2	11.0	−1.2	24.3	2	3	No	Primary TKA
2	70 F	3	11.1	10.7	−0.4	33.0	3	1	No	Primary THA
3	73 F	2	12.4	8.9	−3.5	29.0	2	1	No	Primary THA + gluteus maximus transfer
Mean	73.2	-	11.9	10.2	−1.7	28.8	-	1.7	-	-

ABT, allogenic blood transfusion; ASA, American Society of Anesthesiologists; Hb, hemoglobin; POD, postoperative day.

abductor insufficiency, which resulted in increased intraoperative blood loss. No significant group-wise differences in ABT were observed in relation to the type of operation (THA or TKA), patient sex, age, BMI, or the use of preoperative anticoagulation. No patients who were routinely prescribed anticoagulation medications preoperatively required a postoperative ABT.

Perioperative blood test results

Summary descriptive statistics for patient perioperative blood test results are outlined in Table 3. The overall mean preoperative Hb was 13.8 g/dL (SD 1.5), with significantly lower values observed for patients who received postoperative ABT than for those who did not receive transfusions (11.9 g/dL [SD 0.7] vs 13.9 g/dL [SD 1.5], respectively, $P = .018$). A significant difference in the incidence of postoperative ABT was observed between groups based on a preoperative Hb threshold of 12.5 g/dL ($P = .004$).

The mean preoperative HCT was 42.4% (SD 4.1), with significantly lower values observed for patients who received postoperative ABT than for those who did not receive transfusions (37.0% [SD 1.2] vs 42.5% [SD 4.1], respectively, $P = .016$). A preoperative HCT threshold of under 40.0% was associated with a significantly increased incidence of receiving a postoperative ABT ($P = .015$). Combined categorical thresholds in preoperative Hb <12.5 g/dL and HCT <40.0% were associated with a significantly increased incidence of postoperative ABT ($P = .003$; Figure 1).

Immediate postoperative H&H tests were performed in 246 patients (67%), but no significant differences were observed in the incidence of ABT in relation to this test ($P = .6$). The mean POD 0 Hb was 12.7 g/dL (SD 1.5), with significantly lower values observed in patients who went on to receive ABT than in those who did not (10.2 g/dL [SD 1.1] vs 12.8 g/dL [(SD 1.5], respectively, $P = .009$). The mean POD 0 HCT was 38.5% (SD 4.4), with significantly lower values observed in patients who went on to receive ABT than in those who did not (31.4% [SD 4.0] vs 38.6% [SD 4.3], respectively, $P = .013$).

The mean perioperative Hb change between preoperative and POD 0 values was −1.2 g/dL (SD 1.2), with no significant differences observed between patients who received postoperative ABT and those who did not (−1.7 g/dL [SD 1.6] vs −1.2 g/dL [SD 1.2], respectively, $P = .7$).

POD 1 CBC tests were performed in 324 patients (89%) as 40 patients were discharged on the same day of surgery. Significantly lower Hb and HCT values were observed on POD 1 in the patients who subsequently received an ABT (Hb 8.0 g/dL [SD 1.0] and HCT 24.5% [SD 3.7]) in comparison to those who did not (Hb 11.3 g/dL [SD 1.6] and HCT 34.0% [SD 4.4], $P = .005$ and $P = .006$, respectively).

Table 3
Summary descriptive statistics for patient perioperative blood test results.

Postoperative transfusion	Overall, N = 367[a]	No, N = 364[a]	Yes, N = 3[a]	*P*-value[b]
Preoperation				
Preoperative Hb (g/dL)	13.8 (1.5)	13.9 (1.5)	11.9 (0.7)	**.018**
Preoperative Hb category				**.004**
>12.5 g/dL	306 (83%)	306 (84%)	0 (0%)	
<12.5 g/dL	61 (17%)	58 (16%)	3 (100%)	
Preoperative HCT (%)	42.4 (4.1)	42.5 (4.1)	37.0 (1.2)	**.016**
Preoperative HCT category				**.015**
>40%	276 (75%)	276 (76%)	0 (0%)	
<40%	91 (25%)	88 (24%)	3 (100%)	
Combined Hb & HCT categories				**.003**
Hb >12.5 g/dL & HCT >40%	311 (85%)	311 (85%)	0 (0%)	
Hb <12.5 g/dL & HCT <40%	56 (15%)	53 (15%)	3 (100%)	
Postoperative day 0				
Postoperative day 0 HH drawn	246 (67%)	243 (67%)	3 (100%)	.6
Postoperative day 0 Hb (g/dL)	12.7 (1.5)	12.8 (1.5)	10.2 (1.1)	**.009**
Postoperative day 0 HCT (%)	38.5 (4.4)	38.6 (4.3)	31.4 (4.0)	**.013**
Perioperative Hb change (g/dL)	−1.2 (1.2)	−1.2 (1.2)	−1.7 (1.6)	.7
Postoperative day 1				
Postoperative day 1 CBC drawn	327 (89%)	324 (89%)	3 (100%)	>.9
Postoperative day 1 Hb (g/dL)	11.3 (1.6)	11.3 (1.6)	8.0 (1.0)	**.005**
Postoperative day 1 HCT (%)	33.9 (4.5)	34.0 (4.4)	24.5 (3.7)	**.006**

CBC, complete bloood count; Hb, hemoglobin; HCT, hematocrit; HH, hemoglobin & hematocrit.
Bolded values indicate statistical significance ($P < .05$).
[a] Mean (SD); n (%).
[b] Wilcoxon rank sum test; Fisher's exact test.

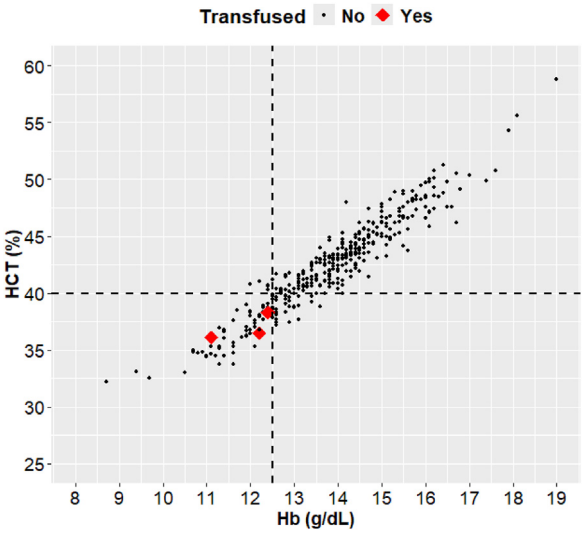

Figure 1. Scatterplot demonstrating the relationship between preoperative hemoglobin (Hb) and hematocrit (HCT) results and the incidence of postoperative transfusions (highlighted in red). The dashed lines represent the thresholds of Hb (12.5 g/dL) and HCT (40.0%), which were associated with a higher incidence of postoperative transfusions.

Patients' LOS in relation to transfusion status

A significant difference in postoperative LOS was observed in relation to the patients' transfusion status ($P < .007$; Table 4). All patients who received a postoperative ABT had a LOS of 2-3 days (n = 3). Most patients who did not receive an ABT had a LOS under ≤1 day (n = 303), with significantly less experiencing an LOS of 2-3 days (n = 50) or ≥3 days (n = 11).

Potential cost-efficiency savings

We determined the potential cost savings of omitting the immediate postoperative H&H test by multiplying the cost per test provided by the financial department of our institution by the number of patients who underwent this test in our cohort. The reimbursement cost per H&H test was quoted as $97, which when multiplied by the 246 patients (67%) who underwent this test gave a total potential cost saving of approximately $23,862 per annum.

Discussion

Postoperative hematological monitoring has become routine in many hospitals due to historically high transfusion rates following elective primary TKA and THA. Recent studies have reported a significant decrease in the incidence of ABTs following these procedures of approximately 1-2%, which are consistent with the findings of this study [4-8]. The significant temporal changes observed in the incidence of postoperative transfusions are the result of incremental improvements in surgical technique, perioperative care and patient optimization, enhanced pharmacological management of bleeding, and an improved understanding of transfusion thresholds. These emerging evidence-based strategies have led to an improved understanding in how to safely monitor the hematological status of surgical patients while minimizing the use of perioperative investigations of low clinical value [16-19].

Table 4
Day of transfusion and in-patient length of stay.

Postoperative transfusion	Overall, N = 367[a]	No, N = 364[a]	Yes, N = 3[a]	*P*-value[b]
Length of stay (days)				**.007**
≤1 d	303 (83%)	303 (83%)	0 (0%)	
2-3 d	53 (14%)	50 (14%)	3 (100%)	
≥3 d	11 (3%)	11 (3%)	0 (0%)	

Bolded values indicate statistical significance ($P < .05$).
[a] Mean (SD); n (%).
[b] Wilcoxon rank sum test; Fisher's exact test.

Perioperative blood-management strategies in patients undergoing elective THA and TKA may be broadly divided into 3 stages: preoperative, intraoperative, and postoperative. These strategies rely upon effective and continuous multidisciplinary team engagement through the patients' perioperative care pathway, from the preoperative clinic to the anesthetic and surgical departments and other consulting hospital specialties. Preoperative hematological screening is justified to determine the baseline Hb and screen for anemia. If anemia is discovered, further workup is recommended to determine the etiology and guide further preoperative treatment and optimization. Iron supplements and erythropoietin are common options for optimizing Hb levels in preparation for surgery [20]. Guidelines for the perioperative management of anticoagulation medications should be established and followed to reduce the risk of intraoperative bleeding. Interestingly, none of the 60 patients (16%) in this study who were prescribed regular anticoagulation medications preoperatively required a postoperative ABT. This finding highlights the effectiveness and importance of adhering to preoperative guidelines regarding the administration of anticoagulation medication.

Intraoperative bleeding may be influenced by the surgical complexity, approach, the use of antifibrinolytic medications, type of anesthesia, and several patient factors [20]. Tourniquets are frequently used in TKA, but recent evidence suggests that these may not reduce blood loss [21,22]. Techniques including cell salvage may also be utilized intraoperatively to manage acute intraoperative blood loss [20]. The routine use of TXA administered intravenously, topically, and/or orally is now widely recognized to decrease the incidence of postoperative transfusion following total joint arthroplasty [20]. Numerous studies have reported on the profoundly positive impact that TXA has in reducing perioperative blood loss and transfusion requirements following total joint arthroplasty, and its use has been incorporated into clinical practice guidelines which have been endorsed by multiple professional societies [23-25].

Within our institution, patients undergo a comprehensive preoperative evaluation and optimization of medical comorbidities within a dedicated clinic staffed by anesthesiologists, internists, and perioperative nurse practitioner specialists. Cardiovascular, pulmonary, and hematologic risk factors are assessed, and laboratory investigations conducted which include a complete blood count, basic metabolic panel, and coagulation studies. All patients receive a standard 2-g dose of intravenous TXA preoperatively in addition to weight-based dosing of local periarticular injection containing ropivacaine, epinephrine, and ketorolac. Blood products are given in accordance with evidence-based Hb thresholds of <7.0 g/dL and <8.0 g/dL for patients with a cardiovascular disease. Our results indicate that patients at higher risk of receiving postoperative transfusion may be identified preoperatively using Hb and HCT thresholds of <12.5 g/dL and <40.0%, respectively. Future studies may help to generate more sensitive and specific predictive models that can be implemented in the preoperative period to help identify patient risk factors associated with higher incidences of postoperative transfusion.

No patient within our study received an emergent postoperative blood transfusion. The clinical value of obtaining an immediate

postoperative H&H test on the day of surgery is therefore questionable. Most patients were discharged from hospital within 24 hours of surgery (n = 303, 83%), and postoperative hematological monitoring in this majority subgroup may be unnecessary. These findings may have implications for the perioperative care pathways used in ambulatory surgical centers that provide outpatient THA and TKA surgery services for low-risk patients. With certain exceptions, the routine use of postoperative hematological monitoring in these settings may be unnecessary, and consideration should be given by supervising physicians for excluding these tests from standard postoperative orders. Selective postoperative hematological monitoring may be most appropriate in patients with recognized preoperative clinical or laboratory risk factors, or in those who experience other perioperative complications such as excessive intraoperative blood loss or duration of surgery.

The economic benefit of discontinuing regular postoperative monitoring was another consideration in this study. Immediate postoperative H&H tests obtained in the recovery room were drawn in 67% of patients but did not influence clinical management regarding transfusion. At a cost of $97 per test, we propose that these tests are unnecessary and would result in savings of $23,862 per annum within a single academic hospital orthopedic department. Extrapolating these findings nationally would result in significant cost savings for patients undergoing elective primary THA and TKA. Given recent trends toward value-based healthcare and bundle payments, this change would optimize the utilization of healthcare resources while decreasing costs and not compromising patient safety.

This exploratory study has several limitations, most notably its retrospective design from a single institution, which increases the risk of selection bias and may limit the wider applicability of the findings to other centers. Another limitation is the relatively small overall number of patients included and low incidence of postoperative blood transfusions identified. This limits the power of this study to confidently identify specific variables associated with an increased risk of postoperative blood transfusion using statistical techniques such as multivariate logistic regression analysis. Further large-scale prospective studies investigating the risk factors associated with increased transfusion risks in patients undergoing elective major joint replacement surgery may help to address this particular limitation.

Conclusions

Immediate postoperative H&H tests were performed in most patients undergoing primary elective TKA and THA but did not influence clinical management regarding transfusion. We report an overall low incidence of postoperative ABT of 0.8% in patients following elective primary THA and TKA performed in an academic hospital setting. No patient received an emergent transfusion on the day of surgery or on POD 1. Patients with a combined preoperative Hb <12.5 g/dL and HCT <40.0% are at higher risk of transfusion. No significant associations were observed in the incidence of postoperative transfusions in relation to the type of operation (THA or TKA), patient sex, age, BMI, or the use of preoperative anticoagulation. Postoperative hematological monitoring may be indicated for high-risk patients, or those who remain in hospital for over 24 hours following surgery. At a cost of $97 per test, we propose that immediate postoperative H&H tests are unnecessary in most patients. Cessation of these tests may result in a cost saving of approximately $23,862 per annum within a single hospital department and may therefore result in substantial cost-efficiency savings when extrapolated nationally.

Conflicts of interest

Mark J. Spangehl, MD, serves as an Associate Editor to the *Arthroplasty Today* journal and will have to be recused from peer review and any editorial decisions; has stock or stock options in Sonoran Biosciences; and receives research support from Stryker and DePuy Synthes. Henry D. Clarke receives royalties from Restor3D/ConforMIS, Zimmer-Biomet, and Aspire-ISE/Optimus; is a paid consultant for Restor3D/ConforMIS and Zimmer-Biomet; is an unpaid consultant for OSSO VR; has stock or stock options in Aspire-ISE/Optimus; is a board member in AAOS, Knee Society, and AAHKS. All other authors declare no potential conflicts to disclose.

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CRediT authorship contribution statement

Daniel J. Howgate: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Roman P. Austin:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Joshua S. Bingham:** Writing – review & editing, Supervision, Conceptualization. **Mark J. Spangehl:** Writing – review & editing, Supervision, Conceptualization. **Henry D. Clarke:** Writing – review & editing, Supervision, Conceptualization.

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