Perioperative Management in Reverse Total Shoulder Arthroplasty

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Abstract

Purpose of Review A successful reverse total shoulder arthroplasty requires careful preoperative planning and perioperative management. Preoperative comorbidity risks, perioperative pain management, and postoperative rehabilitation are all critical components of this arthroplasty. The current review examines available literature to guide the perioperative care of the reverse total shoulder arthroplasty patient.

Recent Findings One of the most important advances for shoulder arthroplasty in recent years has been heightened awareness of various modalities for perioperative pain management. A number of recent studies have focused on the options for regional blockade as a critical tool for postoperative pain relief and the use of either continuous interscalene blocks or single shot blocks are supported. Additional studies are necessary to define the best local anesthetic agent and delivery mechanism to provide appropriate pain relief with a low side effect profile.

Summary Management of the patient throughout the perioperative course is a critical component in achieving better patient outcomes delivering high quality patient care. An orthopedic surgery team focused on perioperative management is better positioned to decrease adverse events and improve patient outcomes after reverse total shoulder arthroplasty.

Keywords Shoulder arthroplasty · Reverse total shoulder arthroplasty

Introduction

A successful reverse total shoulder arthroplasty (RTSA) begins with meticulous preoperative planning and depends on attention to details throughout the perioperative period. Thoughtful perioperative management minimizes patient risk factors and thereby may decrease intraoperative or postoperative complications. Complications in RTSA are widely accepted to be higher than anatomic shoulder arthroplasty

ranging between 15 and 40% and include nerve injury, infection, hematoma, dislocation, notching, impingement, intraoperative fractures and acromial fractures [1]. The surgeon must take steps to minimize these risks where possible. A successful RTSA is affected by patient experience as well thus pain management and postoperative rehabilitation are critical components.

Perioperative Management and Complications

Preoperative Evaluation

Appropriate preoperative planning begins in the clinic when the patient is indicated for surgery. Adequate radiographic imaging allows the surgeon to indicate the patient appropriately for RTSA. Inadequate imaging may lead to unrecognized anatomical differences which can cause challenges intraoperatively. Some wear patterns of cuff tear arthropathy may challenge the ideal positioning of reverse total shoulder arthroplasty implants. For example, superior glenoid wear can become excessive such that a large volume of inferior glenoid

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bone would be reamed down to achieve appropriate inferior placement on the glenoid with the accepted degree of base-plate tilt (Fig. 1a and 1b). Alternatively such superior glenoid wear may be accommodated by augmented components and the surgeon must prepare appropriately to have such implants available.

Appropriate review of the patient's medical history is critical, taking special note of any bleeding or clotting history, use of anti-coagulants or other medications which may affect the planned surgery. Recognition of modifiable risk factors is a critically important role often overlooked. Certain risk factors affect known RTSA complications and should receive particular attention. Obesity is a recognized risk factor in postoperative RTSA instability and acutely affects the patient's medical or anesthetic surgical risk [2]. Osteoporosis is another example of a modifiable risk factor which may affect surgical outcomes and complications [3]. From a position of beneficence but also increasingly important for responsible use of medical resources, surgeons have a duty to counsel patients on reducing risk factors prior to indicating for surgery [4•].

Patient risk factors are not the only aspect influencing surgical outcomes. Surgeon experience also plays a role in the outcomes of shoulder arthroplasty. Experienced surgeons are more efficient and have lower complication rates particularly with RTSA [5, 6]. Intraoperative experience is clearly important though the perioperative management may also be affected with the more experienced surgeon.

Infection

Post-operative infection in shoulder arthroplasty is a rare, but potentially devastating surgical complication that occurs in roughly 1% of primary shoulder arthroplasty cases [7]. The three most common pathogenic organisms have been identified to be *Cutibacterium acnes* (44%), *Staphylococcus epidermidis* (34%), and *Staphylococcus aureus* (22%) [7]. It has been well documented that patients sustaining post-operative infection have worse clinical outcomes, and

substantial research has identified methods to decrease surgical site bacterial load before, during and after surgery [8].

Preoperative Prophylaxis

Prior to elective orthopedic surgery, patient-controlled hygiene has been well studied in relation to bacterial load on the skin and potential risks of infection. Although axillary hair shaving/grooming has not been shown to reduce surgical site culture positivity, several authors have found that utilization of in-home chlorhexidine gluconate (CHG) scrubs may decrease the rates of intraoperative culture positivity and ultimately surgical site infection in elective hip, knee and shoulder surgery [9–11, 12•]. Likewise, preoperative topical benzoyl peroxide (BPO) scrub has been evaluated and proven efficacious at reducing the intraoperative culture positivity for *C. Acnes* in several different studies [13–15]. Neither CHD nor BPO have been shown to demonstrate a significant effect on true rates of periprosthetic shoulder infections, however. Ultimately, although the effect of these preoperative scrubs in the context of shoulder arthroplasty is not clearly understood, the Healthcare Improvements-Project Joining Organization in Tackling SSI's (JOINTS) currently recommends that patients should bathe or shower with CHG soap for at least 3 days prior to surgery [12•]. There are currently no AAOS driven guidelines for the use of either CHG or BP scrubs preoperatively.

Additional topics of recent research have centered around antibiotic prophylaxis for elective shoulder arthroplasty. As it currently stands, the recommended antibiotic prophylaxis for elective shoulder surgery continues to be weight-based cefazolin, which is consistently used across the board in nearly all surgical subspecialties [12•]. For patients with a β -lactam allergy or history of MRSA colonization, vancomycin is substituted for cefazolin. Given its known efficacy against *C. acnes*, recent research has evaluated the effect of augmenting preoperative cefazolin with the addition of IV doxycycline and found no benefit in reducing intraoperative culture positivity [16]. Because of the numerous pilosebaceous glands and hair follicles that provide a hospitable colonization site for bacteria, the shoulder continues to remain a challenging area for preoperative sterilization and infection prevention. This is an area within orthopedic surgery that will certainly benefit from additional prospective, randomized controlled trials.

Perioperative Hemostasis

The operative approach for RSA involves dissection through the deltopectoral interval and there is unavoidable risk of intentional and unintentional violation of soft tissues and vasculature. As such, a common challenge associated with RSA has been maintaining hemostasis both intra and post-operatively. There is considerable variation quoted in the current literature

Fig. 1 **a** Grashey view of this patient with cuff tear arthropathy demonstrating superior humeral migration and superior glenoid wear. **b** Coronal magnetic resonance image from the patient imaged in Fig. 1a illustrating superior glenoid erosion

regarding risks and rates of blood transfusion following TSA and RSA, with rates varying between 4 and 43% [17•]. A recent study that queried over 42,000 TSA, RSA and HA patients in the National Inpatient Sample concluded that RSA patients have a twofold higher likelihood of requiring a blood transfusion post-operatively as compared to their anatomic TSA counterparts [18].

Receiving a blood transfusion is not a benign procedure and predisposes the patient to inherent risks of hemolytic and immune mediated reactions, infection, electrolyte abnormalities as well as life-threatening cardiac and pulmonary complications [19]. In addition to poor patient outcomes, these complications ultimately result in increased healthcare costs, longer hospital stays, and greater risks for surgical site infection post-operatively [20]. As such, a large amount of effort has been directed to identify ways to maintain intra/post-operative hemostasis and mitigate the risks associated with significant blood loss. In the setting of elective orthopedic surgery, there are many different measures that have been shown to minimize perioperative blood loss including autologous blood transfusions, utilization of hypotensive anesthetics, hemodilution, and re-infusion drainage [21, 22]. Below we discuss two hemostasis modalities that have gained increasing traction in the literature, tranexamic acid and closed-suction drain devices.

Tranexamic Acid

Tranexamic acid (TXA) is a synthetic analogue of the amino acid lysine that functions to inhibit the degradation of blood clots. Within the coagulation cascade, plasminogen is converted to plasmin, which subsequently binds to the fibrin meshwork within pre-existing blood clots resulting in clot degradation. TXA is a competitive inhibitor of plasminogen and plasmin, thereby reducing the breakdown of existing blood clots and ultimately leading to a transient hypercoagulable state [23•]. Numerous studies have demonstrated the positive effects of TXA in the context of total hip and total knee arthroplasty regarding the ability to achieve less perioperative blood loss, fewer wound hematomas and significantly lower transfusion rates [23•, 24]. TXA has been shown to have a very low risk profile in the acute surgical setting, however it does leave the patient at a slightly higher risk for thromboembolic events, particularly in patients with decreased renal function [25]. Given TXA's positive impact in lower extremity arthroplasty, there have been several recent publications that seek to explore its potential hemostatic benefits in the realm of shoulder arthroplasty.

In a 2016 retrospective review evaluating the hemostatic properties of TXA in total and reverse arthroplasty, Abildgaard et al found that intravenous administration of TXA to RSA patients led to a statistically significant decrease in intra-op blood loss (791 mL vs. 959 mL; $P = .011$),

decreased drop in hemoglobin (2.3 vs. 2.9 mg/dL; $P < .001$), and decreased drain output (180 mL vs. 370 mL; $P < .001$) [26]. Similar results in decreased blood loss, hemoglobin, and drain output were found in the anatomic TSA patient group in this study. These findings led the authors to conclude that intravenous administration of TXA prior to primary TSA and RSA is an effective way to decrease perioperative blood loss, mitigate decreases in hemoglobin, and reduce overall drain output.

In a 2017 prospective randomized, controlled trial by Vera et al, 102 RSA patients were randomized to receive 2g of preoperative IV TXA versus placebo with primary outcomes measuring total blood loss, drain output and hemoglobin drop [27]. They found that total blood loss was significantly less for the TXA group (1122.4 mL vs. 1472.6 mL; $P < .001$), total drain output was less for the TXA group (221.4 mL vs. 371.9 mL; $P < .001$) and total hemoglobin loss was less in the TXA group (154.57 g vs. 200.1 g; $P = .001$). The authors found a statistically significant decrease in transfusion rates in the TXA group compared to placebo on post-operative day one; however, in subsequent days, there was no statistical significance in transfusion rates. With these findings, they concluded that intravenous TXA given in the setting of RSA results in less total blood loss, a smaller drop in hemoglobin, and decreased drain output as compared to a placebo matched cohort.

Pauzenberger et al (2017) conducted a randomized, controlled trial with 54 patients undergoing primary TSA or RSA, randomized to receive 2g intravenous TXA versus placebo in an attempt to evaluate the effect of TXA on blood loss, transfusion rate and early post-operative clinical outcomes [28]. They found that the mean perioperative blood drainage was significantly lower in the TXA group (50 mL vs. 170 mL; $P = .001$), calculated total blood loss was lower in the TXA group (871 mL vs. 1248 mL; $P = .009$), and frequency of hematoma formation was significantly lower in the TXA group (26% vs. 59%; $P = .027$). No adverse events were associated with the administration of TXA. The authors conclude that IV TXA successfully reduced perioperative blood drainage, total EBL and hematoma formation in reverse and anatomic shoulder arthroplasty.

A 2015 prospective, randomized, double-blinded study by Gillespie et al sought to evaluate the efficacy of 2g topical TXA versus placebo given at case closure to reduce hemoglobin drop, post-operative blood loss and minimizing transfusion requirements after shoulder arthroplasty [29]. They found that the TXA cohort had significantly lower post-operative hemoglobin drop (1.7 g/dL vs. 2.6 g/dL; $P < .001$) and lower post-operative blood drainage (108 mL vs. 170 mL; $P = 0.17$). There were no cases of transfusion required between either groups. Although the authors were not able to specifically comment on the impact of TXA on transfusion rates, they conclude that topical TXA administration at the closure of

the case results in significantly less post-operative drainage and a lower post-operative drop in patient hemoglobin.

Finally, Friedman et al (2016) conducted a retrospective review to evaluate patients that were given preoperative IV TXA versus those that were not to evaluate the effect on blood loss and patient outcomes following both reverse and anatomic total shoulder arthroplasty [23•]. They found that patients given 20mg/kg IV TXA had a significantly lower drop in hemoglobin (2.13g/dL vs. 2.63g/dL). Patients receiving TXA also had spent significantly less time in the PACU (69 min vs. 87 min; $P < .02$) and had shorter hospital admissions (1.18 days vs. 1.4 days; $P = .01$). With these findings, the authors concluded that IV TXA administration results in significantly less blood loss and may result in quicker post-operative recovery and earlier patient discharges.

Closed-Suction Drains

Closed-suction drainage is a surgical concept that has been well studied within the realm of total hip arthroplasty (THA) and total knee arthroplasty (TKA), with theoretical benefits of improved wound healing, lower infection rates, fewer hematomas, and surgical site effusions [30••]. Most of the published literature has found the contrary to be true in that closed-suction drain devices result in increased post-op blood loss, more transfusions, higher risk of infection and ultimately no wound-healing benefits [30••]. Despite these findings, the use of closed-suction drainage devices in shoulder surgery continues without any true evidence-based guidelines. Few studies have sought to analyze the efficacy of closed-suction drain devices in the context of shoulder arthroplasty.

A retrospective review in 2016 by Erickson et al compared 64 RSA/TSA patients without a closed-suction drain to 304 RSA/TSA patients with a closed-suction drain and sought to evaluate the effect that these devices may have on post-operative hemoglobin loss, overall clinical outcomes and complications [31]. They found that patients with closed-suction drains had statistically larger hemoglobin drop from pre to post-operatively (3.1mg/dL vs. 2.6mg/dL change; $P = .001$), lower post-operative hemoglobin values (10.5 vs. 11.5; $P < .001$), and longer hospital admission (55 h vs. 34 h; $P < .001$). Additionally they found the no-drain group to have better clinical outcomes scores post-operatively as measured by the American Shoulder and Elbow Surgeon's Shoulder Score and the Simple Shoulder Test score. They identified no differences between rates of infection and transfusion between the two groups. With these findings the authors conclude that closed-suction drains result in greater loss of hemoglobin, longer length of hospital stay, and decreased clinical outcomes following TSA and RSA. Their effect on transfusion and infection remains unclear.

In 2019, Trofa et al conducted a randomized controlled trial evaluating the short-term outcomes associated with closed-

suction drain devices in shoulder arthroplasty [30••]. A total of 100 patients were enrolled and randomized equally to receive a drain vs. no drain. They evaluated these patients post-operatively and found no significant difference in transfusion rates, perioperative complications, hemoglobin/hematocrit changes, length of admission, or cost of admission between the two groups. They concluded that although drain use appears to be safe, there appears to be no clinical benefit to their use in terms of postoperative anemia, length of hospital stay, or cost.

Perioperative Pain Management

Shoulder arthroplasty has been cited to have among the highest pain scores in the immediate postoperative period [32], and inadequate pain management has been shown to detrimentally affect patient outcomes including readmission rates, delayed return to activities of daily living, and increased hospitalization costs, among other things [33•]. Given its increasingly expansive list of surgical indications, RSA now represents the fastest growing joint replacement surgery in the United States, bringing pain management to the forefront of the conversation and recent research trials in the context of this surgery.

Established Pain Control Modalities

The established standard of care for post-operative pain management in RSA patients is multimodal in nature [34••]. Acetaminophen, NSAIDs, anticholinergic muscle relaxants, gabapentin and opioids (oral, IV and PCA) are commonly the first line pharmacologics used in managing RSA patients postoperatively. However, opioid pain medications are frequently overprescribed and often misused [35], with a constellation of negative side effects that include nausea/vomiting, respiratory depression, somnolence, pruritus, urinary retention, constipation, and risk of dependence [32].

In an effort to mitigate these risks and minimize the utilization of narcotics as a first-line medication, preoperative regional nerve blockade and intraoperative local wound infiltration with long acting anesthetics have become common practice in the setting of shoulder arthroplasty [36]. These interventions are now considered to be the analgesic technique of choice for pain control in shoulder surgery [36], and have been shown to reduce post-operative opioid use, reduce time spent in the PACU and ultimately lead to earlier discharge [32]. They are, however, accompanied by the risk of significant adverse side effects that may include failure or unpredictable duration of neurologic blockade, rebound pain as blockade wears off, phrenic nerve palsy with respiratory compromise, Horner syndrome, hoarseness, local paresthesias, and systemic toxicity [36].

Long Acting Anesthetics

Given the premium that has been placed on minimizing opioid use and the desire to mitigate the risk of serious adverse events associated with regional nerve blockade, many resources have been devoted to investigating other modalities of pain control within the past 5 years. One major development has been the FDA approval of liposomal bupivacaine (LB) for local wound infiltration and interscalene nerve block. LB is a multivesicular lipid-based formulation of standard bupivacaine (SB) that has been engineered to have sustained release of anesthetic over a 48–72 h after administration, which is upwards of 3-fold the duration of standard ropivacaine or bupivacaine formulations. LB has been well studied in various fields of general surgery and lower extremity arthroplasty regarding its opioid sparing effect and long term control of pain [37, 38]. Not until recently, however, have there been randomized, prospective studies within the published literature that evaluate the various modalities of administration and the effect of extended release anesthetic in the contexts as described above.

Okoroa et al compared patients randomized to receive only local infiltration of LB intraoperatively vs. patients that received an interscalene block (ISB) preoperatively [39]. They found that the LB group had higher pain scores in the first 8 h post-operatively; however, the ISB group ultimately required more narcotics at the end of POD#1. They found no difference in reported pain scores, opioid consumption, length of stay, or complications after POD#1 and concluded that local LB infiltration provides equivalent pain relief with no increase in complications or length of stay as compared to standard ISB.

In a similar RCT, Namdari et al (2017) randomized patients to the same experimental arms (local LB vs. ISB) and found that patients receiving ISB had a significantly lower pain scores immediately and 8 h post-operatively as compared to the LB infiltration group, however the ISB had worse pain scores at 24 h and beyond [40]. They additionally found that the LB group required an equivalent amount of narcotics post-operatively. Ultimately they concluded that LB is an equivalent alternative to ISB in terms of post-operative opioid requirements, and may provide greater pain relief beyond 24 h after surgery.

In a different RCT, Namdari et al (2018) randomized patients into two groups to evaluate the effects of receiving an ISB in addition to a local infiltration of LB vs. local infiltration of LB alone [41]. They found that there were no statistically significant differences between post-operative pain scores between groups within the first 72 h, and additionally they found that the ISB required fewer narcotics as compared to the cohort that received an ISB as well as local infiltration of LB. With these results they concluded that there is no additional pain control or opioid sparing effect of adding LB to a traditional ISNB.

Abildgaard et al (2017) conducted a prospective RCT that compared patients receiving a continuous interscalene nerve block (CISB) via indwelling catheter versus patients receiving equal-volume local infiltrations of LB and standard bupivacaine (SB) [42]. They evaluated postoperative VAS pain scores, opioid consumption, LOS, and postoperative complications. They found that patients in the LB/SB infiltration group had higher pain scores on POD#0 but then had lower pain scores moving forward through the duration of admission. However, they also found that opioid consumption was significantly higher in the LB/SB infiltration group throughout the entirety of the post-operative period. There were no significant differences in postoperative complications. With these findings they conclude that CISB provides superior pain management in the immediate post-operative time period, and ultimately leads to decreased narcotic consumption as compared to local infiltration with LB and SB.

Finally, a prospective RCT conducted by Sabesan et al evaluated the effect of receiving a CISB versus a single shot ISB with the addition of local infiltration of LB [33•]. They found that the ISB + LB group had statistically equivalent narcotic use, pain scores and time to first narcotic rescue as compared to the CISB group. They additionally found that the ISNB + LB had better overall post-operative patient satisfaction scores and fewer overall complications as compared to the CISB group. They concluded that ISNB + LB provide excellent post-operative pain relief and have fewer complications and lower cost as compared to CISNB.

Postoperative Care

Rehabilitation protocols for sling use and motion early after reverse total shoulder arthroplasty have been varied among surgeons [43, 44]. The initiation of mobilization and timeline for motion progression was shown to vary widely in these systematic reviews. There is little comparative data including outcome measures to support a specific protocol approach. Additional research in this area is needed. There is however, increasing literature about what activities a patient may return to after reverse total shoulder arthroplasty [45•, 46•]. This data may help guide surgeons return their patients to activities and hobbies after reverse total shoulder arthroplasty.

Conclusion

There are many factors which make up the overall success or outcome of a reverse total shoulder arthroplasty. The process begins in the clinic with appropriate indication of the patient and careful management of patient risk factors or medical comorbidities. Protocols for perioperative management including steps to decrease blood loss, manage pain control,

and accelerate patient return to activity not only improve patient outcomes but also decrease adverse events. Improving patient outcomes and decreasing adverse events are steps that are good for patients but are also critical in reducing cost of care for our health systems. The importance of perioperative management cannot be overemphasized and will likely continue to receive additional attention by surgeons, health systems, and patients.

Declarations

Conflict of Interest Matthew Godlewski declares that he has no conflict of interest.

Michael Knudsen declares that he has no conflict of interest.

Jonathan Braman is a consultant for Zimmer Biomet.

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- 4.•• Bronson WH. Ethics of provider risk factor modification in total joint arthroplasty. *J Bone Joint Surg Am.* 2015;97(19):1635–9. <https://doi.org/10.2106/JBJS.O.00564> **The current environment of limited health-care resources demands efficient delivery of medical care to achieve a financially sustainable health-care model. Several initiatives in the Patient Protection and Affordable Care Act (PPACA) of 2010 require that hospitals simultaneously improve quality and decrease the cost of care or face financial penalties. One strategy to achieve more efficient care is to decrease the number of risk factors with which patients present prior to a surgical procedure such as total joint arthroplasty. We believe that it is moral to engage in patient risk factor modification prior to elective joint replacement.**
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- 17.•• Kuo LT, Hsu WH, Chi CC, Yoo JC. Tranexamic acid in total shoulder arthroplasty and reverse shoulder arthroplasty: a systematic review and meta-analysis. *BMC Musculoskelet Disord.* 2018;19(1):60 **Background: The effects of tranexamic acid (TXA) in the setting of shoulder arthroplasty are unclear. The objective of this study was to examine the effects of TXA in reducing the need for blood transfusions and blood loss in patients undergoing primary total shoulder arthroplasty (TSA) and reverse total shoulder arthroplasty (RTSA). Methods: We conducted a systematic review and meta-analysis of randomized controlled trials (RCTs) and retrospective cohort studies (RCS) that compared outcomes of patients who did and did not receive TXA during TSA or RTSA. We searched Cochrane Central Register of Controlled Trials, EMBASE, and MEDLINE for relevant studies. We assessed the risk of bias of the included studies and calculated pooled risk estimates. The primary outcome was transfusion rate, and secondary outcomes were changes in hemoglobin, estimated total blood loss (ETBL), blood loss via drainage, operative time, hospital stay, overall complications, and thromboembolic events. Results: We identified 3 RCTs and 3 RCS including 677 patients with 680 shoulders (343 TXA and 337 non-TXA). The random-effects model meta-analysis showed that TXA group had a lower**

- transfusion rate (risk ratio (RR) 0.34, 95% CI 0.14 to 0.79), less change in hemoglobin (mean difference (MD) -0.64 g/dl, 95% CI -0.81 to -0.46), and reduced ETBL (MD -249.24 ml, 95% CI -338.74 to -159.74). In patients with RTSA, the TXA group had a lower transfusion rate (RR 0.28, 95% CI 0.14 to 0.79), less ETBL (MD -249.15 ml, 95% CI -426.60 to -71.70), less change in hemoglobin (MD -0.64 g/dl, 95% CI -0.86 to -0.42), and less blood loss via drainage (MD -84.56 ml, 95% CI -145.72.14 to -23.39) than non-TXA group. **Conclusions:** The use of TXA in primary shoulder arthroplasty appears safe, and can reduce transfusion rate, changes in hemoglobin, and perioperative total blood loss, especially in patients with RTSA.
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 23. Friedman RJ, Gordon E, Butler RB, Mock L, Dumas B. Tranexamic acid decreases blood loss after total shoulder arthroplasty. *J Shoulder Elb Surg*. 2016;25(4):614–8 **Background:** Tranexamic acid (TXA) significantly decreases blood loss and transfusion rates after total hip and total knee arthroplasty. The purpose of this study was to determine the effects of intravenous TXA on blood loss and patient outcomes after total shoulder arthroplasty (TSA). **Methods:** TXA was used in 106 consecutive patients undergoing primary anatomic and reverse TSA with a dose of 20 mg/kg intravenously (TXA group) and compared with the previous consecutive 88 patients without TXA (non-TXA group). All patients had a blood sample drawn for a hemoglobin and hematocrit determination the morning after surgery. Analysis of variance and χ^2 techniques were used to analyze study hypotheses. **Results:** Statistically significant differences in both hemoglobin loss (TXA group $\Delta = 2.13$ vs. non-TXA group $\Delta = 2.63$; $P = .01$) and hematocrit loss (TXA group $\Delta = 6.4$ vs. non-TXA group $\Delta = 8.14$; $P < .01$) were seen in the TXA group compared with the non-TXA group. In patients receiving TXA, there were statistically significant decreases in the time spent in the recovery room (mean, TXA group 69 minutes vs. non-TXA group 87 minutes; $P < .02$) and total length of hospitalization (mean, TXA group 1.18 days vs. non-TXA group 1.4 days; $P = .01$). Two patients in the TXA group received a blood transfusion, whereas 6 patients in the non-TXA group did. **Conclusions:** TXA 20 mg/kg intravenously given just before primary anatomic and reverse TSA results in statistically significant reductions in blood loss. Patients spent 21% less time in the recovery room and had a 16% shorter hospitalization, resulting in financial savings for the hospital.
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 30. Trofa DP, Paulino FE, Munoz J, Villacis DC, Irvine JN, Jobin CM, et al. Short-term outcomes associated with drain use in shoulder arthroplasties: a prospective, randomized controlled trial. *J Shoulder Elb Surg*. 2019; 28(2):205–11 **Background:** This study examined the immediate outcomes during the perioperative period associated with drains in the setting of total shoulder arthroplasty or reverse shoulder arthroplasty. We hypothesized that drain use would result in lower postoperative hemoglobin and hematocrit levels that would increase transfusion rates and longer hospital stays that would increase hospital costs. **Methods:** The study prospectively randomized 100 patients (55% women; average age, 69.3 years) who underwent total shoulder arthroplasty or reverse shoulder arthroplasty to receive a closed-suction drainage device (drain group, n = 50) or not (control group, n = 50) at the time of wound closure. **Basic demographic information and intraoperative and postoperative data were collected. Results:** The groups were similar with respect to basic patient demographics. Postoperatively, drains had no effect on transfusion rates or any perioperative complication ($P > .715$). There were also no significant differences in hemoglobin or hematocrit levels immediately after surgery or on postoperative day 1. On average, patients were discharged from the hospital 1.6 days and 2.1 days postoperatively in the control and drain groups, respectively ($P = .124$). The average cost associated for the control cohort's hospital stay was \$35,796 $\pm$ \$13,078 compared with \$43,219 $\pm$ \$24,679 for the drain cohort ($P = .063$). **Discussion:** Drain use after shoulder arthroplasty had no appreciable difference on short-term perioperative outcomes, postoperative anemia, length of hospital stay, or cost. It is possible that the potential negative effects of postoperative drainage are blunted by the routine use of tranexamic acid.
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 33. Sabesan VJ, Shahriar R, Petersen-Fitts GR, Whaley JD, Bou-Akl T, Sweet M, et al. A prospective randomized controlled trial to identify the optimal postoperative pain management in shoulder arthroplasty: liposomal bupivacaine versus continuous interscalene catheter. *J Shoulder Elb Surg*. 2017;26(10):1810–7 **Background:** Shoulder arthroplasty is the fastest growing joint replacement surgery in the United States, and optimal postoperative pain management is critical to optimize outcomes for these surgeries. Liposomal bupivacaine (LB) has gained popularity for its potential to provide extended postoperative pain relief with possibly fewer side effects. The goal of this study was to assess the impact of LB compared with continuous interscalene nerve block (CISB) in terms of postoperative pain control, outpatient

- pain scores, and patient-reported and functional outcomes after shoulder arthroplasty surgery. **Methods:** A prospective randomized controlled clinical trial compared consecutive patients undergoing shoulder arthroplasty treated with CISB vs. LB with a single bolus interscalene block. The primary outcome measures included pain assessment up to 24 hours after surgery; in addition, all doses and times of narcotics administered during the inpatient stay were recorded. Patient-reported outcome measures for pain, satisfaction, and functional outcomes were recorded postoperatively. **Results:** A total of 70 of 74 consecutive patients who underwent shoulder arthroplasty were included in the study. The LB group had equivalent narcotic use, pain scores, and time to first narcotic rescue compared with the CISB group within the first 24 hours ($P > .05$). The LB group had higher American Shoulder and Elbow Surgeons score and Penn Shoulder Score at final follow-up. There was an increased number of complications and cost for the CISB group. **Conclusion:** This prospective randomized controlled trial demonstrated that LB provides excellent postoperative pain relief for shoulder arthroplasty patients. In addition, LB had fewer complications and lower cost, making it a promising addition to a multimodal pain regimen for shoulder arthroplasty.
34. DC ML, Cheah JW, Aleshi P, Zhang AL, Ma CB, Feeley BT. Multimodal analgesia decreases opioid consumption after shoulder arthroplasty: a prospective cohort study. *J Shoulder Elb Surg.* 2018;27(4):686–91 **Background:** Studies on perioperative pain control in shoulder arthroplasty focus on regional anesthesia, with little research on other approaches. Perioperative multimodal analgesia regimens decrease opioid intake and opioid-related side effects in lower-extremity arthroplasty. In this study we compare pain scores, opioid consumption, length of stay, and readmission rates in postoperative shoulder arthroplasty patients treated with a standard or multimodal analgesia regimen. **Methods:** A prospective cohort analysis was performed at a single institution. Patients undergoing elective shoulder arthroplasty were treated with either a standard opioid-based regimen or a multimodal analgesia regimen perioperatively. Outcome measures included inpatient pain scores, opioid use, length of stay, and 30- and 90-day emergency department visits and readmission rates. **Results:** Seventy-five patients were included in each cohort. Patients treated with the multimodal analgesia regimen had lower postoperative day 0 pain scores (mean, 1.5 vs 2.2; $P = .027$). Opioid use in the multimodal cohort was lower on all days: 47% lower on postoperative day 0, 37% on day 1, and 44% on day 2 (all $P < .01$). The length of inpatient stay was significantly shorter for multimodal patients than for patients treated with the standard regimen (1.44 days vs 1.91 days, $P < .01$). There was no difference in the rate of 30- or 90-day emergency department visits or readmission. **Conclusion:** Patients undergoing shoulder arthroplasty have decreased postoperative pain and opioid consumption and shorter hospital stays when given a multimodal analgesia regimen. There is no increase in short-term complications or unplanned readmissions, indicating that this is a safe and effective means to control postoperative pain.
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 45. Garcia GH, et al. Patient activity levels after reverse total shoulder arthroplasty: what are patients doing? *Am J Sports Med.* 2015. **Background:** The indications for reverse total shoulder arthroplasty (RTSA) continue to expand, which has resulted in younger patients who want to remain active after RTSA. Little information is available to manage expectations of both physicians and patients for return to sporting activities. **Purpose:** To determine the rate of return to sporting activities and assess average time to return to sports after RTSA. **Methods:** This was a retrospective review of consecutive RTSA patients collected from our institution's shoulder arthroplasty registry. All patients who played sports preoperatively and had a minimum of 1-year follow-up were included. **Final follow-up** consisted of an additional patient-reported questionnaire with questions regarding physical fitness and sporting activities. Each patient also completed an assessment with the American Shoulder and Elbow Society (ASES) Shoulder Score and a visual analog scale (VAS) for pain. **Results:** Seventy-six patients played a sport preoperatively and met inclusion and exclusion criteria. The average follow-up was 31.6 months (range, 12–65 months), and average age was 74.8 years (range, 49.9–92.6 years). Average VAS pain scores improved from 6.57 to 0.63 ($P < .001$). Average ASES scores improved from 34.30 to 81.45 ($P < .001$). Subjectively, 11.8% of patients complained of stiffness and 10.5% complained of chronic pain. After RTSA, 85.5% of patients returned to at least 1 sport. Average time to return to full sports was 5.3 months. Fitness sports had the highest direct rate of return (81.5%), followed by swimming (66.7%), running (57.1%), cycling (50.0%), and golf (50%). Postoperatively, 41.1% of patients reported improved physical fitness; 88.2% felt that their sports outcome was good to excellent, and 93.4% felt that their surgical outcome was good to excellent. **Conclusion:** Patients undergoing RTSA had an 85% rate of return to 1 or more sporting activities at an average of 5.3 months after surgery. Age greater than 70 years was a

significant predictor of decreased return to activities. The present study offers valuable information to help manage patient and surgeon expectations.

46. • SJ MI, Mackie KE, Titchener A, Gibbons R, Wang AW. Activity following reverse total shoulder arthroplasty: what should surgeons be advising? *Should Elb.* 2019;11(2 Suppl):4–15. <https://doi.org/10.1177/1758573218793648> **Background:** Reverse total shoulder arthroplasty (RTSA) is now the most frequently performed form of shoulder arthroplasty. There is currently no consensus on recommended levels of activity and sport following RTSA. The aim of this review is to outline the current evidence and provide a guide for surgeons on what to advise their patients regarding activity level following RTSA. **Methods:** A systematic review of the literature was performed using the Preferred Reporting for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The search was performed using the electronic databases PubMed and Medline. Included studies were of level 1 to 4 evidence in the English

language evaluating complications and return to sport after RTSA. **Results:** Eleven studies were selected and included a total of 621 patients (67% female) with a mean age of 73 years (range 22–92). All of the included patients participated in sports prior to RTSA. The rate of return to sport ranged from 60 to 86% and varied with the level of sport activity. Mean time to return to sport after surgery varied greatly between studies. **Conclusions:** Return to sport is tolerated following RTSA; however, studies are short to medium term only and although the reported complication rate is low, the studies did not include radiographic evaluation. Longer term studies with subgroup analysis evaluating common recreational activities after RTSA are required, particularly in the younger population, in order to establish clear post-operative guidelines.

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