

## ANSWERS TO CASE 1: BRACHIAL PLEXUS INJURY

*Summary:* A large (4800 g) infant of a diabetic mother is delivered after some difficulty and cannot move its right arm. There is a shoulder dystocia (the infant's shoulders are stuck after delivery of the head).

- ◆ **Most likely diagnosis:** Brachial plexus injury, probably Erb palsy
- ◆ **Most likely etiology for this condition:** Stretching of the upper brachial plexus during delivery
- ◆ **Likely anatomical mechanism for this disorder:** Stretching of nerve roots C5 and C6 by an abnormal increase in the angle between the neck and the shoulder

## CLINICAL CORRELATION

During delivery, particularly of a large infant, shoulder dystocia may occur. In this situation, the fetal head emerges, but the shoulders become wedged behind the maternal symphysis pubis. An obstetrician will use maneuvers such as flexion of the maternal hips against the maternal abdomen (McRobert maneuver) or fetal maneuvers such as pushing the fetal shoulders into an oblique position. These actions are designed to allow delivery of the fetal shoulders without excessive traction on the fetal neck. Despite such carefully executed maneuvers, infants may be born with stretch injuries to the brachial plexus, resulting in nerve palsies. The most common of these is an upper brachial plexus stretch injury in which nerve roots C5 and C6 are affected, resulting in the infant's arm being limp and to its side. Most such injuries resolve spontaneously.

## APPROACH TO THE BRACHIAL PLEXUS

### Objectives

1. Be able to describe the spinal cord segments, named terminal branches, and the motor and sensory deficits of an **upper brachial plexus injury**.
2. Be able to describe the mechanism, spinal cord segments, named terminal branches, and the motor and sensory deficits of a **lower brachial plexus injury**.
3. Be able to describe the mechanism, spinal cord segments, named terminal branches, and the motor and sensory deficits with **cord injury** of the brachial plexus.

### Definitions

**Brachial plexus:** A major peripheral nerve network formed by the anterior primary rami of the fifth cervical to the first thoracic spinal nerves.

**Upper brachial plexus injury:** Typically involves nerve roots C5 and C6, resulting in the upper limb hanging at the side, with medial rotation and the palm facing posteriorly.

**Lower brachial plexus injury:** Less common injury involving C8 through T1 and the ulnar nerve, leading to interosseous muscle atrophy and claw hand.

**Shoulder dystocia:** Condition whereby the fetal head delivers vaginally, but the shoulders are impacted behind the maternal bony pelvis.

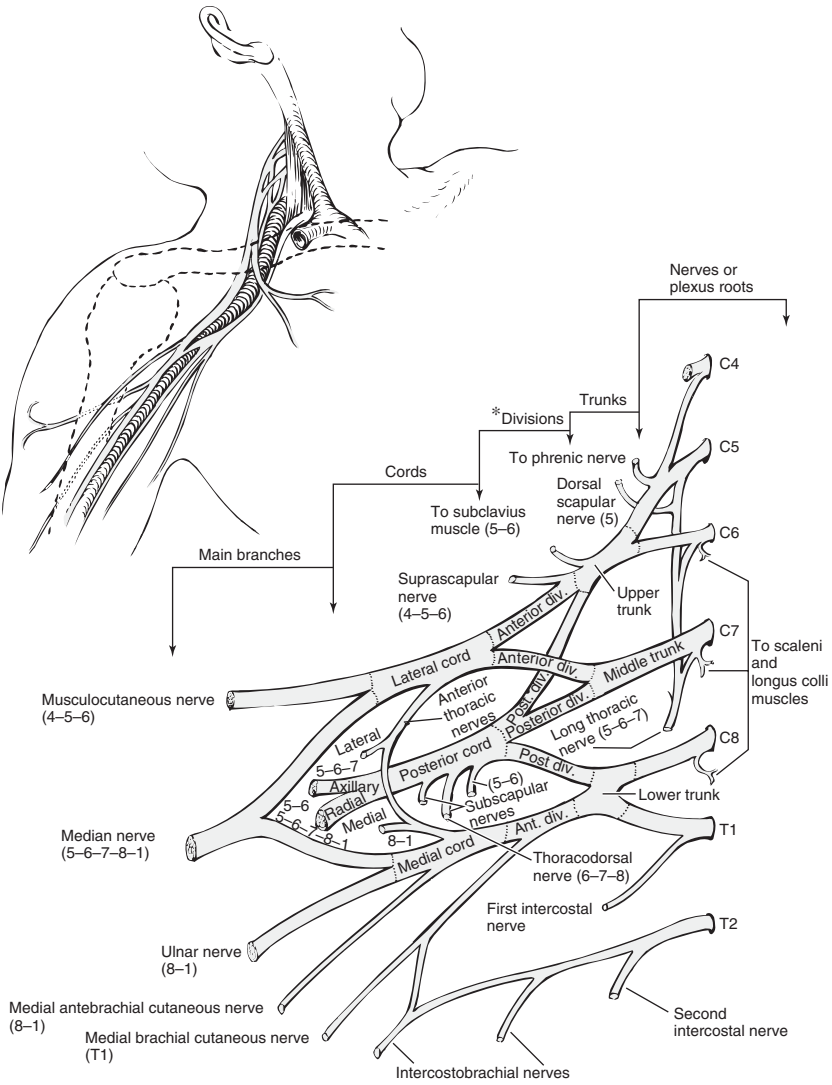
## DISCUSSION

The **brachial plexus** arises from the inferior portion of the cervical spinal cord enlargement. It is formed by the ventral **primary rami of spinal nerves C5 through C8** and most of **T1**. The network of nerves that form the brachial plexus is divided anatomically from proximal (medial) to distal (lateral) into **roots, trunks, divisions, cords, and terminal branches** (mnemonic: **Randy Travis Drinks Cold Texas Beer**). The roots of the plexus emerge from between the anterior and middle scalene muscles together with the subclavian artery. Arising from the roots are branches to the **longus colli and scalene muscles and the dorsal scapular and long thoracic nerves**. The roots unite to form **superior, middle, and inferior trunks**. The **suprascapular nerve** and the nerve to the **subclavius muscle** arise from the **superior trunk**. Each trunk is divided into **anterior and posterior divisions**, which will innervate musculature of the anterior and posterior compartments, respectively (Figure 1-1).

The anterior divisions of the superior and middle trunks unite to form the **lateral cord**. The **lateral cord** gives off the **lateral pectoral nerve**. The anterior division of the inferior trunk continues distally as the medial cord, whose branches are the **medial pectoral, medial brachial cutaneous, and medial antebrachial cutaneous nerves**. The posterior divisions of all three trunks unite to form the **posterior cord**, and its branches are the **upper and lower subscapular and thoracodorsal nerves**. The three cords are named for their relation to the **axillary artery**, which passes through the plexus at this level. The terminal branches of the brachial plexus are the **axillary, musculocutaneous, median, ulnar, and radial nerves**.

The **axillary nerve (C5 and C6)** arises from the **posterior cord** and courses posteriorly around the **surgical neck of the humerus**, where it is at risk of injury. The **posterior circumflex humeral artery** accompanies the nerve in this course. The axillary nerve supplies the **deltoid and teres minor muscles**, is sensory to the skin over the lower portion of the deltoid, and is optimally tested on the “**shoulder patch**” portion of the upper arm. **Axillary nerve injury** such as by fracture at the **surgical neck of the humerus** results in an **inability to abduct the arm at the shoulder to a horizontal position** and **sensory loss in the shoulder patch area** (Figure 1-2).

The **musculocutaneous nerve (C5–C7)** is the continuation of the lateral cord. It courses distally through the coracobrachialis muscle to innervate it in



\* Splitting of the plexus into anterior and posterior divisions is one of the most significant features in the redistribution of nerve fibers, because it is here that fibers supplying the flexor and extensor groups of muscles of the upper extremity are separated. Similar splitting is noted in the lumbar and sacral plexuses for the supply of muscles of the lower extremity.

**Figure 1-1.** The brachial plexus. (*Reproduced, with permission, from Waxman SG. Clinical Neuroanatomy, 25th ed. New York: McGraw-Hill, 2003:348.*)



addition to the biceps brachii and brachialis muscles. The lateral antebrachial cutaneous nerve to the skin of the lateral forearm represents the terminal continuation of this nerve. Damage to the **musculocutaneous nerve** causes **weakness in supination and flexion of the shoulder and elbow**.

The upper portion of the brachial plexus arises from spinal cord segments C5 and C6, forms the **superior trunk**, and makes major contributions to the **axillary, musculocutaneous, lateral pectoral, and suprascapular nerves and the nerve to the subclavius muscle**. Injury to the upper plexus typically occurs with an increase in the angle between the shoulder and the neck. This can occur in a newborn during an obstetrical delivery or in adults as the result of a fall on the shoulder and side of the head and neck, which produces a widened angle. The resultant muscle paralysis due to such an injury may be understood more easily in an adult with such an injury. The **upper extremity hangs by the side** because the **deltoid and supraspinatus** (abductors of the arm) are paralyzed due to injury of the **axillary and suprascapular nerves**, respectively. In addition, the anterior deltoid, biceps brachii, and coracobrachialis (flexors of the arm) are paralyzed due to injury of the **axillary and musculocutaneous nerves**. The **elbow is extended and the hand is pronated due to paralysis of the biceps brachii and brachialis muscles**, both of which are innervated by the **musculocutaneous nerve**. The extremity is medially rotated due to paralysis of the teres minor and infraspinatus muscles (lateral rotators of the arm) and to injury to the axillary and suprascapular nerves. The palm of the hand is turned posteriorly in the **“waiter’s tip” sign**. There is loss of sensation along the lateral aspect of the upper extremity, which corresponds to the **dermatome at C5 and C6**. The upper brachial plexus injury is known as **Erb or Erb-Duchenne palsy**.

The **ulnar nerve (C8 and T1)** is a continuation of the **medial cord**, which enters the posterior compartment through the medial intermuscular septum and passes distally to enter the forearm by curving posteriorly to the **medial epicondyle**. Here it is superficial and at risk of injury. It enters the anterior compartment of the forearm, where it innervates the **flexor carpi ulnaris and the bellies of the flexor digitorum profundus** to the **ring and little fingers**. The **ulnar nerve** enters the hand through a **canal (Guyon canal) superficial to the flexor retinaculum**. The nerve supplies all the **intrinsic muscles of the hand except the three thenar muscles and the lumbricals of the index and middle fingers**. It is sensory to the **medial border of the hand, the little finger, and the medial aspect of the ring finger**. Damage to the ulnar nerve in the upper forearm causes lateral (radial) deviation of the hand, with weakness in flexion and adduction of the hand at the wrist and loss of flexion at the distal interphalangeal joint of the ring and little fingers. Damage to the ulnar nerve in the upper forearm or at the wrist also results in loss of abduction and adduction of the index, middle, ring, and little fingers due to paralysis of the interossei muscles. A **“claw hand” deformity results**, and with longstanding damage, **atrophy of the interosseous muscles** occurs.

**Injury to the lower brachial plexus, known as Klumpke palsy**, occurs by a similar mechanism, that is, an abnormal widening of the angle between the

upper extremity and the thorax. This may occur at obstetrical delivery by traction on the fetal head or when an individual reaches out to interrupt a fall. The roots from **C8 and T1** and/or the inferior trunk are stretched or torn. Spinal cord segments **C8 and T1 form the ulnar nerve** and a significant portion of the **median nerve**. The majority of the **muscles of the anterior forearm** is **innervated by the median nerve** (see Case 4) and will display weakness. Most of the **muscles of the hand** are innervated by the **ulnar nerve**. There will be loss of **sensation** along the **median aspect of the arm, forearm, hypothenar eminence, and little finger (C8 and T1 dermatome)**.

Compression of the brachial plexus cords may occur with prolonged **hyperabduction** while performing overhead tasks. The **hyperabduction syndrome of pain** down the arm, **paresthesia, hand weakness, and skin redness**, may result from compression of the cords between the **coracoid process and pectoralis minor**. An **axillary-type crutch** that is too long can compress the posterior cord, leading to radial nerve palsy.

## COMPREHENSION QUESTIONS

- [1.1] A 12-year-old boy is diagnosed with an upper brachial plexus injury after falling from a tree. He presents with his right upper arm at his side due to loss of abduction. Which of the following muscles are primarily responsible for abduction of the arm at the shoulder?
- A. Deltoid and biceps brachii
  - B. Deltoid and supraspinatus
  - C. Deltoid and infraspinatus
  - D. Supraspinatus and infraspinatus
  - E. Coracobrachialis and supraspinatus
- [1.2] Injury to the lateral cord of the brachial plexus will also injure its continuation, the musculocutaneous nerve. Which of the following findings would you observe in a patient with this injury?
- A. Weakness of abduction of the arm at the shoulder
  - B. Weakness of adduction of the arm at the shoulder
  - C. Weakness of extension of the forearm at the elbow
  - D. Weakness of flexion of the forearm at the elbow
  - E. Weakness of supination of the forearm and hand
- [1.3] A 22-year-old man is brought into the emergency department with a knife injury to the axilla. The physician suspects injury to the lower brachial plexus. Which of the following nerves is most likely to be affected?
- A. Axillary
  - B. Musculocutaneous
  - C. Vagus
  - D. Radial
  - E. Ulnar