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.

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Theoretical benefits of closed-suction drainage in orthopedic surgery include reduction in hematoma and effusion formation, improved healing, and reduced infection risk.14,21,30 However, drain use has also been correlated to increased blood transfusion and infection risks postoperatively without providing clear wound healing benefits.3,7,20 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%,2,11,14,18,22,24,26 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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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.

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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 χ2 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 ≤ .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 (PDO0) 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 preoperative

| 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 | 12 ± 0.4 | 16 ± 0.6 | <.001* |
| Total drain output, mL | 1676 ± 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.
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. Despite this, closed-suction drainage is routinely used after shoulder arthroplasty. 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. 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.

One chief concern with drain use is the increased risk for requiring a blood transfusion postoperatively. 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%. Others found rates of transfusion in TSA to be 4.3%, 6.0%, 21.8%, and 18%, and 38%. Fewer studies have investigated RSA specifically, but transfusion rates of 18.0% and 73.7% 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 g/dL or greater had an increased risk of transfusion compared with patients with lower Hgb levels. This finding is clinically important as patients with low Hgb levels may warrant further preoperative workup or treatment to mitigate the risk for transfusion and closer postoperative monitoring.

### 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 significantly greater than after TSA, 209 vs. 168 mL, respectively. An increase of 1 unit in preoperative Hgb reduced the risk of a postoperative transfusion by 92% and 53% among TSA and RSA patients, 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).

### Table VI

| Subgroup analysis of patients undergoing transfusion and those who did not require transfusion |
|-----------------------------------|----------|----------|----------|
| TSA                               | No transfusion | Transfusion | P value |
| Age, y                            | 68.4 ± 10.3 | 68.9 ± 11.7  | .882     |
| Gender, male                      | 50%        | 25%        | .282     |
| Surgery duration, h               | 3.5 ± 0.7  | 3.6 ± 0.5  | .776     |
| Hospital duration, d              | 2.1 ± 0.6  | 3.3 ± 1.3  | <.001*   |
| Total drain output, mL            | 171.3 ± 131 | 96.9 ± 67  | .113     |
| Drain duration, d                 | 1.2 ± 0.4  | 1.3 ± 0.4  | .592     |
| Preoperative Hgb level, g/dL      | 13.6 ± 1.6 | 10.7 ± 1.5 | <.001*   |

| RSA                               | No transfusion | Transfusion | P value |
|-----------------------------------|----------|----------|----------|
| Age, y                            | 73.8 ± 8.7 | 74.9 ± 19.3 | .723     |
| Gender, male                      | 32.7%     | 6.3%      | .039*    |
| Surgery duration, h               | 3.4 ± 1.0  | 3.6 ± 1.5  | .485     |
| Hospital duration, d              | 2.6 ± 2.2  | 4.3 ± 2.8  | .008*    |
| Total drain output, mL            | 214.4 ± 150 | 165.5 ± 139 | .234     |
| Drain duration, d                 | 1.6 ± 0.5  | 1.7 ± 0.6  | .514     |
| Preoperative Hgb level, g/dL      | 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.
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.

Conclusion

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