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Risk factors associated with blood transfusion after shoulder arthroplasty

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Background: Closed-suction drainage has been studied extensively in hip and knee arthroplasty literature. However, little is known about outcomes in patients treated with drainage after shoulder arthroplasty, particularly relative to transfusion requirements.
Methods: All primary total and reverse total shoulder arthroplasties (TSAs and RSAs) performed at a single institution during a 5-year period were retrospectively reviewed. Data collected included patient demographic information, estimated blood loss (EBL), drain output, length of drain use, changes in hemoglobin (Hgb) level postoperatively, transfusions, and complications. A multivariable regression analysis was performed to identify independent risk factors for transfusion.
Results: There were no differences in surgery duration, EBL, or complications between TSA and RSA patients ($P > .05$). Patients undergoing RSA were older (74.0 vs. 68.4 years; $P < .001$) and had lower preoperative and postoperative Hgb levels ($P < .001$) compared with TSA patients. Reverse arthroplasty was also associated with longer hospital stays (2.8 vs. 2.2 days; $P < .001$), longer drain durations (1.6 vs. 1.2 days; $P < .001$), increased total wound drainage (209 vs. 168 m; $P = .006$), and higher transfusion rates (11.7% vs. 3.1%; $P = .002$). Independent risk factors for transfusion included low preoperative Hgb levels in both TSA ($P = .024$) and RSA ($P = .002$) and higher EBL in TSA ($P = .031$).
Conclusion: Low preoperative Hgb level is an independent risk factor for requiring blood transfusion after TSA and RSA. Increased wound drainage was not a risk factor for transfusion, and the 40-mL increase in wound drainage found in RSA is of questionable clinical significance.

Theoretical benefits of closed-suction drainage in orthopedic surgery include reduction in hematoma and effusion formation, improved healing, and reduced infection risk.[1,14,21,30] However, drain use has also been correlated to increased blood transfusion and infection risks postoperatively without providing clear wound healing benefits.[5,27-29] In hip and knee arthroplasty, significant research has been undertaken to better clarify the clinical impact of closed-suction drainage. Interestingly, such an intense level of research has not been applied to patients undergoing shoulder arthroplasty. Given routine use of drains in many of these patients,[9,17,19] research regarding the impact of drain use is warranted.

Transfusion in shoulder arthroplasty has garnered significant attention in recent years. A national epidemiologic study of shoulder arthroplasties, including total shoulder arthroplasty (TSA) and reverse total shoulder arthroplasty (RSA), revealed an overall blood transfusion rate of 6.7%.[22] The same study cited a number of prior investigations to determine that there is a large range of blood transfusion rates published in the literature: 4.3% to 43%.[2,11,13,18,22,24,26] Multiple independent risk factors for blood transfusion in shoulder arthroplasty have been identified in these studies and include advanced age, female gender, low preoperative hemoglobin (Hgb) level, race, implantation of RSA, and increased estimated blood loss (EBL). Furthermore, Hardy et al found a higher frequency of postoperative drain use in patients requiring transfusion in a heterogeneous population of shoulder arthroplasty patients but did not report on which arthroplasties investigated (TSAs, RSAs, hemiarthroplasties, and revision arthroplasties) received a drain or on the amount of postoperative drain output.[13] As such, to our knowledge, no study has specifically investigated the risk of drain output on postoperative blood transfusion among a homogeneous group of patients.

The goal of this study was 2-fold; we sought to provide descriptive data comparing closed-suction drainage in TSA and RSA and to confirm and further identify factors associated with transfusion

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requirement after TSA and RSA. We hypothesized that patients undergoing RSA would have higher amounts of drain output than patients undergoing TSA and that patients with increased amounts of drainage postoperatively would have a higher likelihood of requiring a blood transfusion.

Materials and methods

All primary TSAs and RSAs performed between April 2009 and April 2014 at a single, tertiary care academic medical center were identified and retrospectively reviewed. Patients were selected from billing records identifying TSA and RSA patients by *Current Procedural Terminology* codes. Patients with complete records with respect to preoperative blood counts and blood collection into drainage canisters were included for review. Patients undergoing revision arthroplasty, hemiarthroplasty, or resurfacing or with incomplete records were excluded. Of the 448 arthroplasties performed during this time, 370 patients representing a total of 258 TSAs and 128 RSAs satisfied all inclusion and exclusion criteria. A combination of different implants was used, including arthroplasties from Arthrex (Naples, FL, USA), Zimmer (Warsaw, IN, USA), and Tornier (Bloomington, MN, USA). In our institution, closed-suction drainage is routinely used in shoulder arthroplasty with a 400-mL Davol closed wound suction evacuator (C.R. Bard, Inc., Covington, GA, USA). The drain was positioned deep to the deltopectoral interval with the suction tubing exiting laterally. Drains were removed when the output was <30 mL during a 12-hour period or at the attending orthopedic surgeon's discretion. All patients received postoperative deep venous thrombosis (DVT) prophylaxis with bilateral lower extremity Venodynes (Ecolab, St. Paul, MN, USA), early ambulation, and chemoprophylaxis, the standard of which consisted of aspirin 325 mg twice daily starting on postoperative day (POD) 1 for 2-4 weeks based on the surgeon's preference.

For each patient, the following data were collected: age, gender, procedure (primary TSA or RSA), preoperative and postoperative Hgb levels, length of surgery (determined by anesthesia records of time spent in the operating room), EBL as estimated by the attending orthopedic surgeon and anesthesiologist, hospital duration, drain output, and drain duration. Postoperative blood transfusion events as well as units transfused were noted as well. In addition, perioperative complications including superficial and deep infection, persistent wound bleeding or drainage, persistent swelling, ecchymosis, hematoma, wound dehiscence, DVT, pulmonary embolism, mortality, and reoperation within 1 year from the initial surgery were noted. The decision to transfuse postoperatively was clinically based and made by the treating surgical team along with medical consultation where appropriate.

Statistical analyses were performed using GraphPad Prism version 6.0e (GraphPad Software, San Diego, CA, USA) and R 3.1.2. Statistical significance was determined using a Student 2-tailed *t*-test when comparing the means of 2 or more groups or χ^2 test when analyzing continuous data. Multivariate logistic regression analyses were performed to identify risk factors associated with probability of transfusion in both TSA and RSA patients. Statistical significance was set at $P \leq .05$.

Results

A total of 370 arthroplasty patients (258 TSAs, 128 RSAs) were included in this study. Fifteen patients underwent bilateral TSA, and 1 patient underwent bilateral RSA. Demographic information for these patient groups can be found in Table I. Patients undergoing TSA were younger (68.4 vs. 74.0 years; $P < .001$) and more commonly male (49.2% vs. 29.7%; $P = .018$). There were no differences in surgical duration or EBL between the 2 groups. RSA was associated with a 0.6-day increase in length of stay ($P = .001$). Patients undergoing TSA had higher preoperative Hgb levels, 13.5 vs. 12.5 g/dL for RSA patients ($P < .001$; Table II). The average Hgb levels were also significantly lower in RSA patients immediately postoperatively (POD0) and on POD1 and POD2.

RSA patients had higher total wound drain output compared with TSA patients (209 vs. 168 mL; $P = .006$; Table III). The duration of drainage in RSA patients was 1.6 days compared with 1.2 days for TSA ($P < .001$). There were no differences in the drainage output recorded immediately postoperatively in the postanesthesia care unit.

The transfusion rates for TSA and RSA were 3.1% and 11.7%, respectively ($P = .002$; Table IV). There was no difference in the average number of units transfused or the timing of transfusion. When transfusions were excluded, there were a similar number of postoperative complications between both groups, 6.20% and 6.25% for TSA and RSA, respectively (Table V).

Comparisons were made between patients in each cohort who received a transfusion compared with those who did not (Table VI). TSA patients who required transfusions had an average preopera-

Table I
Patient demographic and surgical information

	TSA	RSA	*P* value
No. of patients	258	128	
Age, y	68.4 ± 10.36	74.0 ± 10.35	<.001*
Gender, male	49.2%	29.7%	.018*
Surgery duration, h	3.5 ± 0.7	3.4 ± 1.1	.301
EBL, mL	220.4 ± 162.3	243.1 ± 157.0	.192
Hospital duration, d	2.2 ± 0.4	2.8 ± 0.6	<.001*

TSA, total shoulder arthroplasty; *RSA*, reverse total shoulder arthroplasty; *EBL*, estimated blood loss.
Continuous variables are presented as mean ± standard deviation.

Table II
Measurement of baseline and postoperative hemoglobin levels

	TSA	RSA	*P* value
Preoperative	13.5 ± 1.7	12.5 ± 1.6	<.001*
POD0	12.0 ± 1.6	11.0 ± 1.6	<.001*
POD1	10.9 ± 1.4	10.0 ± 1.5	<.001*
POD2	10.7 ± 1.5	9.7 ± 1.4	<.001*

TSA, total shoulder arthroplasty; *RSA*, reverse total shoulder arthroplasty; *POD*, postoperative day.
Values are reported as hemoglobin levels (g/dL) ± standard deviation.

Table III
Closed-suction drainage data

	TSA	RSA	*P* value
Drain duration, d	1.2 ± 0.4	1.6 ± 0.6	<.001*
Total drain output, mL	167.6 ± 131	208.7 ± 149	.006*
Drain output recorded by PACU, mL	110.0 ± 76	107.4 ± 70	.768
Percentage of total drain output recorded in PACU	58.3%	54.1%	.184

TSA, total shoulder arthroplasty; *RSA*, reverse total shoulder arthroplasty; *PACU*, postanesthesia care unit.
Continuous variables are presented as mean ± standard deviation.

Table IV
Transfusion events

	TSA	RSA	*P* value
Patients transfused	8 (3.1%)	15 (11.7%)	.002*
Average number of units transfused	1.5 ± 0.5	1.7 ± 0.6	.364
Average POD of transfusions	1.0 ± 0.8	1.9 ± 1.6	.155

TSA, total shoulder arthroplasty; *RSA*, reverse total shoulder arthroplasty; *POD*, postoperative day.
Continuous variables are presented as mean ± standard deviation.

Table V
Perioperative complications

	TSA	RSA	
Superficial infection	0	0	
Septic joint	1	0	
Wound bleeding, swelling, or ecchymosis	10	2	
Hematoma	1	1	
Wound dehiscence	0	0	
DVT	0	1	
In-house mortality	1	0	
Reoperation within 1 y	3	4	
Total	16 (6.20%)	8 (6.25%)	$P = .842$

TSA, total shoulder arthroplasty; *RSA*, reverse total shoulder arthroplasty; *DVT*, deep venous thrombosis.

tive Hgb level of 10.7 g/dL, which was 2.9 g/dL lower than that of patients who did not receive a transfusion ($P < .001$). Transfusion in TSA patients was also associated with a 265.9-mL increase in EBL ($P < .001$; Table VI). For RSA, patients requiring transfusion were more commonly female (93.8%; $P < .039$) and also had a significantly lower preoperative Hgb level (11 vs. 12.7 g/dL; $P < .001$; Table VI). Age, drain duration, and total drain output had no significant effect on transfusion in either cohort. Transfusion resulted in an increased hospital duration of 1.2 days and 1.7 days for TSA and RSA, respectively.

Risk factors associated with an increased probability of postoperative blood transfusion in both TSA and RSA populations were determined using a multivariable logistic regression analysis and are presented in Tables VII and VIII, respectively. In both TSA and RSA, age, gender, surgical duration, and drain output were not found to affect transfusion. Preoperative Hgb level was an independent risk factor for transfusion in both TSA and RSA, $P = .024$ and $P = .002$, respectively. An increase of 1 unit in preoperative Hgb reduced the odds of postoperative transfusion by 92% in the population of TSA patients and by 53% in the population of RSA patients. In addition, EBL was found to be an independent risk factor for transfusion in TSA, such that 100 mL of intraoperative blood loss increased the odds of transfusion by 7.2 times compared with baseline ($P = .024$).

Discussion

One purpose of this investigation was to provide the first descriptive data on closed-suction drainage in homogeneous populations of TSA and RSA patients. In line with our hypothesis, we found that postoperative wound drainage after RSA is significantly greater than after TSA, 209 vs. 168 mL, respectively. An increase in drain output in patients with RSA is expected, given the resultant larger dead space from the procedure; however, it is unclear if this increase is clinically relevant.[8] We are not aware of any other studies documenting the relative difference in drainage between these 2 arthroplasty groups, and further research is warranted to indicate if this increase in drainage results in any significant clinical impact.

There is a stark contrast between the paucity of literature regarding drainage in shoulder arthroplasty and the numerous investigations on drain use in hip and knee arthroplasty. In the literature, several studies have reported no definitive clinical benefit with use of closed-suction drainage postoperatively, whereas many have documented detrimental outcomes and longer in-patient hospitalizations when drainage systems are employed.[3,6,7,10,12,15,20,25,27,31,32] Despite this, closed-suction drainage is routinely used after shoulder arthroplasty.[9,17,19] The only previously published study of drain use in shoulder arthroplasty was a prospective comparison of 300 open shoulder operations in 1997 by Gartsman et al.[9] Among the 3 treatment cohorts (open rotator cuff repair, open anterior stabilization, and arthroplasty), no difference was identified in hematoma formation, wound dehiscence, infection, transfusion, or return to the operating room based on drain use. In considering absolute output, the average drainage found in our study (160-200 mL) is similar to or less than the drainage reported in hip and knee arthroplasty studies (160-620 mL), further questioning the utility of drainage in shoulders.[3,16]

One chief concern with drain use is the increased risk for requiring a blood transfusion postoperatively.[27,31] As such, the second purpose of this investigation was to identify risk factors associated with transfusion in the TSA and RSA cohorts, with the hypothesis that increased drainage would lead to higher transfusion requirements. There was an overall transfusion rate of 6.0% among study patients, with higher rates found in patients undergoing RSA compared with TSA (11.7% vs. 3.1%). These rates are lower than the transfusion rates previously documented in the literature. For instance, a recent 2000-2009 study on transfusions in shoulder arthroplasties, which included but did not differentiate between TSA and RSA, using the National Inpatient Sample found an overall transfusion rate of 6.7%.[22] Others found rates of transfusion in TSA to be 4.3%,[2] 6.0%,[13] 21.8%,[18] and 38%.[11] Fewer studies have investigated RSA specifically, but transfusion rates of 18.0%[13] and 73.7%[11] have been documented.

In addition, our study was unique in that it segregated patients undergoing both TSA and RSA to determine relevant risk factors for requiring a transfusion postoperatively. Contrary to our hypothesis, drain output was not found to be an independent risk factor for postoperative blood transfusion. Instead, a decreased preoperative Hgb level was found to be the most significant independent risk factor for transfusion for patients undergoing both TSA and RSA. In our investigation, patients with a preoperative Hgb level of 10.7 to 11 g/dL appeared to be at higher risk for requiring blood transfusion after surgery. Furthermore, we found that an increase in just 1 unit of preoperative Hgb decreased the risk of a postoperative transfusion by 92% and 53% among TSA and RSA patients, respectively. This finding is clinically important as patients with low preoperative blood counts may warrant further preoperative workup or treatment to mitigate the risk for transfusion and closer postoperative monitoring. Moreover, consideration may be given for

Table VI
Subgroup analysis of patients undergoing transfusion and those who did not require transfusion

	TSA			RSA		
	No transfusion	Transfusion	*P* value	No transfusion	Transfusion	*P* value
Age, y	68.4 ± 10.3	68.9 ± 11.7	.882	73.8 ± 8.7	74.9 ± 19.3	.723
Gender, male	50%	25%	.282	32.7%	6.3%	.039*
Surgery duration, h	3.5 ± 0.7	3.6 ± 0.5	.776	3.4 ± 1.0	3.6 ± 1.5	.485
Hospital duration, d	2.1 ± 0.6	3.3 ± 1.3	<.001*	2.6 ± 2.2	4.3 ± 2.8	.008*
Total drain output, mL	171.3 ± 131	96.9 ± 67	.113	214.4 ± 150	165.5 ± 139	.234
Drain duration, d	1.2 ± 0.4	1.3 ± 0.4	.592	1.6 ± 0.5	1.7 ± 0.6	.514
Preoperative Hgb level, g/dL	13.6 ± 1.6	10.7 ± 1.5	<.001*	12.7 ± 1.5	11.0 ± 1.2	<.001*

TSA, total shoulder arthroplasty; *RSA*, reverse total shoulder arthroplasty; *Hgb*, hemoglobin.
Continuous variables are presented as mean ± standard deviation.

Table VII
Multivariable logistic regression for the probability of blood transfusion in the population of total shoulder arthroplasty patients

	OR	95% CI for OR	*P* value
Age, y	1.134	0.908-1.417	.268
Gender	27.860	0.298-2604.843	.151
Surgery duration, h	0.026	0.001-1.308	.068
EBL, 100 units	7.166	7.039-7.296	.031*
Total drain output, mL	0.974	0.944-1.005	.105
Preoperative Hgb level	0.008	0.000-0.526	.024*

OR, odds ratio; *CI*, confidence interval; *EBL*, estimated blood loss; *Hgb*, hemoglobin.

autotransfusion during surgery to obviate need for postoperative transfusion.

A number of prior studies have also attempted to identify specific factors that place patients at risk for transfusion after shoulder arthroplasty. For example, Ryan et al found certain characteristics of patients to be independently associated with transfusion, including age, gender, race, insurance status, presence of anemia, and comorbidity burden.[22] However, this large national epidemiologic study was unable to differentiate between TSA and RSA patients, which is a limitation, given the unique characteristics of each population of patients. For instance, in this study, RSA patients were significantly older, were more commonly female, and had lower preoperative Hgb levels. These 3 characteristics have been previously implicated as risk factors for transfusion in heterogeneous populations of shoulder arthroplasty patients[11,13,18,24,26] as well as in total knee and hip arthroplasty.[4,23] Thus, given the difference in characteristics between TSA and RSA patients, an assessment of independent risk factors for transfusion in a combined population may be of limited utility. On the other hand, in a study of 1922 TSA cases, Anthony et al retrospectively analyzed the National Surgical Quality Improvement Program database and found that patients with preoperative anemia, defined in their study as hematocrit <38%, were 3 times more likely to require a blood transfusion.[2] This study as well as the results of the current investigation did not find gender or age to be an independent risk factor for transfusion in TSA.

Finally, elevated EBL was found to be an independent risk factor for transfusion in TSA but not in RSA. Both Hardy et al and Millett et al have found high EBL to be predictive of transfusion among heterogeneous populations of shoulder arthroplasty patients.[13,18] Interestingly, Millett et al did not include EBL in their multivariate analysis because of the variability in reporting and relatively limited use of EBL as a predictive measure. We agree with the authors that EBL is of limited utility as a predictive measure unless strict prospective measures are followed, but we provided it in this analysis as it is still a variable that is routinely measured in surgery. However, its usefulness as a clinical predictor of transfusion requirement is limited until more accurate reflections of EBL are incorporated into the model.

This study does have certain important limitations. As it was a retrospective review, there were no protocols in place for deciding whether a patient needed a blood transfusion postoperatively. Prospective data collection would have benefited from such a protocol. However, such firm guidelines are not routinely used in daily practice, as input from the provider, medical consultants, and the patients themselves are typically required in initiating blood transfusion. Furthermore, preoperative Hgb levels were typically collected and reported in patient care centers where arthroplasty patients underwent routine preoperative testing. This testing was not done entirely at our institution. Therefore, variability in outside laboratory protocols and measurement systems may have affected preoperative Hgb measurements. Again, however, this limitation was applicable to all patients; therefore, any impact of this nonstandardization would be minimized across both cohorts of patients. Another limitation is that we did not assess for the role of increased drain output postoperatively as it related to the use of anticoagulant agents. However, given that the majority of drains were removed at some time on POD1, the same day that DVT prophylaxis was initiated, it probably had minimal effect. Furthermore, in prior investigations, anticoagulation use was not found to be a risk factor for transfusion in shoulder arthroplasty.[18] Finally, the severity of either osteoarthritis or cuff tear arthropathy was not individually assessed for each patient undergoing TSA or RSA, respectively, which may have affected surgical time, blood loss, and postoperative pain.

Table VIII
Multivariable logistic regression for the probability of blood transfusion in the population of reverse total shoulder arthroplasty patients

	OR	95% CI for OR	*P* value
Age, y	0.977	0.922-1.036	.433
Gender	0.116	0.010-1.377	.088
Surgery duration, h	1.029	0.545-1.945	.929
EBL, 100 units	1.184	1.178-1.189	.458
Total drain output, mL	0.998	0.993-1.004	.573
Preoperative Hgb level	0.466	0.287-0.756	.002*

OR, odds ratio; *CI*, confidence interval; *EBL*, estimated blood loss; *Hgb*, hemoglobin.

Conclusion

This study indicates that RSA is associated with higher drain output than TSA by about 40 mL but that drain output in patients undergoing shoulder arthroplasty is similar to or lower than drainage in patients undergoing knee and hip arthroplasty. We identified an overall low rate of transfusion among shoulder arthroplasty patients in this cohort but a higher rate among RSA patients, 11.7%, compared with TSA patients, 3.1%. High drain output was not found to be an independent risk factor for transfusion as was originally hypothesized. However, the likelihood of requiring a postoperative transfusion was associated with preoperative Hgb levels below 11 g/dL. Furthermore, our multivariate analysis found that an increase of just 1 unit in preoperative Hgb substantially reduced the odds of transfusion in both TSA and RSA patients by 92% and 53%, respectively. Future prospective research in the form of a randomized controlled trial may help determine whether closed-suction drainage provides any clinical benefit in patients undergoing shoulder arthroplasty as well as help develop effective strategies for reducing postoperative transfusions to optimize postoperative outcomes.

Disclaimer

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