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CHAPTER 10.2

Shoulder/Arm Surgery

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Arthroscopic Shoulder Surgery

Surgical Considerations

Description: The role of arthroscopy in shoulder surgery has advanced tremendously in the past decade and is now routinely performed by most shoulder surgeons. Arthroscopic procedures include **subacromial decompression (SAD), distal clavicle resection (Mumford procedure), debridement** (for labral tear, infection, or synovitis), **rotator cuff (RC) repair, anterior capsule-labral repair** for recurrent dislocation (**Bankart repair**), **capsular plication** for multidirectional instability (MDI), **capsular release for frozen shoulder,** and **repair of SLAP lesions** (superior labral anterior-posterior tears).

Procedures done arthroscopically are less painful postoperatively than open procedures, because they produce less trauma to normal tissues. Rehabilitation is, therefore, facilitated. Interscalene block has been shown to provide good postop analgesia of shorter duration, but its clinical application with arthroscopic procedures is surgeon-dependent because the postoperative pain is usually moderate to mild. Some surgeons prefer only a general anesthesia for shoulder arthroscopy. The use of indwelling intra-articular pain catheters has fallen out of favor in the past few years due to multiple case reports of chondrolysis, a devastating complication characterized by end-stage arthrosis of the glenohumeral joint.

Arthroscopic shoulder surgery may be performed in the beach-chair or lateral decubitus position. Beachchair positioners are available with a trough for the head and a breakaway shoulder pad to provide important access to the posterior shoulder. The lateral decubitus position utilizes distal traction of 5–10 lbs, with the arm abducted 30–45°. Both are safe positions for the brachial plexus, because the shoulder is not excessively abducted. The “down” arm in the lateral position is placed in forward flexion, and an axillary roll is placed underneath the upper chest wall.

Initially, an 18-ga spinal needle is inserted into the glenohumeral joint, passing through the posterior deltoid and infraspinatus muscle and the posterior capsule of the joint (see shoulder anatomy, Fig. 10.2-1). Placement is verified by injecting saline to inflate the joint capsule. A stab incision is made using a No. 11 blade in the direction previously defined by the finder needle. Sharp, then blunt trocars are used to gain access to the joint and permit insertion of the arthroscopic device. Improper insertion of the instruments can injure the axillary or suprascapular nerves and the cartilage of the glenohumeral joint. Initial diagnostic arthroscopy is carried out through the posterior portal. Bupivacaine 0.5% with epinephrine 1:200,000 often is infiltrated into portals and the joint or subacromial space at the onset of surgery to help with hemostasis. An anterior portal is used for instrumentation within the glenohumeral joint. After joint arthroscopy, the scope is placed into the subacromial space, where a direct lateral portal is used for instrumentation. Accessory portals are established as needed, depending on the procedure performed. Joint debridement and anterior capsulolabral stabilization are usually performed through anterior portals. RC repair, subacromial bursectomy, acromioplasty, and distal clavicle resection are done within the subacromial space (deep to the deltoid and superficial to the RC). Epinephrine (1 mg/3 L) in the irrigation fluid and maintaining MAP < 80 mmHg help control bleeding, thus enhancing visualization during surgery.

Usual preop diagnosis: Rotator cuff tear; subacromial impingement; glenohumeral instability; AC arthritis; labral tear

Summary of Procedures

Position	Lateral decubitus or beachchair
Incision	Posterior arthroscopic portal, anterior instrumentation portal, lateral instrumentation portal for visualizing subacromial

	bursa; superior portal for semisitting position
Special instrumentation	Arthroscope; power burrs; arthroscopic shavers; suture-passing instruments; bone anchors; radiofrequency cautery
Unique considerations	Rigid eye patch over ipsilateral eye, to prevent corneal abrasion, suggested. Positioning of the head with appropriate support, removing upper section of operating table, if possible, for better access with semisitting position. ETT taped to opposite side of face. MAP ≥ 80.
Antibiotics	Cefazolin 1 g iv preop, particularly if bone work performed.
Surgical time	Positioning the patient is time-intensive; can add as much as 45 min. Reconstructive: 1–4 h Diagnostic: < 1–1.5 h
EBL	Minimal: < 200 mL (less with use of epinephrine, electrocautery, and laser)
Postop care	Frequently outpatient; may be overnight if interscalene or supraclavicular block is given or reconstructive procedure performed. Intraarticular pain catheter commonly used.
Mortality	Rare
Morbidity	VAE possible Extravasation of fluid (NS or LR): > 50% Brachial plexus injury (lateral decubitus position): Rare Breakage of instruments: < 1% Infection: 0–3%
Pain score	4 (diagnostic); 5–7 (reconstruction)

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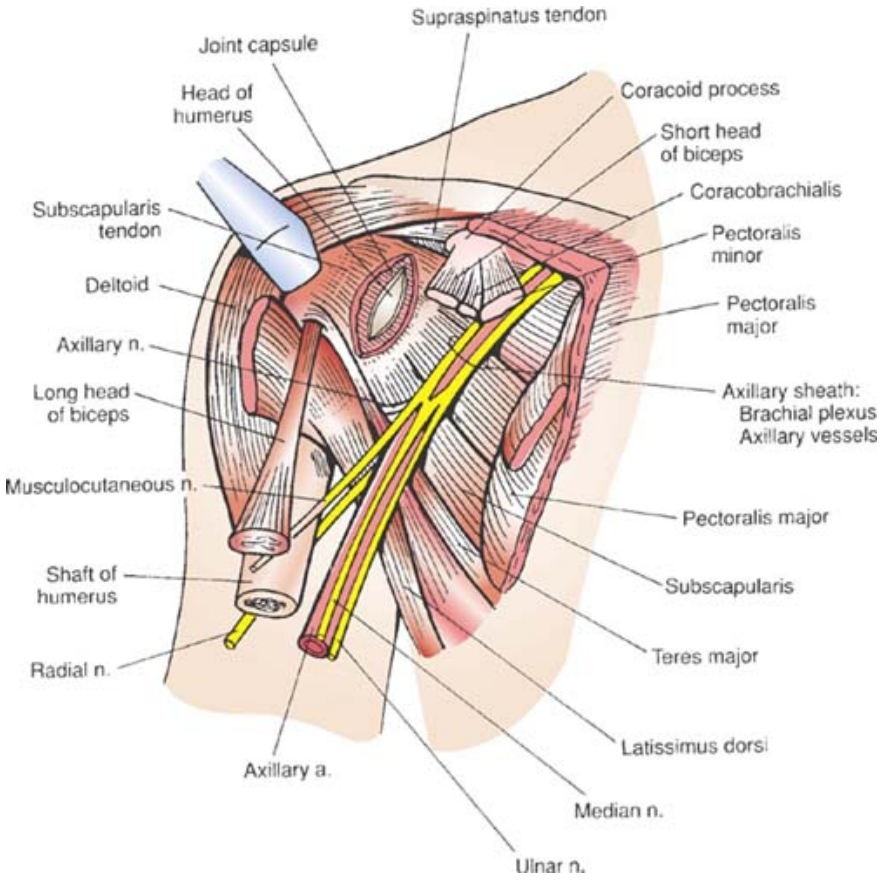

Figure 10.2-1. 1. Anatomy of the shoulder joint, anterior. (Reproduced with permission from Hoppenfeld S, deBoer P, *Surgical Exposures in Orthopaedics: The Anatomic Approach,* 2nd edition. Lippincott Williams & Wilkins, 1994.)

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Patient Population Characteristics

Age range	15–40 yr (instability); 35–75 yr (rotator cuff and acromial pathology)
Male:Female	2:1–4:1
Incidence	Very common: > 50,000/yr
Etiology	Young patients: usually sports-related Older patients: cuff and acromial pathology; age-wear phenomenon Rotator cuff pathology and acromial impingement (frequently coexist)
Associated conditions	Cervical arthritis and radiculopathy with rotator cuff pathology

Anesthetic Considerations

See Anesthetic Considerations following Surgery for Shoulder Instability, p. 944.

Suggested Readings

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Surgery for Acromial Impingement, Rotator Cuff Tears, and Acromioclavicular Joint Arthritis

Surgical Considerations

Description: Subacromial impingement is a common degenerative condition of middle age. It may be related to extrinsic anatomic factors (e.g., hooked acromion), a traumatic episode, or intrinsic factors (e.g., tissue degeneration). The subacromial space (space between the acromion and humeral head) is occupied by the supraspinatus (superior rotator cuff [RC]) muscle and tendon and the bursa, which allows for smooth gliding of the cuff tendon under the acromion. Trauma produces hemorrhage and inflammation in the bursa; swelling of the bursa decreases the space available under the acromion. These tissues may then be "pinched" between the greater tuberosity of the humerus and the lateral aspect of the acromion (Fig. 10.2-2) with forward elevation or abduction of the arm. This further increases the inflammation, producing a vicious cycle.

Impingement of the anterolateral acromion on the insertion of the supraspinatus (along with poor vascularity of this part of the cuff) is a leading hypothesis for the etiology of degenerative **RC tears.**

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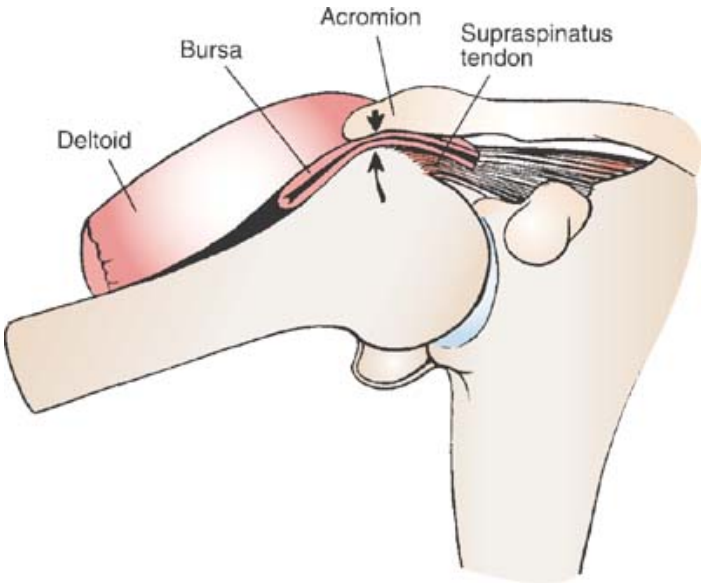

Figure 10.2-2. 2. Abduction of the arm can impinge the subacromial bursa between the greater tuberosity and the undersurface of the acromion and coracoacromial ligament. (Reproduced with permission from Hoppenfeld S, deBoer P: *Surgical Exposures in Orthopaedics: The Anatomic Approach,* 2nd edition. Lippincott Williams & Wilkins, 1994.)

AC joint arthritis is a common radiographic finding in adults, but it is often asymptomatic. Distal clavicle excision is performed for clinically symptomatic AC joint arthritis.

Subacromial impingement: Surgical treatment of subacromial impingement is indicated when nonoperative treatment (e.g., cortisone injection, physical therapy) fails. Surgery involves shaving of the anterolateral aspect of the undersurface of the acromion (creating a flat surface, and providing more room in the subacromial space). This may be accomplished with open techniques in combination with open RC repair, but it is more commonly done arthroscopically. The bursa is usually inflamed and quite vascular. Bleeding may obscure arthroscopic visualization and is controlled with electrocautery, epinephrine in the irrigant, and by maintaining relative ↓ BP (MAP < 80 mmHg).

Rotator cuff tears: RC (Fig. 10.2-3) repair may be performed using the **direct lateral open approach, the mini-open (deltoid-splitting) approach** in conjunction with arthroscopy, or all arthroscopically. If a deltoid-splitting incision is used, care is taken not to extend the split more than 5 cm distal to the acromion because of possible injury to the axillary nerve, which innervates the deltoid 5 cm or more from the lateral aspect of the acromion. If the beachchair position is used for open RC surgery or arthroscopy, the upper limb is draped free. The arm is manipulated, and traction is frequently applied. It is important that the head is secured (the

head may be taped to the table or special beachchair positioner), the eyes are protected, and that the anesthesiologist frequently checks to see that the surgeon is not pulling the patient off the table (not always apparent from the surgeon's side of the drape). Traction on the brachial plexus is more likely in the lateral decubitus position 2° arm traction.

Open RC repair involves suturing the cuff insertion back to the greater tuberosity through drill holes or with suture anchors. Arthroscopic repair requires percutaneous anchor placement and arthroscopic suture-passing and knot-tying. Bleeding is minimal with the arthroscopic technique, but may approach 400 mL with an open procedure. Both require that the patient remain relaxed until all dressings are applied and he/she is fitted with an abduction sling. Patients typically are admitted for 24 h for pain control or if a drain is used.

AC joint disease: Surgery for **AC joint arthritis** is usually performed in conjunction with SAD and/or RC repair and may be done open or arthroscopically. It involves simple resection of the distal 5 mm of the clavicle through an incision directly over the joint or through an accessory anterior portal. Again, relative ↓ BP is required for the arthroscopic procedure.

Repair of AC joint dislocation ("shoulder separation") is uncommon. Most AC *(Print pagebreak 940)* separations are treated nonoperatively, because long-term functional results are the same or better than those treated surgically. Severe AC separations occasionally require surgery, when the dislocated clavicle is buttonholed posteriorly through the trapezius, the deltoid origin has been avulsed from the clavicle, or the clavicle is displaced inferiorly below the cricoid process. Repair is performed in the beachchair position with the incision carried out over the AC joint and distal third of the clavicle. The clavicle is reduced and held in place with a large screw into the base of the coracoid, a large suture wrapped around the coracoid, or with K-wires across the AC joint. The coracoclavicular ligament often is repaired or reconstructed with tendon graft, or the coracoacromial ligament is transferred from the edge of the acromion to the clavicle. Following reduction and fixation, the deltoid is reattached to the clavicle if it has been avulsed, and the patient is placed in an immobilizer after skin closure. The operation is technically challenging and the brachial plexus and subclavian vessels are at risk with screw placement and with inferior dislocations.

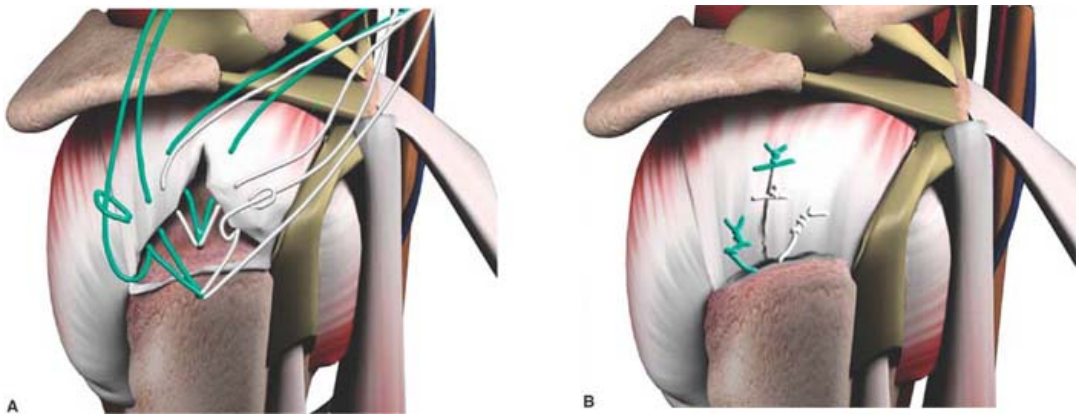

Figure 10.2-3. 3. Lateral view of the right shoulder showing a rotator cuff repair. Reproduced with permission from Lafosse L, Brozska R, Toussaint B, et al. The outcome and structural integrity of arthroscopic rotator cuff repair with use of the double-row suture anchor technique. *J Bone Joint Surg,* 2007; 89:1533-41. **A:** Rotator cuff tear. **B:** Rotator cuff repair with suture anchors.

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Usual preop diagnosis: RC tears (partial or complete); AC arthritis; impingement; bursitis; bicipital tendinitis; AC separation

Summary of Procedures

Position	Beachchair; semisitting, 40–70°; or lateral decubitus
Incision	Oblique, saber-type incision anteriorly over distal acromion; lateral or deltopectoral incision for wider exposure; deltoid-splitting incision for RC tears
Special instrumentation	Power equipment for bone work; self-retaining retractors for cuff repairs; suture anchors
Unique considerations	Rigid eye protection for ipsilateral eye and careful head positioning
Antibiotics	Cefazolin 1 g iv preop

Surgical time	1–3 h
Closing considerations	Muscle relaxation when mobilizing cuff and during closure. Arm in sling and swathe, or abduction pillow for large tears. Immobilizer should be positioned prior to awakening patient to minimize potential for rupture of repair.
EBL	200–400 mL
Postop care	Maintenance of position in sling and swathe; no active motion of shoulder girdle for 2 d–6 wk, depending on procedure.
Mortality	Rare
Morbidity	Infection: 1–5% Axillary nerve damage: < 2% Musculocutaneous nerve damage: < 2% Breakage of instruments: < 1% Brachial plexus damage (position-dependent) Suprascapular nerve at risk for RC mobilization
Pain score	5–8

Patient Population Characteristics

Age range	Rotator cuff tears > 40 yr (younger for athletes)
Male:Female	3:1
Incidence[3,4]	5–30% of general population affected by RC and acromial conditions, depending on age, thickness of tear, associated conditions
Etiology	Age-related; trauma (70% involved in light work)
Associated conditions	Bursitis; tendinitis; impingement; RC disease (especially in first-time glenohumeral dislocations > 40 yr); diabetes and renal failure; hypermobility

Anesthetic Considerations

See Anesthetic Considerations following Surgery for Shoulder Instability, p. 944.

Suggested Readings

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7. Neer CS II: Impingement lesions. *Clin Orthop* 1983; 173:70–7.

8. Peterson CA II, Altchek DW: Arthroscopic treatment of rotator cuff disorders. *Clin Sports Med* 1996; 15(4):715–36.

9. Schlegel TF, Burks RT, Marcus RL, et al: A prospective evaluation of untreated acute grade III acromioclavicular separations. *Am J Sports Med* 2001; 29(6):699–703.

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11. Yamaguchi K, Ball CM, Galatz LM: Arthroscopic rotator cuff repair: transition from mini-open to all-arthroscopic. *Clin Orthop* 2001; 390:89–94.

Surgery for Shoulder Instability

Surgical Considerations

Description: Shoulder instability is classified as multidirectional (MDI)/atraumatic, or unidirectional/traumatic.

MDI is associated with generalized ligamentous laxity (e.g., Ehlers Danlos or Marfan syndromes, or idiopathic), and is treated primarily nonoperatively with physical therapy. Open or arthroscopic **capsular shift** is performed for recalcitrant cases. This involves "plication" of the capsule and/or labrum to decrease the capsular volume of the shoulder. Patients with MDI, known as "voluntary dislocators," frequently have psychiatric disorders and are very poor candidates for surgery.

Traumatic instability is usually anterior and is quite common in the young, active population. The shoulder is the most commonly dislocated joint. Recurrent dislocation in young, active patients is common (80–90%) and is associated with avulsion of the capsule/labrum from the anterior-inferior glenoid rim (Bankart lesion). The population undergoing a **Bankart repair** is almost invariably young and healthy. Older first-time dislocators (age >50 yr) more commonly sustain rotator cuff (RC) tears or fractures, which do not result in chronic instability, but may require operative reduction and RC repair or fracture fixation. Posterior traumatic dislocation is much less common and is associated with high-energy trauma, seizures, or electrocution.

Instability surgery is often preceded by exam under anesthesia and arthroscopic examination, either in the beachchair or lateral decubitus position. The essential feature of instability surgery, whether arthroscopic or open, is the reattachment of the anterior inferior capsulolabral complex back to the rim of the glenoid, thus re-establishing the normal "bumper" effect of the anterior-inferior labrum and decreasing the capsular volume of the shoulder. Nonanatomic procedures (reconstructive) are much less common, but are still performed occasionally. These include transfer of the coracoid process to the anterior glenoid rim (**Bristow or Latarjet procedure**).

The **open Bankart repair** is performed in the beachchair position using the deltopectoral approach, with the interval between the deltoid and pectoralis major. The subscapularis (anterior RC muscle) lies just anterior to the joint capsule (Fig. 10.2-4), and this is either detached from its insertion or split. The capsule may then be opened to visualize the joint and rim of the glenoid. The glenoid rim is decorticated, providing bleeding bone to promote healing, and the anterior capsule is reattached through drill holes in the glenoid or with suture anchors. The capsule often is imbricated (overlapping folds) if it is redundant.

The shoulder and deltoid are highly vascular; however, bleeding is usually slight, with careful surgical technique. Major nerves are close but out of the plane of the operative field. The **musculocutaneous nerve** may be stretched by excessive medial retraction of the coracobrachialis (especially if a coracoid osteotomy is used) and the **axillary nerve** may be injured if the surgeon strays too far inferiorly.

If a **subscapularis-releasing technique** is used, the muscle is reattached and must be protected postop. External rotation of the shoulder is prevented for several weeks while the repair heals, and the surgeon prefers that the patient remain anesthetized until a shoulder immobilizer is applied.

The **arthroscopic Bankart repair** is similar to the open procedure but is performed through two anterior portals with the scope coming in posteriorly. This procedure is less painful postop and allows for more rapid rehabilitation, because the subscapularis is

not detached.

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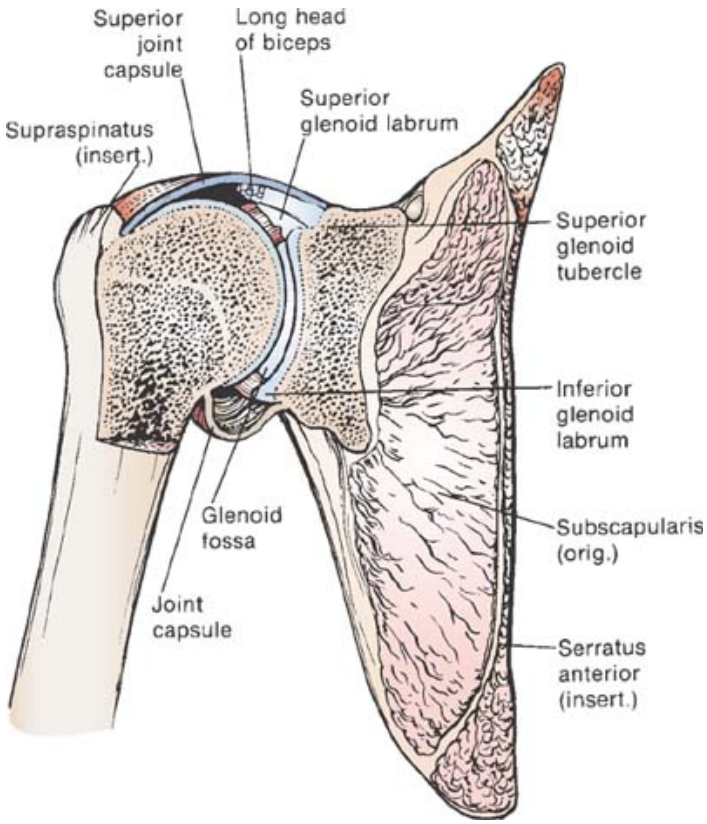

Figure 10.2-4. 4. Cross section of the joint: The joint capsule is redundant inferiorly to allow abduction. The long head of the biceps tendon traverses the joint. The tendon is surrounded by synovium and, therefore, is anatomically intracapsular but extrasynovial. (Reproduced with permission from Hoppenfeld S, deBoer P: *Surgical Exposures in Orthopaedics: The Anatomic Approach,* 2nd edition. Lippincott Williams & Wilkins, 1994.)

Open surgery for posterior dislocation is similar to the open Bankart repair, but it is done in the lateral position and utilizes the interval between the infraspinatus and teres minor. The RC attachment is preserved, but the posterior deltoid is detached and must be protected postop.

Usual preop diagnosis: Recurrent traumatic anterior or posterior instability; MDI; fracture dislocation

Summary of Procedures

	Open	Arthroscopic
Position	Beachchair for anterior; lateral decubitus for posterior	Lateral decubitus or beachchair
Incision	Deltopectoral (anterior); posterior approach (posterior)	Multiple small portals
Special instrumentation	Arthroscopic shaver; suture anchors; glenoid and humeral instrumentation	+ arthroscopic instruments for suture passing and knot-tying
Antibiotics	Cefazolin 1 g iv preop if bone work performed.	
Surgical time	2–4 h	
Closing considerations	Continuous anesthesia until application of sling and swathe or abduction pillow	
EBL	200–400 mL	Minimal
Postop care	No active motion for 6 wk	
Mortality	Minimal	

Morbidity	Axillary nerve palsy: 15% (may be pre-existing) Suprascapular nerve injury	
Pain score	8	5

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Patient Population Characteristics

Age range	15–35 yr
Male:Female	2:1
Incidence	Common
Etiology	Trauma; hypermobility; Sz
Associated conditions	RC tears (> 50 yr); hypermobility syndrome; Sz disorder; Hill-Sachs lesion (humeral head defect) may require bone grafting; superior labral tears; in most axillary nerve palsies from the injury; iatrogenic (rare)

Anesthetic Considerations

(Procedures covered: shoulder arthroscopy; surgery for acromial impingement, RC tears, and AC disease; surgery for shoulder dislocations or instability)

Preoperative

Typically, three patient populations present for repair of RC tears or shoulder arthroscopy: (a) healthy post-trauma, (b) nonrheumatoid arthritic, and (c) rheumatoid arthritic. Individuals presenting for repair of shoulder dislocations also may include those with a joint hypermobility syndrome (e.g., Marfan or Ehlers-Danlos) or Sz disorder patients.

Respiratory	Arthritic patients may exhibit Sx of pleural effusion or pulmonary fibrosis. Hoarseness may indicate cricoarytenoid joint (CAJ) involvement → difficult intubation. (See Anesthetic Considerations for Wrist Procedures, p. 914.) Seizure disorder patients who suffer from recurrent shoulder dislocation as a result of frequent grand mal Sz also may suffer from occult aspiration pneumonia or pneumonitis. **Tests:** Consider CXR; PFTs; ABGs in debilitated rheumatoid patients
Cardiovascular	Arthritic patients may suffer from chronic pericardial effusions, valvular disease, and cardiac conduction defects. Patients presenting for shoulder stabilization because of joint hypermobility syndromes are likely to have valvular dysfunction and are vulnerable to aortic dissection 2° HTN. These patients may require antibiotic prophylaxis for bacterial endocarditis. **Tests:** Consider ECG, ECHO in patients with severe rheumatoid arthritis. Recent ECHO to assess valve function and aortic root size indicated in most patients with Marfan syndrome.
Neurological	Arthritic patients may have cervical or lumbar radiculopathies that should be documented carefully preop. For example, head flexion may cause cervical cord compression. Patients with severe Sz disorders can suffer from recurrent shoulder dislocations 2° frequent violent grand mal Sz. Such patients should be treated maximally for Sz disorder prior to elective surgery. Be aware that as many as 15% of shoulder dislocations can be accompanied by

	axillary nerve palsy, which should be documented carefully preop. **Tests:** Consider C-spine radiographs to r/o occult subluxations in arthritic patients with neck complaints or upper extremity radiculopathy. Verify therapeutic levels of antiepileptic medication in Sz disorder patients.
Musculoskeletal	Arthritic patients may have limited neck and jaw ROM and may require fiber optic intubation techniques. Bony deformities or muscle contractures may necessitate special attention to positioning. Patients with joint hypermobility syndromes presenting for shoulder surgery also may suffer other joint dislocations 2° positioning problems.
Hematologic	Virtually all patients will be on some type of anti-inflammatory medication that may result in anemia or Plt inhibition. Ideally, patients should D/C NSAIDs at least 5 d preop; aspirin, 7 d. In addition, selected patients with Ehlers-Danlos are known to have severe coagulation defects that may preclude the use of regional anesthesia. **Tests:** A coag profile is mandatory in Ehlers-Danlos patients.
Endocrine	Rheumatoid patients may be on oral corticosteroids and may require supplemental perioperative steroids (e.g., 100 mg hydrocortisone q 8 h iv) to treat adrenal suppression, although the routine use of "stress-dose steroids" has been questioned.
Laboratory	Hb/Hct (in healthy patients); other tests as indicated from H&P. Patients with Ehlers-Danlos syndrome should always have banked blood available for surgery, except for the most trivial of procedures.
Premedication	Mild-to-moderate premedication (e.g., in adults, midazolam 1–2 mg iv, fentanyl 50–100 mcg iv, titrated to effect) is often desirable before placement of a regional block.

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Intraoperative

Anesthetic technique: GETA or regional anesthesia (interscalene block), or a combination of the two techniques, can be used. A suprascapular block (when interscalene block is contraindicated) can be used for intraop → postop pain control in arthroscopic shoulder procedures. When logistically feasible, a combined technique is ideal. Unless contraindicated, a long-acting local anesthetic should be used in regional anesthesia for shoulder surgery to ameliorate postop pain.

General anesthesia:

Induction	Standard induction (see p. B-2). Arthritic patients may require awake fiber optic intubation (see p. B-5).
Maintenance	Standard maintenance (see p. B-2).
Emergence	Management of emergence and extubation should be routine, except in difficult airway cases which require awake extubation. Patients should remain anesthetized until the shoulder is immobilized.

Regional anesthesia:

Local anesthetics	2% lidocaine or 1.5% mepivacaine have similar onset times (10–15 min), and similar duration (4–6 h). If extended postop pain control is desired, 0.5% bupivacaine, or 0.5% ropivacaine (each with epinephrine 1:400,000) can be used. Onset is usually within 30 min, with duration up to 10–12 h. Ropivacaine may be preferred for peripheral nerve block due to its decreased cardiotoxicity.

Interscalene block	Anesthetics and doses (epinephrine [2.5–5 mcg/mL]) should be added to local anesthetic whenever possible to decrease peak plasma concentrations: • 2% lidocaine or 1.5% mepivacaine 30 mL for procedures ≥ 2.5 h. • 0.5% bupivacaine, levobupivacaine, or ropivacaine 30 mL for procedures lasting > 2.5 h. The skin on the top of the shoulder (C3-C4) and the medial aspect of the upper arm (T2) often require separate subcutaneous field blocks. Phrenic nerve block → hemidiaphragmatic paralysis is an inevitable consequence of the interscalene block, which may not be tolerated by patients with significant preexisting respiratory compromise. Major complications, such as total spinal or pneumothorax resulting from interscalene block, are extremely rare; therefore, this technique is suitable for use in outpatients. Interscalene block is contraindicated in patients with contralateral recurrent laryngeal nerve or phrenic nerve palsy (e.g., post CABG). If sedation is needed, midazolam (0.5–1.0 mcg boluses), alfentanil (0.125–0.25 mcg/kg/min by infusion) or propofol (50–100 mg/kg/min by infusion), given initially in subanesthetic doses and thereafter titrated to effect, are good choices.	
Blood and fluid requirements	Minimal-to-moderate blood loss IV: 18 ga × 1 NS/LR @ 1.5–3 mL/kg/h	IV catheter placed in contralateral upper extremity.
Monitoring	Standard monitors (see p. B-1). ± Precordial Doppler ± Arterial line	BP cuff should be placed on the arm for beach chair procedures. To help detect VAE, consider precordial Doppler monitoring when semisitting position used. Consider intraarterial BP monitoring for patients with hypermobility disorders because of risk for aortic dissection 2° HTN.
Positioning	and pad pressure points. eyes. ↑ VAE risk in semisitting position	Postural ↓ BP is the most common complication of the semisitting position. Changing to this position gradually can help prevent ↓ BP, as can the use of antiembolism stockings, plus fluid-loading the patient. Marfan and Ehlers-Danlos patients require very gentle positioning to prevent joint dislocations.
Interscalene block complications	Total spinal Accidental epidural injection Local anesthetic toxicity (Sz/dysrhythmias) Stellate ganglion block (Horner's syndrome) Laryngeal nerve block Phrenic nerve block Pneumothorax Persistent paresthesia	Resuscitative equipment, including airway management tools, should be immediately available. When possible, nerve blocks should be performed in responsive and cooperative patients to minimize complications.
Other complications	↓ BP during surgical prep and positioning	May last ≥ 6 wk. ↓ BP during long surgical preps normally can be avoided by using light inhalation anesthesia (e.g., isoflurane 0.3–0.5%) to ensure amnesia, with moderate muscle relaxation to prevent bucking on the ETT, and maintaining adequate hydration. Antiembolism stockings will help prevent venous pooling in lower limbs.
	Cardiac dysrhythmia VAE	Dysrhythmias may be 2° to irrigation fluids containing epinephrine.

(Print pagebreak 946)

Postoperative

Pain management	PCA (see p. C-3) or regional block techniques.	Combined regional-general anesthetic techniques are excellent for shoulder procedures, especially with respect to postop pain management.
Tests	None indicated routinely.	

Suggested Readings

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(Print pagebreak 947)
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19. White RH: Preoperative evaluation of patients with rheumatoid arthritis. *Semin Arthritis Rheum* 1985; 14(4):287–99.

Glenohumeral Shoulder Arthroplasty

Surgical Considerations

Description: Shoulder replacement is performed for pain associated with end-stage arthritis. Primary osteoarthritis (wear-and-tear arthritis) is much less common in the shoulder than in the weight-bearing joints, such as the hip and knee. The most common causes of shoulder arthritis requiring **total shoulder arthroplasty (TSA)** are osteoarthritis, rheumatoid arthritis; avascular necrosis (AVN); posttraumatic arthritis, and rotator cuff tear arthropathy. Most patients are older than 65 years.

TSA involves replacement of the humeral head with a stemmed prosthesis and resurfacing the glenoid with a polyethylene component. Both components may be cemented or uncemented, depending on the surgeon's preference. **Hemiarthroplasty** involves only replacement of the humeral side. This is indicated when the humeral head is involved primarily and the glenoid is in good condition, as in severe proximal humerus fractures, AVN of the humeral head, and some chronic dislocators. Replacement of the glenoid is contraindicated in the presence of an unreconstructable massive RC tear because eccentric forces lead to rapid loosening of the glenoid component. Some revision cases require glenoid bone grafting, which increases the complexity and potential blood loss.

Shoulder arthroplasty utilizes the beachchair position and the deltopectoral incision (Fig. 10.2-5). The deltopectoral interval is developed. The subscapularis insertion is incised, and the muscle is reflected medially. The capsule is incised and the joint exposed. The humeral head is dislocated anteriorly, and the head is removed with an oscillating saw. Reamers and broaches are used to prepare the proximal humerus for the prosthesis. If the glenoid is to be resurfaced, it is done before implantation of the final humeral component. The labrum is excised and a motorized reamer is used to remove the cartilage of the glenoid. Glenoid drill holes are made to conform to the back of the prosthesis. The glenoid prosthesis is cemented into place, with the component held in position manually until the cement hardens (15 min). Trial humeral components are placed, and the appropriate sizing of the head and stem are assessed. The final humeral component is inserted with or without cement. The joint is reduced, and the subscapularis is repaired. Skin closure is followed by placement of a sling or shoulder immobilizer. Postop management includes *(Print pagebreak 948)* early passive ROM, limiting active internal rotation, and passive external rotation until the subscapularis has healed. Additional limitations may be instituted in revision situations or if RC repair is performed.

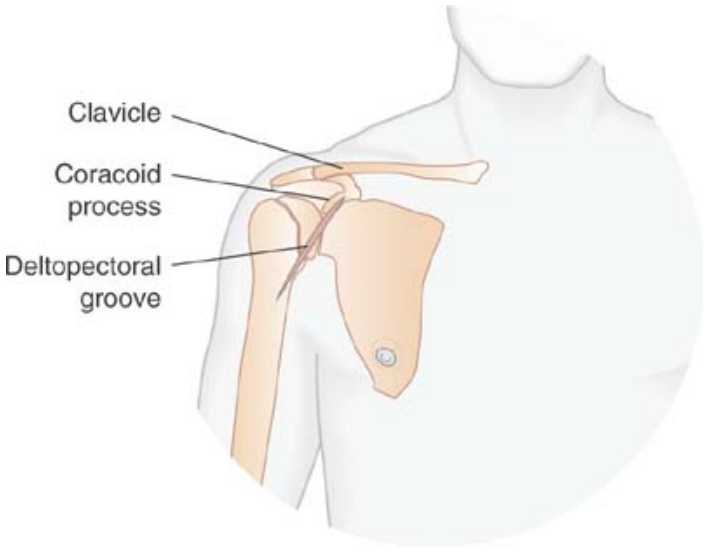

Figure 10.2-5. 5. Incision in the deltopectoral groove. (Reproduced with permission from Hoppenfeld S, deBoer P: *Surgical Exposures in Orthopaedics: The Anatomic Approach,* 2nd edition. Lippincott Williams & Wilkins, 1994.)

Usual preop diagnosis: Rheumatoid arthritis; posttraumatic arthritis; AVN; RC arthropathy; 4–part proximal humerus fracture

Summary of Procedures

Position	Semisitting, beachchair
Incision	Deltopectoral incision (Fig. 10.2-5) or extended incision for complex revision
Special instrumentation	Glenoid and humeral instrumentation, in addition to usual shoulder instruments; mixing and introduction of cement
Unique considerations	Systemic illnesses of the patient; systemic complications of use of cement in the patient; precautions in pregnant staff working with methylmethacrylate; usage of laminar flow or UV lighting for total joint precautions, depending on the surgeon's preference and capabilities of the OR.
Antibiotics	Cefazolin 1 g iv preop, and 48 h postop
Surgical time	2–5 h
Closing considerations	Drain; sling and swathe
EBL	200–1,000 mL
Postop care	Immediate passive motion. No active internal rotation for 6 wk.
Mortality	< 1%
Morbidity	Blood loss Nerve injury: Rare ↓ BP 2° cement: Rare Infection
Pain score	8

(Print pagebreak 949)

Patient Population Characteristics

Age range	45–80 yr
Male:Female	1:1
Incidence	Uncommon

Etiology	Osteoarthritis; inflammatory arthritis; trauma; avascular necrosis; systemic disease
Associated conditions	Inflammatory disease; systemic disease; alcoholism; RC pathology; arthritis and radiculopathy; cervical arthritis

Anesthetic Considerations

Preoperative

Typically, three patient populations present for shoulder arthroplasty: (a) healthy post-trauma, (b) nonrheumatoid arthritic, and (c) rheumatoid arthritic.

Respiratory	Rheumatoid arthritic patients may exhibit Sx of pleural effusion or pulmonary fibrosis. Hoarseness may indicate cricoarytenoid joint (CAJ) involvement → difficult intubation. (See Anesthetic Considerations for Wrist Procedures, p. 914.) **Tests:** Consider CXR; PFTs; ABGs in debilitated rheumatoid patients.
Cardiovascular	Rheumatoid arthritic patients may suffer from chronic pericardial effusions, valvular disease, and cardiac conduction defects. **Tests:** Consider ECG and ECHO in patients with severe rheumatoid arthritis.
Neurological	Arthritic patients may have cervical or lumbar radiculopathies that should be documented carefully preop. For example, head flexion may cause cervical cord compression. **Tests:** C-spine radiographs to r/o occult subluxations in rheumatoid patients with neck complaints or upper extremity radiculopathy
Musculoskeletal	Arthritic patients may have limited neck and jaw ROM that may require special intubation techniques. Bony deformities or muscle contracture may necessitate special attention to positioning.
Hematologic	Virtually all nontrauma patients will be on some type of anti-inflammatory medication that may result in anemia or Plt inhibition. Ideally, patients should D/C NSAIDs at least 5 d preop.
Endocrine	Rheumatoid patients may be on oral corticosteroids and may require supplemental perioperative steroids (e.g., 100 mg hydrocortisone q 8 h iv) to treat adrenal suppression, although the routine use of "stress-dose steroids" has been questioned.
Laboratory	Hb/Hct (healthy patients); other tests as indicated from H&P.
Premedication	Mild-to-moderate premedication (e.g., in adults, midazolam 1–2 mg iv, fentanyl 50–100 mcg iv, titrated to effect) is often desirable before placement of a regional block.

Intraoperative

Anesthetic technique: GETA or a combination of GETA and regional anesthesia can be used. An interscalene brachial plexus block in combination with GA is excellent for surgical procedures on the shoulder. Unless contraindicated, a long-acting local anesthetic should be used in regional anesthesia for shoulder surgery to ameliorate postop pain.

General anesthesia:

Induction	Standard induction (see p. B-2). Rheumatoid patients may require awake fiber optic intubation (see p. B-5).
	Standard maintenance (see p. B-2). Because of the typically long

Maintenance	duration of these cases, the opioid selected as part of the balanced anesthetic technique may be given by continuous infusion (e.g., iv sufentanil [0.25–1.0 mcg/kg/h]). Some surgeons prefer muscle relaxation beyond that provided by volatile anesthetic. The surgeon may request reduction in BP: careful in sitting position to maintain cerebral circulation.
Emergence	Management of emergence and extubation should be routine except in difficult airway cases that require awake extubation. Emergence from anesthesia should be delayed until patient's shoulder is securely immobilized in the sling and swathe to prevent undesired movement of the newly placed prosthesis.

(Print pagebreak 950)

Regional anesthesia:

Local anesthetics	Significant discomfort may be associated with this procedure; therefore, extended postop pain control is desirable. When a single-shot technique is used, 0.5% bupivacaine, or 0.5% ropivacaine (each with epinephrine 1:400,000) can be used. Onset is usually within 30 min, with duration up to 10–12 h. Ropivacaine may be preferred for peripheral nerve block, due to its decreased cardiotoxicity. For continuous catheter techniques, a postop infusion of 6–8 mL/h of 0.2% of any of these agents is appropriate.
Interscalene block	Typical anesthetics and doses. Note that epinephrine [2.5–5 mcg/mL] should be added to the local anesthetic whenever possible to decrease peak plasma concentrations: • 0.5% bupivacaine, or 0.5% ropivacaine, 30 mL. The skin on the top of the shoulder (C3-C4) and the medial aspect of the upper arm (T2) may require separate subcutaneous field blocks. Phrenic nerve block → hemidiaphragmatic paralysis is an inevitable consequence of the interscalene block, which may not be tolerated by patients with significant preexisting respiratory compromise. A continuous interscalene catheter may be placed for postop pain management. Major complications, such as total spinal or pneumothorax resulting from interscalene block, are extremely rare. Interscalene block is contraindicated in patients with contralateral recurrent laryngeal nerve or phrenic nerve palsy. If sedation is needed, midazolam (0.5–1.0 mg boluses), or propofol (25–100 mcg/kg/min by infusion), titrated to effect, are good choices.
Blood and fluid requirements	Moderate-to-significant blood loss IV: 16 ga × 1 NS/LR @ 1.5–3.0 mL/kg/h RBC recovery and reinfusion techniques (e.g., Cell Saver) are advisable because blood loss can be considerable. IV in nonoperative upper extremity.
Monitoring	Standard monitors (see p. B-1). Precordial Doppler Consider invasive, hemodynamic monitoring in the debilitated or elderly patient. Since VAE is a possible complication of the semisitting position, consider using precordial Doppler for cases done in this position.
Positioning	and pad pressure points. eyes. ↑ VAE risk Postural ↓ BP is the most common complication of the semisitting position. Changing patient to this position gradually can help prevent ↓ BP, as can the use of antiembolism stockings and fluid-loading the patient. Care with neck positioning. Check head position intraoperatively as shoulder traction may lead to injury.
Interscalene block complications	Total spinal Epidural anesthesia Local anesthetic toxicity (Sz/dysrhythmias) Stellate ganglion block (Horner's syndrome) Resuscitative equipment, including airway management tools, should be immediately available.

	Laryngeal nerve block Phrenic nerve block Pneumothorax Persistent paresthesia	May last ≥ 6 wk.
Other complications	Potential for embolic event ↓ BP during prep and positioning	Because of the increased risk of VAE during shoulder arthroplasty, N_2O may be D/C'd during placement of humeral component. Use of methylmethacrylate cement has been associated with the sudden onset of ↓ BP and even cardiac arrest, presumably due to profound vasodilation ± associated VAE. ↓ BP during long surgical prep usually can be avoided by using light inhalation anesthesia (isoflurane 0.3–0.5%) to ensure amnesia, with moderate muscle relaxation to prevent bucking on ETT, and maintaining adequate hydration.

(Print pagebreak 951)

Postoperative

Pain management	PCA (see p. C-3) or regional block/catheter	Combined regional-general anesthetic techniques are excellent for shoulder procedures, especially for postop pain management.
Tests	None indicated routinely.	

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19. White RH: Preoperative evaluation of patients with rheumatoid arthritis. *Semin Arthritis Rheum* 1985; 14(4):287–99.

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Shoulder Girdle Procedures

Surgical Considerations

Description: Trauma about the shoulder girdle in young patients ranges from athletic injuries to life-threatening trauma. Some of these injuries include common athletic injuries, such as **acromioclavicular joint separations,** which rarely require surgery unless there are associated **acromial** or **clavicular fractures. Posterior sternoclavicular dislocations** may warrant surgical stabilization if the trachea is compressed. **Clavicle fractures,** frequently associated with **scapular fractures,** occasionally require open reduction.

Scapular fractures involving the glenoid also may require surgical stabilization. Extreme fractures involving the shoulder girdle (**scapulothoracic dissociations**) include scapular fracture, clavicle fracture, subclavian or axillary artery disruption, and brachial plexus injury. These may coexist with **proximal humerus fractures,** rib fractures, and pneumothorax. In the older, debilitated patient, the most common injury is proximal humeral fracture, which may be amenable to surgical stabilization or may be so comminuted as to warrant hemiarthroplasty.

A displaced proximal humerus fracture may require open reduction internal fixation with a plate and screws or hemiarthroplasty through a deltopectoral approach utilizing a beachchair position (see Surgery for Shoulder Instability, p. 942, and Glenohumeral Shoulder Arthroplasty, p. 947). A displaced clavicle fracture may require open reduction internal fixation with a plate and screws utilizing a beachchair or supine position. A scapular body fracture would be stabilized with a plate and screws via a posterior approach utilizing a prone or lateral position (see Surgery for Shoulder Instability, p. 942). As with other shoulder procedures,

relaxation is necessary upon awakening the patient after the shoulder is placed into an immobilization device.

Usual preop diagnosis: Trauma about the shoulder girdle

Summary of Procedures

	Anterior	Posterior
Position	Semisitting or prone	Lateral decubitus (scapula)
Incision	Anterior, superior, or oblique for acromioclavicular; supraclavicular for clavicle; deltopectoral for proximal humerus and glenoid	Posterior lateral border or medial border of scapula, spinous scapula, depending on location
Special instrumentation	Plates and screws; tension band wiring; proximal humerus replacement for comminuted fractures	
Unique considerations	Multiple traumas warrant early stabilization; may require vascular repair and brachial plexus exploration.	
Antibiotics	Cefazolin 1 g iv	
Surgical time	2–10 h	
Closing considerations	Fracture-dependent; most commonly requires application of sling and swathe.	
EBL	200–1,200 mL or greater, depending on trauma	
Postop care	May require ICU for multiple-trauma patients; otherwise, early mobilization with physical therapy	
Mortality	Mortality dependent on associated conditions: Infection Neurologic injury Respiratory failure Massive blood loss Unrecognized pneumothorax Cardiac tamponade	
Morbidity	Nerve injury (axillary, brachial plexus) Stiffness Poor healing	Axillary and suprascapular
Pain score	6–10	6 (clavicle and AC joint) 8 (scapula and proximal humerus)

(Print pagebreak 953)

Patient Population Characteristics

Age range	15–80 yr, depending on nature of trauma
Male:Female	5:1
Incidence	Common
Etiology	Trauma
Associated conditions	Axillary nerve palsy; musculocutaneous nerve palsy; brachial plexus injury; arterial disruption in high-energy trauma; brachial and great vessel injuries and posterior sternoclavicular dislocation pneumothorax

Anesthetic Considerations

See Anesthetic Considerations following Brachial Plexus Surgery, p. 955.

Suggested Readings

1. Butters KP: Fractures and dislocations of the scapula. In *Fractures in Adults,* Vol II, 4th edition. Rockwood CA Jr, Green DP, Bucholz RW, et al., eds. Lippincott-Raven, Philadelphia: 1996, 1163–92.

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3. Craig EV: Fractures of the clavicle. In *Fractures in Adults,* Vol II, 4th edition. Rockwood CA Jr, Green DP, Bucholz RW, et al., eds. Lippincott-Raven, Philadelphia: 1996, 1109–62.

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5. Neviaser RJ: Injuries to the clavicle and acromioclavicular joint. *Orthop Clin North Am* 1987; 18(3):433–8.

6. Richards RR, Sherman RM, Hudson AR, et al: Shoulder arthrodesis using a pelvic-reconstruction plate. A report of eleven cases. *J Bone Joint Surg* [Am] 1988; 70(3):416–21.

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Brachial Plexus Surgery

Surgical Considerations

Description: Brachial plexus injuries occur most commonly in two groups: traumatic birth injuries and high-energy trauma. Surgery ranges from exploration with neurolysis, to repairs, to cable nerve grafting. Typically, the latter requires grafting with the sural nerve, and nerve pedicle transfer, such as transfer of the spinal accessory nerve to denervated paralyzed muscle, combined with muscle transfers. C5-C6 is most commonly injured in obstetrical (Erb's) palsy. Injuries in adults are more commonly closed-traction. Similar to obstetrical palsy, they occur with an outstretched, abducted arm with the neck rotated in the opposite direction. The most severe form includes complete avulsion at the preganglionic level, presenting with a Horner's syndrome, winging of the scapula, and a flail arm. *(Print pagebreak 954)* These are typically “supraclavicular” injuries, and have a poorer prognosis. Surgical exposure may proceed above the clavicle similar to an anterior neck dissection, or may require an extension below the clavicle. Occasionally, an osteotomy of the clavicle for extensive dissection is required. For axillary nerve dissection, a posterior approach also is used. Open injuries, such as gunshot or knife wounds, are typically “infraclavicular” and have a better prognosis. (See diagram of brachial plexus, Fig. 10.2-6.)

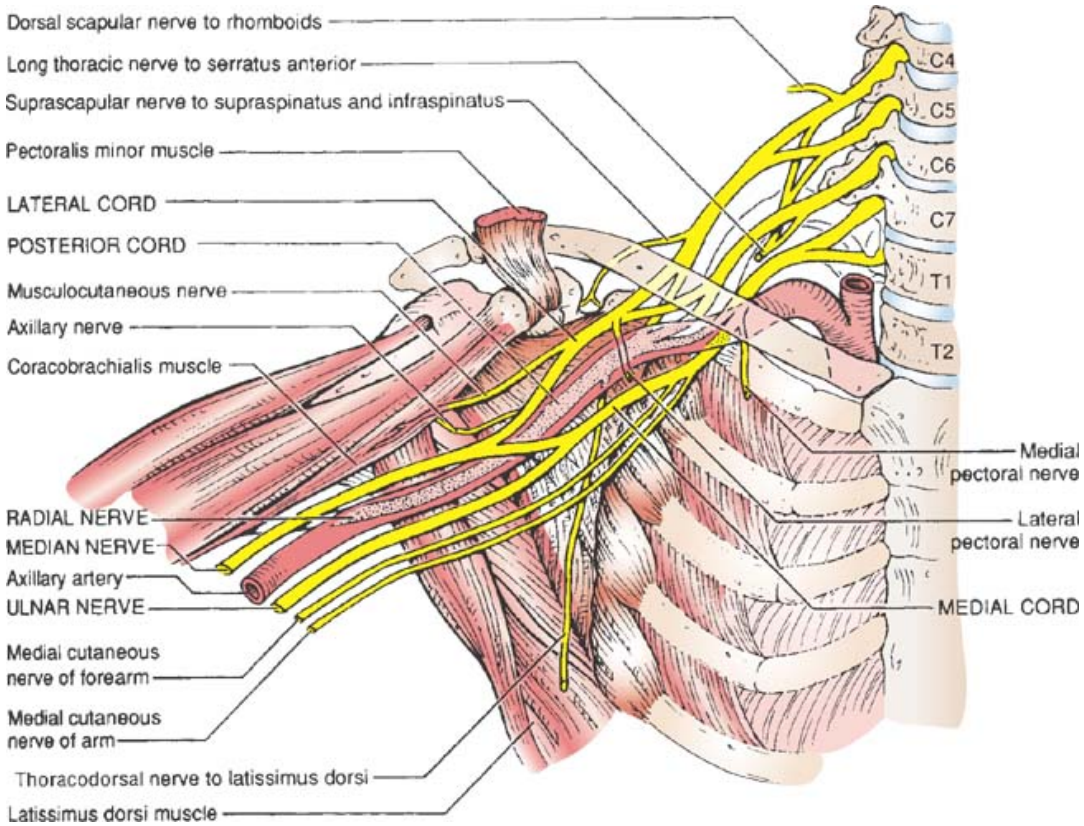

Figure 10.2-6. 6. Brachial plexus: Its division into supraclavicular and infraclavicular portions is apparent. The proximal origin of the dorsal scapular nerve and the long thoracic nerve are demonstrated. The T1 spinal nerve arises below the head of the 1st rib. The relation of the cords of the plexus to the axillary artery at the level of the coracoid process (origin of the pectoralis minor and coracobrachialis muscles) is illustrated. The posterior cord and the radial nerve behind the axillary artery are stippled for clarity. (Reproduced with permission from Tindall GT, Cooper PR, Barrow DL: *The Practice of Neurosurgery,* Vol III. Williams & Wilkins, Baltimore, 1996.)

Usual preop diagnosis: Obstetrical palsy; adult trauma—most commonly motorcycle accident

Summary of Procedures

Position	Lateral decubitus or semisitting
Incision	Supra- or infraclavicular, extensile to include deltopectoral incision. Clavicle osteotomy incision will provide for improved exposure. Supraclavicular incision used for supraclavicular brachial plexus.
Special instrumentation	Nerve stimulator
Unique considerations	Associated trauma
Antibiotics	Cefazolin 1 g iv preop
Surgical time	4–10 h
Closing considerations	Other incisions if nerve grafts obtained.
EBL	400–2,000 mL
Mortality	Minimal
Morbidity	Bleeding Hematoma Pneumothorax Clavicular nonunion
Pain score	8

(Print pagebreak 955)

Patient Population Characteristics

Age range	Infants and children: 3 mo–8 yr; adults: 20–40 yr
Male:Female	Adult: 5:1
Incidence	Infants: 0.3–8/1,000 births; adults: commonly associated with motorcycle accidents
Etiology	Obstetrical palsy; trauma
Associated conditions	None known

Anesthetic Considerations

(Procedures covered: shoulder girdle procedures; brachial plexus surgery)

Preoperative

With the exception of traumatic birth injuries, most of these patients are healthy males who have suffered major blunt or penetrating trauma. For the acute and subacute trauma victim, the major anesthesia-related concerns center on associated traumatic injuries. Many adult trauma victims with brachial plexus injuries will be operated on in the first few days after their injury. For infants (usually operated on at 6–12 mo), the major anesthesia-related concerns are those routinely associated with pediatric anesthesia (see Pediatric Orthopedic Surgery, p. 1354.). Approximately half of all trauma victims are intoxicated. The anesthesia-related implications of ethanol intoxication include: decreased anesthetic requirements, diuresis, vasodilation, and hypothermia.

Respiratory	As suggested by coexisting disease or acute trauma injuries. Look for evidence of occult chest injury, including pneumothorax (tachypnea, wheezing, ↓ BP, ↓ PaO_2 CXR changes) and pulmonary contusion (multiple rib fracture, ↓ PaO_2). **Tests:** Consider CXR and ABGs in victims of significant trauma; other tests as indicated from H&P.
Cardiovascular	As suggested by coexisting disease or acute trauma injuries. Look for evidence of occult cardiac or mediastinal injuries, such as myocardial contusion (e.g., ECG abnormalities typically consistent with ischemia) or great vessel rupture (e.g., widened mediastinum). **Tests:** Consider CXR (with NG tube in place to assess mediastinal widening) and ECG in victims of significant trauma; others as indicated from H&P.
Neurological	Victims of shoulder trauma are vulnerable to brachial plexus damage. Look for evidence of upper extremity nerve dysfunction and document any injuries preop. The possibility of closed-head injury also should be considered. **Tests:** Head CT prior to beginning a procedure under GA in a patient with evidence of head trauma.
Musculoskeletal	As suggested by coexisting disease or acute trauma injuries. The amount of force necessary to produce a brachial plexus injury mandates a C-spine series to r/o C-spine fracture in all victims of brachial plexus trauma.
Laboratory	In general, most victims of significant trauma are best served by obtaining a wide variety of baseline lab studies to screen for unrecognized injury. These studies generally should include: Hct; CBC; ABGs; UA; renal function tests; LFTs; serum amylase.
Premedication	None

(Print pagebreak 956)

Intraoperative

Anesthetic technique: GETA is preferred over regional techniques because of the unpredictable and prolonged length of these procedures and the need to evaluate brachial plexus function postop.

Induction	Rapid-sequence induction (see p. B-4) is mandatory in unscheduled cases, unless awake fiber optic intubation is performed (see Anesthetic Considerations for Thoracolumbar Neurosurgical Procedures, p. 122). C-spine fracture patients or those with facial injuries may require awake fiber optic intubation (see p. B-5) or other special airway techniques, as indicated from H&P. Hemodynamically unstable, acute-trauma patients can be induced more safely with etomidate (0.3–0.4 mg/kg iv) or ketamine (1–3 mg/kg iv).	
Maintenance	Balanced anesthesia with low-dose isoflurane (0.4–0.6%), iv sufentanil (0.25–1.0 mcg/kg/h), and N_2O in O_2 is suitable for stable patients. Hemodynamically unstable, acute-trauma victims undergoing emergency surgery are not likely to tolerate this regimen and are better served by using a combination of medications designed to have minimal hemodynamic consequences (e.g., fentanyl for analgesia, vecuronium for muscle relaxation, and scopolamine or midazolam for amnesia). N_2O is best avoided in the trauma patient. For brachial plexus surgery, some surgeons prefer minimal muscle relaxation after tracheal intubation so that a nerve stimulator can be used to help identify surgical anatomy.	
Emergence	Management of emergence and extubation should be routine except in difficult airway or full-stomach cases, which require that extubation be delayed until the patient's airway reflexes have returned and the patient is fully awake.	
Blood and fluid requirements	Significant blood loss IV: 14–16 ga × 1–2 NS/LR @ 1.5–3 mL/kg/h + replacement of blood loss @ 3 × volume Fluid warmer Airway humidifier	IV catheter placed in the nonoperative upper extremity is usually adequate in hemodynamically stable patients. Unstable, acute-trauma victims require a minimum of 2 large-bore iv catheters or large-bore central lines.
Monitoring	Standard monitors (see p. B-1). ± SSEP ± TEE	Invasive hemodynamic monitoring and TEE should be considered in acute, multiple-trauma victims. Some surgeons request SSEP to make continuous assessment of preop intact brachial plexus possible. When using SSEP monitoring, high doses of volatile anesthetic agents should be avoided because they adversely affect SSEP readings.
Positioning	and pad pressure points. eyes. VAE risk	Postural ↓ BP is the most common complication of the semisitting position, particularly during the surgical prep period. SCD or antiembolism stockings may be beneficial. VAE is a potential complication of this position.
Complications	Hemodynamic instability	Previously unrecognized injuries (e.g., pneumothorax, cardiac tamponade, intracranial bleeding) should be considered as a cause of unexplained intraop hemodynamic instability in all acute-trauma victims.
	Possible VAE	VAE risk is increased with patient in semisitting position.

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Postoperative

Complications	Sepsis ARDS	Many trauma victims survive the initial insult only to die later of sepsis or ARDS.
Pain management	PCA (see p. C-3).	
Tests	Based on concurrent injuries.	

Suggested Readings

1. Grundy BL: Intraoperative monitoring of sensory-evoked potentials. *Anesthesiology* 1983; 58(1):72–87.

2. Johnstone RE: Acute trauma with multiple injuries. *Curr Opin Anesthesiol* 2000; 13(2):175–9.

3. Leifert RD: Neurological problems. In *The Shoulder.* Rockwood CA Jr, Matsen FA III, eds. WB Saunders, Philadelphia: 1990, 750–8.

4. Nanakas AO: Injuries to the brachial plexus. In *The Pediatric Upper Extremity: Diagnosis and Treatment.* Bora FW Jr, ed. WB Saunders, Philadelphia: 1986, 247–58.

5. Thompson RW, Petrinec D, Toursarkissian B: I. Surgical treatment of thoracic outlet compression syndromes. II. Supraclavicular exploration and vascular reconstruction. *Ann Vasc Surg* 1997; 11(4):442–51.

Arm Surgery

Surgical Considerations

Description: Surgical procedures on the arm are primarily for trauma or tumor surgery. Other procedures include extended approaches from the shoulder for significant trauma or tendon transfer. Exploration of peripheral nerves, most commonly of the radial nerve, are also included in this category, as are distal extensile approaches from the elbow for trauma or for lateral epicondylitis (“tennis elbow”). Depending on the lesion or fracture, the incision is developed through an internervous or intramuscular compartment. Procedures include **excisional biopsy** for soft tissue or bone tumors of the arm; **tumor excision,** which may be marginal, wide, or radical, depending on the tumor encountered; **tendon transfers,** such as pectoralis transfer to replace biceps function, used primarily for brachial plexus injuries; and **fractures and nonunion fractures of the humerus.** Positioning and location of incision is dependent on the level of the pathology. For example, for fractures involving the proximal half of the humerus, the standard **deltopectoral incision** may be extended distally along the interval between the biceps and triceps on the lateral aspect of the arm. This approach requires a beachchair (Figure 10.2-7) or, occasionally, supine position. Distal-third fractures are best approached posteriorly with the **triceps-splitting approach.** Distal fractures that extend into the elbow joint often require an olecranon osteotomy to visualize the fractured joint surface. Posterior approaches to the distal humerus are performed in either the lateral or prone position.

Usual preop diagnosis: Trauma; tumor

Summary of Procedures

Position	Supine; semisitting position for extended deltopectoral; lateral decubitus or prone for distal humerus fractures
Incision	Anterolateral approach; posterior approach in the lateral decubitus or prone position
Special istrumentation	Plate and screws; external fixators; intramedullary rods; occasionally, methylmethacrylate cement for tumor surgery; sterile tourniquet for distal humerus; I.I. for fracture surgery
Unique considerations	CT-guided sclerotherapy preop for vascular tumors; longitudinal incisions for biopsy and tumor excisions (not

	violating fascial planes)
Antibiotics	Cefazolin 1 g iv preop
Surgical time	45 min–6 h
Closing considerations	Drain frequently required.
EBL	Minimal—500+ mL, depending on pathology
Mortality	Varies with pathology
Morbidity	Bleeding Shoulder stiffness Nerve injury
Pain score	4–9

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Patient Population Characteristics

Age range	Varies with procedure
Male:Female	Varies with procedure
Incidence	Procedure-dependent
Etiology	Fractures; nerve entrapment (radial) following trauma; tumors
Associated conditions	Radial or ulnar nerve injury with humeral fractures

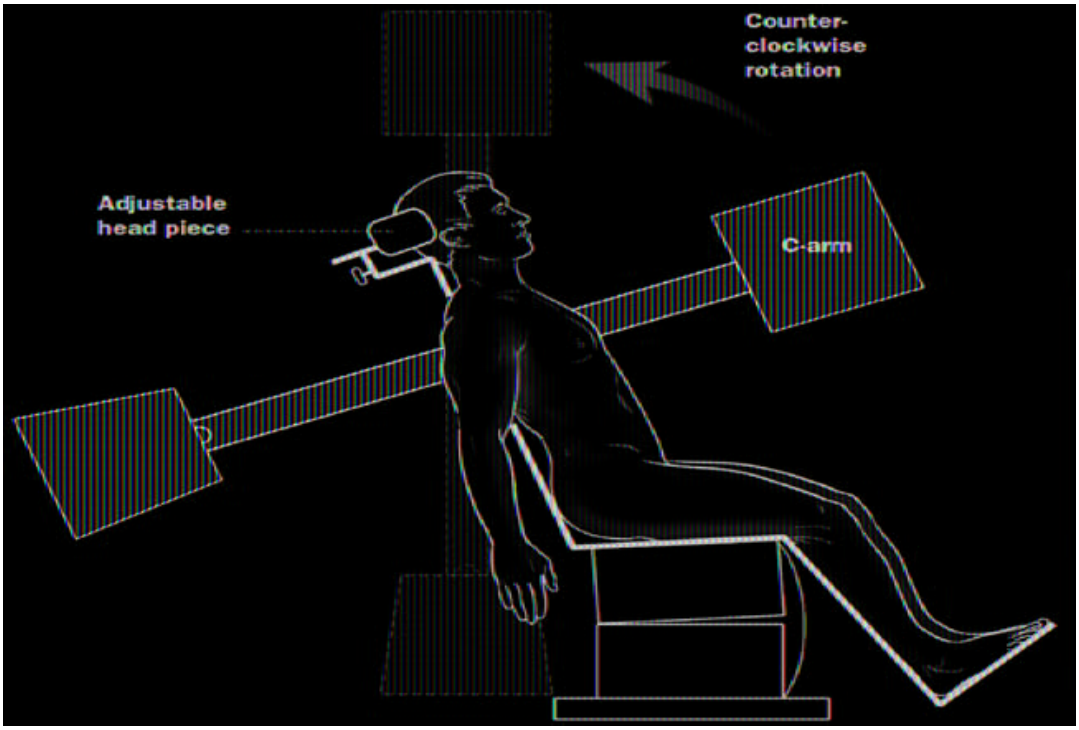

Figure 10.2-7. 7. Beachchair positioning for shoulder surgery. Image intensification may be needed for intraoperative radiography (e.g., fracture surgery). (Reproduced by permission from Robinson CM, Page RS. Severely impacted proximal humerus fractures. *J Bone Joint Surg* 2004; 86:143-55.)

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Anesthetic Considerations

Preoperative

Patients presenting for arm procedures are relatively young and otherwise healthy. Most of these patients present for elective repair of a traumatic injury. The preop workup is appropriate to patient's medical history. Some arm procedures, such as repair of a compound fracture, require immediate attention and necessitate emergency surgery and full-stomach considerations (p. B-4).

Laboratory	Hb/Hct (healthy patients); other tests as indicated from H&P.
Premedication	Mild-to-moderate premedication (e.g., in adults, midazolam 1–2 mg iv, fentanyl 50–100 mcg iv, titrated to effect) is often desirable before placement of a regional block.

Intraoperative

Anesthetic technique: GA or regional anesthesia, or a combination of the two, can be used for surgical procedures on the arm. A brachial plexus block via the supraclavicular, infraclavicular or axillary approach is excellent for procedures on the distal arm. The interscalene approach to the brachial plexus is suitable for more proximal humerus procedures. Regional anesthesia alone is a means of avoiding the risk of aspiration pneumonitis associated with GA in the patient with a full stomach. Procedures longer than 3 h usually require general anesthesia in addition to regional. Regional anesthesia with sedation is usually well tolerated in shorter procedures.

General anesthesia:

Induction	Standard induction (see p. B-2) except in acute-trauma patients, where rapid-sequence induction is appropriate (see p. B-4).
Maintenance	Standard maintenance (see p. B-2).
Emergence	Management of emergence and extubation should be routine, except in difficult airway cases, which require awake extubation. Skin closure is frequently followed by application of a splint; patient should remain anesthetized during splinting procedure.

Regional anesthesia:

Local anesthetics	2% lidocaine or 1.5% mepivacaine have similar onset times (10–15 min), and similar duration (4–6 h). If extended postop pain control is desired, 0.5% bupivacaine, or ropivacaine (each with epinephrine 1:400,000) can be used. Onset is usually within 30 min, with duration up to 10–12 h. Ropivacaine may be preferred for peripheral nerve block due to its decreased cardiotoxicity.
Brachial plexus block	Supraclavicular, infraclavicular and axillary approaches are all suitable. Supraclavicular or infraclavicular blocks are better tolerated in fracture patients, because the arm need not be moved. Ultrasound guidance can improve speed and comfort during block placement. A peripheral nerve catheter may be placed to prolong pain relief in appropriate patients. • 2% lidocaine or 1.5% mepivacaine 30 mL for procedures lasting ≥ 2.5 h. • 0.5% bupivacaine, or ropivacaine 30 mL for procedures lasting > 2.5 h. If sedation is needed, midazolam (0.5–1.0 mg boluses), alfentanil (0.125–0.25 mcg/kg/min by infusion), or propofol (25–100 mcg/kg/min by infusion), titrated to effect, are good choices.