INTRODUCTION

Elective elbow surgery is usually an outpatient procedure except for more complex reconstructions performed for arthritis or posttraumatic conditions. Common outpatient procedures include ulnar nerve transposition for cubital tunnel syndrome, procedures for lateral epicondylitis, olecranon bursectomy, arthroscopy with radial head resection or other joint debridement for arthritis, and arthroscopy for loose-body removal and joint debridement. Complex procedures that require postoperative hospitalization include capsule release for joint contractures, corrective osteotomy for malunion, and joint replacement. The duration of outpatient procedures range from 30 min to 2 h. The majority of patients undergoing these procedures are healthy. Conversely, some patients undergoing complex elbow surgery may be debilitated from rheumatoid arthritis and/or advanced age.

Biomechanics of the Elbow Joint

The elbow joint is essentially a hinge, with the primary articulation between the trochlea of the distal humerus and the olecranon of the ulna, which allows approximately 140 degrees flexion. The elbow also includes the proximal articulation between the radius and ulna and that between the radius and the capitellum of the distal humerus. These articulations in combination with the distal radioulnar joint allow forearm rotation, which is about 160 degrees. Because the elbow's articulations are highly congruous, this joint is particularly prone to stiffness from articular damage due to trauma or arthritis. Ligament complexes on the medial and lateral aspects of the elbow provide additional joint stability. Powerful muscles originating from the humerus and shoulder region drive elbow motion. These muscles include the biceps, brachialis, and triceps. Other muscles that originate from the distal humerus contribute to both elbow and forearm movement, including the brachioradialis and the forearm flexor and extensor muscle wads. Although less common than stiffness, joint instability from cumulative ligamentous injury (especially of the medial collateral ligament) is a well-recognized condition in throwing athletes.

ANATOMIC CONSIDERATIONS OF ELBOW SURGERY

Surgical Anatomy

The ulnar, median, and radial nerves that supply both motor and sensory innervation to the forearm and hand cross the elbow joint at different locations (Fig. 8-1). Several cutaneous nerves also cross the elbow or terminate near it. The terminal branches of the medial, lateral, and posterior brachial cutaneous nerves supply cutaneous sensation about the elbow. In addition, branches of the medial, lateral, and posterior antebrachial cutaneous nerves may have early branches about the elbow. Thus, there is abundant and redundant cutaneous innervation to the elbow region. Following Hilton’s law that any nerve crossing a joint innervates the joint, the elbow joint is also abundantly supplied, with the potential for any of the above-named nerves to supply branches to the joint.

The ulnar nerve has minimal protection by soft tissue at the elbow. It lies behind the medial intermuscular septum in the midarm and then passes through a fibroosseous groove behind the medial epicondyle. The depth of the
groove varies among individuals. Subluxation of the nerve over the epicondyle is common during elbow flexion; in some cases the nerve may fully dislocate with a recognizable snap. Thus, the nerve should be palpated with the elbow in different positions of flexion before proceeding with a local nerve block or surgical procedure. The nerve passes beneath a fibrous arch, called Osborne's ligament, at the origin of the flexor carpi ulnaris. The ulnar nerve is particularly prone to acquired neuropathy, which is termed cubital tunnel syndrome. Neuropathy can be due to chronic compression, traction, or mechanical irritation at the elbow.

A compression neuropathy about the elbow rarely involves the median nerve (pronator syndrome) or radial nerve (radial tunnel syndrome). The median nerve travels along the brachial artery through the medial aspect of the arm anterior to the medial intermuscular septum. At the elbow, the nerve briefly emerges from beneath the biceps muscle medial to its tendon and then passes under the fibrous arch (lacertus fibrosus), which extends medially from the tendon. It then dives deep to travel beneath forearm flexor muscles. Nerve compression can occur anywhere along its course from just above the elbow to the midforearm. When a needle is being inserted in the antecubital region for vascular access, care must be taken to avoid nerve injury.

The radial nerve spirals around the posterior aspect of the midhumerus to emerge on the lateral aspect of the arm anterior to the lateral intermuscular septum. It then passes beneath the forearm extensor muscle mass. After giving off branches to the most proximal of these muscles, it divides into the posterior interosseous nerve (PIN) and the superficial branch of the radial nerve (SRN). The radial nerve is susceptible to traumatic injury anywhere along its course from the midhumerus to the proximal forearm.

With the exception of the lateral antebrachial cutaneous nerve, the sensory nerves pass across or terminate in the regions of the elbow corresponding to their names. For example, the branches of the medial antebrachial cutaneous nerve course over the medial aspect of the elbow near the medial epicondyle. The lateral antebrachial cutaneous nerve is a branch of the musculocutaneous nerve. It emerges from the lateral margin of the biceps tendon near the elbow and passes through the forearm toward the middorsal wrist.

**Surgeon Operations**

**Positioning on the Operating Table**

Patient positioning for elbow surgery varies widely and includes supine, lateral decubitus, and prone positioning. The choice of position depends on the surgical approach, patient comfort and tolerance, and surgeon’s preference. For example, elbow arthroscopy can be performed in any of the above three positions. Both the anesthetic and surgical teams should be involved in deciding patient positioning. The patient’s physical limitations and anesthetic risks may influence this decision. The surgeon may be able to alter the initial surgical plan to meet these requirements. The supine position is preferred for complex arthritis procedures. In some cases, the arm is positioned over the chest with the forearm resting on a bolster. The location of the bolster and forearm must be checked during surgery as they may slip toward the patient’s face and ventilation tube. In other cases, the arm is placed on a “hand table” attached to the patient’s bed. The lateral decubitus position is popular for arthroscopy. The upper arm is positioned over a support attached to the operating table, which allows the elbow to flex through 90 degrees. Proper padding is necessary to protect against nerve compression at susceptible sites, such as the peroneal nerve at the knee. In addition, a chest pad is necessary to support and protect the shoulder and brachial plexus. The prone
position is popular for both arthroscopy and complex procedures performed through a posterior elbow approach.

**Tourniquet**

A tourniquet on the upper arm is typically used to improve visualization. In some cases, a sterile tourniquet may be placed after the patient has been draped to ensure surgical access in the upper arm. The potential for tourniquet-induced pain should be considered preoperatively and during the procedure. The generally accepted safe duration for a tourniquet on an upper extremity is 2 h. For longer procedures, the tourniquet may be deflated for approximately 15 min to allow temporary blood flow and then reinflated.

**Common Basic Elbow Procedures**

Common disorders for routine elective surgery of the elbow are cubital tunnel syndrome, chronic olecranon bursitis, lateral epicondylitis, loose-body removal, and mild arthritis. Procedures for these conditions are typically performed through incisions 5 to 10 cm in length and extended to or through the elbow capsule; they may involve small amounts of bone resection. Elbow arthroscopy is rapidly increasing in popularity for the treatment of many conditions. It usually requires multiple small portals around the entire joint for insertion of the scope and other instruments. As previously discussed, the patient can be in the supine, prone, or lateral decubitus position. Because elbow arthroscopy involves a higher risk of nerve injury than other arthroscopic procedures, some surgeons request that regional anesthesia not be used so that nerve function can be assessed accurately immediately after surgery. The duration of arthroscopy ranges from 30 min to 2 h. Loose-body removal may be done quickly, while capsule release for stiffness and joint debridement for arthritis require longer surgical times.

Because these are elective and ambulatory procedures, they should probably be postponed if the patient has substantial medical problems that are not under proper control. The surgeon often requests a single dose of prophylactic antibiotics, usually cephalixin, timed so that the blood level of the drug reaches its peak at the time of the surgical incision (see Chap. 3). When regional anesthesia is used, excessive sedation may cause the patient to become disoriented and uncooperative, which is particularly problematic if the patient is in the lateral decubitus or prone position. Minimizing sedation also allows more rapid discharge from the postsurgical recovery unit. Many surgeons and anesthesiologists prefer postoperative use of nonsteroidal anti-inflammatory agents, such as ketorolac (30 mg), given by intravenous injection in younger healthy patients. Discharge analgesics range from ibuprofen to oral narcotics, sometimes in combination with mild sedatives such as hydroxyzine.

A bulky dressing to allow for swelling is commonly applied and an elbow splint is sometimes used. Nearly all patients will be discharged with an arm sling. If regional anesthesia has been used, a well-fitted sling should be mandatory (see Chap. 3). Depending on the extent of the surgery, light use of the arm and hand for daily activities and clerical work is often permitted by the second postoperative day. Patients return after 10 to 14 days for wound inspection, removal of sutures, and instructions for progressive use of the hand. If oral narcotics are still being used, they are discontinued at this time. The need for formal rehabilitation depends on the risk of postoperative joint stiffness, which is greater in patients undergoing surgery for arthritis or other substantial intraarticular conditions.

**Complex Elbow Procedures**

Complex elbow surgery is most commonly performed for trauma, arthritis, and posttraumatic stiffness. Trauma involves all age groups, with causes ranging from simple falls in the elderly to severe motor vehicle injuries in young adults. Many traumatic injuries are emergent, including open fractures with severe comminution and closed fractures in children with neurovascular disorders. The elbow is susceptible to osteoarthritis, inflammatory arthritis, and posttraumatic arthritis. Stiffness and pain are the primary symptoms of arthritis. Stiffness and contractures can result from isolated soft tissue injury such as an elbow dislocation or a simple radial head fracture. Excessive immobilization contributes to the stiffness. Because loss of elbow motion can be functionally debilitating, patients are interested in treatment that will not only relieve pain but also restore motion.

As elbow fractures are discussed elsewhere (See Chap. 16), this section highlights the treatment of severe posttraumatic stiffness and arthritis. The most common open surgical procedure for moderate arthritis and posttraumatic stiffness is capsule resection with or without partial bone resections, such as the radial head, tip of the olecranon, or tip of the coronoid process. Joint replacement is indicated for severe arthritis in low-demand patients. Patient with arthritis, especially those with multiple joint involvements, commonly take anti-inflammatory medications, which increase the risk of excessive bleeding during surgery and anesthetic procedures.

In addition, rheumatoid patients commonly have morbidities associated with systemic arthritis and chronic use of steroids and immunosuppressive medications. Special needs related to chronic corticosteroid use should be recognized and appropriately managed by additional perioperative dosage. Such patients may also need additional padding on the operating table to reduce the risk of pressure sores. Preoperative prophylactic antibiotics are nearly always utilized, especially
when the patient uses immunosuppressive drugs. Regional anesthesia is typically preferred to reduce the overall anesthetic risk and improve postoperative pain management. A continuous nerve block is used during the initial postoperative period and extended throughout the hospitalization, which is typically 48 h.

For capsule resection and extensive joint debridement, the patient is supine with the extremity either positioned on a hand table or flexed over the chest, depending on the surgical approach and surgeon’s preference.

**Elbow Arthroplasty**

**Surgical Options**

Interpositional and implant are the two types of arthroplasty used. *Implant arthroplasties* are engineered as “constrained,” “semiconstrained,” and “unconstrained,” depending on the rigidity with which the humeral component is fixed to the ulnar component. Because of the tendency to loosen and break, the constrained prosthesis is rarely used. *Interpositional arthroplasty* refers to the placement of fascia between the articular or surfaces of the joint, which is usually the triceps fascia or fascia lata.

The primary indications for total elbow arthroplasty are pain, instability, and bilateral elbow ankylosis. Another indication is rheumatoid arthritis with roentgenographic evidence of joint destruction that is too far advanced to benefit from radial head excision and synovectomy, especially in patients whose activities are limited by painful instability and stiffness. Deformity or dysfunction without pain are not indications for arthroplasty. Similarly, weakness and discomfort due to instability are relative indications, especially in patients with posttraumatic arthritis.

**Authors’ Technique**

Total elbow joint replacement (Fig. 8-2) is usually performed with the patient supine, a small pad placed under the ipsilateral scapula, and the extremity positioned over the chest. A dorsal surgical approach is used. During the initial dissection, the ulnar nerve is released and transposed anterior to the medial epicondyle. Division, lifting, or splitting of the triceps tendon exposes the joint. The collateral ligaments are released and the joint is dislocated to complete the exposure. Using special cutting guides, the distal humerus and proximal ulna are cut. The medullary canals of the two bones are prepared with broaches. Implant trials are inserted and the joint is tested for range of motion and stability. Additional soft tissue releases may be needed to achieve maximum motion. The final implant is inserted with cement (see Chap. 35), which is typically impregnated with antibiotic. Cementation for elbow replacement is rarely associated with blood pressure reductions, as reported for total hip replacement. The triceps tendon is repaired and the skin closed. A suction drain is inserted to prevent hematoma formation; however, overall blood loss does not usually exceed 250 mL. A bulky sterile dressing incorporating a plaster splint is applied.

**ANESTHETIC CONSIDERATIONS**

**Preoperative**

Many patients suffer from rheumatoid arthritis and multiple organ system involvement. Side effects of drugs used to treat rheumatoid arthritis must be appreciated in planning the anesthesia, which include the effects of steroid and nonsteroidal anti-inflammatory therapy on coagulation and adrenal function. Methotrexate can cause bone marrow suppression and liver cirrhosis. Anticytokine therapy may cause inhibition of tumor necrosis factor but does not have any implications for anesthesia. Corticosteroids are frequently used and can subject the patient to higher risks of osteoporosis, infection, myopathy, and poor wound healing. The immunosuppressive agents cyclophosphamide and azathioprine are also frequently used to treat rheumatoid arthritis and may also lead to a higher incidence of infection.

Airway management may be difficult in these patients. Flexion deformity of the cervical spine may
lead to airway obstruction during induction of anesthesia, while atlantoaxial subluxation may increase the risk of cervical spinal cord compression or interfere with blood flow in the vertebral artery. Furthermore, limited temporomandibular joint mobility may impair visualization of the vocal cords during direct laryngoscopy. Cricothyroid inflammation and arthritis may obstruct the view of the glottic opening during direct laryngoscopy and cause postextubation laryngeal obstruction. Fiberoptic intubation in the awake patient, a laryngeal mask airway (LMA), or regional anesthesia with or without mild sedation may have to be considered.

Preoperative pulmonary function tests and blood gas and pH analysis may be necessary if severe lung disease due to rheumatoid arthritis is suspected. The need for postoperative ventilatory support should be anticipated if a patient has severe restrictive lung disease.

Nerve Block

Elbow surgery is very often performed under regional anesthesia alone, for which many blocks of the brachial plexus have been promoted (see Chaps. 23, 24, and 25). It should, however, be kept in mind that for complete surgical anesthesia of the elbow, complete block of the entire brachial plexus is required. If a tourniquet is used, the branches of the intercostobrachial nerve to the inner upper arm must also be blocked. It is therefore our practice to use a single injection infraclavicular block of all three brachial plexus cords (see Chap. 24) for minor surgery to the elbow. Supraclavicular block (see Chap. 23) is also useful, and in both instances the branches of the intercostobrachial nerve usually have to be blocked separately, although this may not be necessary with the supraclavicular block.

Single-injection blocks should probably not be used routinely for major elbow surgery since they do not contribute anything to the relief of postoperative pain, which is usually severe. Arguably, single-injection blocks may even worsen situations, because the patient may awake alone in the middle of the night following surgery and with severe unmanageable pain. Readmission for pain management is common in these situations and counterproductive if cost-effective surgery and pain management are goals of ambulatory surgery. Continuous supraclavicular block may be of value, but again, it is important to block the entire brachial plexus to achieve anesthesia and analgesia for major surgery to the elbow. Our experience is that distal brachial plexus blocks (supraclavicular, infraclavicular and axillary blocks) provide excellent surgical anesthesia after the initial large bolus dose of local anesthetic agent. However, when used as a continuous block, the catheter settles on one of the cords or terminal branches of the brachial plexus and provides incomplete analgesia during the days after the surgery, since small volumes and lower concentrations of local anesthetic agents are infused. Our practice is therefore to use a continuous cervical paravertebral block (see Chap. 23) for major elbow surgery, which blocks all roots of the brachial plexus, to provide anesthesia for the procedure and postoperative analgesia.

Intraoperative

Intraoperatively, special care should be taken to protect vulnerable nerves against compression by using appropriate padding, since this surgery can last for 3 to 4 h. Furthermore, the eyes and pressure points of patients with rheumatoid arthritis should receive special attention.

If the surgery is anticipated to last a long time, general anesthesia or deep sedation is considered. Our practice when the surgery is to last longer than 2 h is to use an infusion of propofol with a LMA and controlled ventilation in the presence of a solid cervical paravertebral block. In case of poor pulmonary compliance due to restrictive lung disease, tracheal intubation is used. For shorter operations, a block of the entire brachial plexus with or without sedation will provide excellent surgical conditions. For sedation, our practice is to use varying doses of midazolam in combination of small doses of meperidine. In addition to the usual monitoring, the patient’s respiration should be monitored throughout by capnography via a divided cannula. Modern noise-cancellation headphones with soothing music of the patient’s choice go a long way toward comforting the patient during surgery.

Because a tourniquet is used during most or all of the surgery, it is not necessary for the anesthesiologist to participate in controlling the quality of the surgical field.

Postoperative

Patients who have undergone day-case ambulatory surgery under peripheral nerve block anesthesia should be instructed in how to care for the anesthetized limb and to prevent trauma to vulnerable nerves (see Chap. 32). They should also be instructed to start taking oral analgesic medication before the effects of the block wear off. If severe pain follows the surgery and discharge from the hospital, single-injection blocks are inappropriate treatment. Instead, patients are discharged with continuous blocks in place (see Chap. 21).

A main feature of modern orthopaedic anesthesia is the treatment of acute postoperative pain with continuous nerve blocks. There are very few instances in which this cannot be offered. If such cases do occur, intravenous patient-controlled morphine sulfate should be offered as an absolute minimum. Continuous peripheral nerve blocks should be adjusted continuously to the patient’s analgesic and physical therapy needs on an individual basis and should be discontinued only when the patient no longer requires the continuous block (see Chap. 21).
POSTOPERATIVE PROTOCOL
(ARTHROPLASTY)

After total elbow arthroplasty, patients are hospitalized for 48 h for pain control, antibiotics, bandage change, and initial rehabilitation. The bandages are changed on the morning of the second postoperative day, after which the patient is seen in the physiotherapy department for fabrication of a thermoplastic elbow splint and instruction in gentle exercises. When an anesthetic catheter is used for regional anesthesia, it is typically retained until the second day, at which time the patient’s analgesic regimen is converted to oral analgesics.

The goals of reconstructive elbow surgery are to restore function through the relief of pain and the restoration of motion and stability.

COMMON COMPLICATIONS

Excessive swelling with persistent drainage are the most common problems after elbow arthroplasty in the first week. Wound dehiscence can occur if swelling is severe and aggressive motion is started too early. Stiffness of the elbow is sometimes prolonged, requiring formal rehabilitation. Light use of the hand is allowed within a few days. Depending on the condition of the triceps tendon, general use of the arm begins after 6 weeks. Implant loosening is the greatest long-term concern. The infection rate for elbow replacement is slightly higher than for other major joint replacements.

SUGGESTED FURTHER READING