(vi) Management of acute nerve injuries of the hand

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Abstract

Acute nerve injuries of the hand demand careful consideration and management to ensure an optimal outcome. Appreciation of the neural anatomy of the hand and its variations is fundamental to the diagnosis and subsequent treatment of any sensory or motor deficit. In this article, the principles of managing acute nerve injuries of the hand are reviewed, focussing on the relevant anatomy, key features of assessment, and principles of treatment including nerve repair and grafting.

Keywords nerve conduits; nerve grafting; nerve injury; nerve repair

Introduction

Acute nerve injuries of the hand are common and require a careful assessment prior to considering surgical exploration. In this article we will discuss the relevant neural anatomy of the hand and key features in clinical assessment. The principles and indications of nerve repair and grafting are also reviewed.

Anatomy

A detailed understanding of the nerve supply of the hand will allow accurate diagnosis and potentiate the best possible recovery for these injuries. The three nerves supplying the hand are the median, radial and ulnar nerves (Figures 1 and 2). These can be injured in isolation or in varying combinations. It is important to delineate and document intact motor-sensory function in the all three nerves at the initial assessment of the injured patient.

Median nerve

After entering the forearm medial to the biceps tendon, the nerve passes between the two heads of pronator teres. The anterior interosseous (AIN) branch is given off at this level. The AIN supplies motor innervation to the flexor digitorum profundus (FDP) of the index and middle fingers, pronator quadratus and flexor pollicis longus. The median nerve itself then innervates all of the other forearm flexors except for the flexor carpi ulnaris (FCU) and FDP of the ring and little fingers which are innervated by the ulnar nerve. Distal to pronator teres, the nerve lies between the flexor digitorum superficialis (FDS) and FDP. The palmar cutaneous branch arises from the median nerve approximately 5 cm proximal to the wrist flexion crease running on the radial side of the median nerve, between palmaris longus and flexor carpi radialis (FCR). This provides cutaneous sensation to the base of the thenar eminence.

At the level of the transverse carpal ligament, a radially-sided motor branch provides innervation to the muscles of the thenar eminence (the superficial head of flexor pollicis brevis (FPB), opponens pollicis and abductor pollicis brevis (APB) and the radial two lumbricals. The three common variations of the course of the motor branch are: extraligamentous (50%), subligamentous (30%) and transligamentous (20%).[1]

The sensory areas of the hand supplied by the median nerve are the palmar aspects of thumb, index, middle fingers and radial half of the ring finger. Dorsally these three and a half digits are supplied from the level of the DIPJ. The volar digital nerves lie deep to the superficial palmar arch and then run superficially to the digital arteries. The digital nerves trifurcate at the level of the DIPJ making approximation here extremely challenging.

Ulnar nerve: the ulnar nerve enters the forearm between the two heads of FCU. Distal to this it runs between FCU and FDP. Motor branches are given off to FDP of the ring and little fingers at this level. A dorsal ulnar sensory nerve branches off the main nerve in the distal third of the forearm. Approximately 5 cm proximal to the wrist crease, this branch exits dorsal to the FCU and provides sensation to the ulnar side of the dorsum of the hand and the ulnar two fingers.[2] Another palmar cutaneous branch, which originates from the ulnar nerve at approximately 14 cm distal to the medial epicondyle and pierces the forearm fascia just proximal to the distal wrist crease, supplies sensory innervation to the hypothenar region of the palm.[3]

At the level of the wrist the ulnar nerve, accompanied by the ulnar artery, enters Guyon's canal. The deep branch innervates the hypothenar eminence muscles (abductor digiti minimi, flexor digiti minimi and opponens digiti minimi), the ulnar two lumbricals, all the interossei, deep head of FPB and the adductor pollicis. The superficial branch innervates palmaris brevis before supplying sensation to the ulnar one and a half fingers.

Radial nerve

At the level of the elbow, the radial nerve divides into the posterior interosseous nerve (PIN) and superficial radial branch. The superficial radial branch proceeds deep to brachioradialis until approximately 4 cm proximal to the wrist where it becomes superficial and passes between extensor carpi radialis longus and brachioradialis. Sensation is provided to the dorsum of the hand. Notably the first dorsal webspace is the area without any sensory overlap of median/ulnar nerves. The PIN exits deep to the fascia of the proximal edge of the supinator muscle (Arcade of Frohse) after branching from the radial nerve. It innervates this muscle and all other extensors of the forearm.

It is important to appreciate that there are a number of anomalous communications between median and ulnar nerves which may confuse the clinical picture following injuries. A detailed summary has been provided by Unver Dogan et al.[4] The Martin-Gruber anastomosis refers to a communicating branch from the median nerve/AIN to join the ulnar nerve in the forearm, ultimately innervating the intrinsic hand muscles. In

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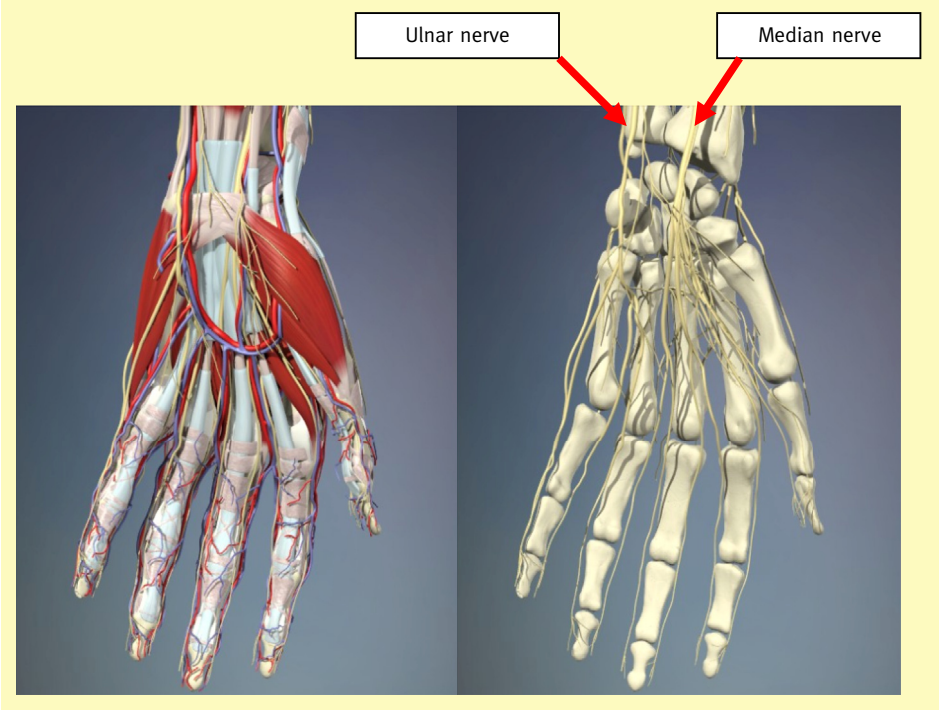

Figure 1 Anatomy of the volar aspect of the hand. 3D Anatomy images courtesy and copyright of Primal Pictures Ltd. www.primalpictures.com.

contrast, the Marinacci communication refers to the reverse ulnar-to-median communication in the forearm. In this case for instance, a laceration to the ulnar nerve at the wrist level may not result in paralysis of intrinsic muscles as they receive innervation from the uninjured median nerve. In the hand, the Riche-Cannieu anastomosis refers to a connection between the deep branch of the ulnar nerve and the recurrent branch of the median nerve whilst the Berretini anastomosis refers to a communicating branch between common digital nerves that arise from the ulnar and median nerves.

Micro-anatomy of the peripheral nerve: an appreciation of the microscopic structure of the peripheral nerve helps elucidate contemporary concepts of nerve repair. The epineurium is a loose collagenous layer surrounding the fascicles. It is an elongation of the dural sleeve of spinal nerves. The external layer serves to anchor overlying blood vessels and the overall thickness varies with anatomical location. The epineurium becomes thickened with trauma and may represent a large proportion of scar tissue seen after nerve injury.

The perineurium surrounds fascicles and comprises up to 10 concentric lamellae of flattened cells. Longitudinal collagen fibres are present and prominent basement membranes are linked together within this layer. It acts like a blood–brain barrier controlling the intraneural ionic environment and can limit diffusion and block the transmission of infection. It is also the major contributor to endogenous nerve tensile strength.[5]

The endoneurium is the collagenous tissue "packing" around axons. It participates in Schwann cell tube formation. Axons running through this layer are protected and nourished by it.[5]

The fascicle constitutes the smallest unit of nerve tissue that can be manipulated surgically. It contains neurons that are surrounded by endoneurium that are in turn enclosed within perineurium.

The neuron has a distinctive structure and is the basic functional and morphologic unit of the peripheral nerve. It consists of a cell body, axon and dendrites. The axon is a cylindrical extension of the neuron arising from the axonal hillock. Axonal transport and nerve conduction are bidirectional. The myelinated axon has areas called nodes of Ranvier which represent gaps in the myelin sheath that allow saltatory conduction of electrical activity along the axon.

Assessment

History

The typical patient who sustains an acute nerve injury to the hand is a young male.[6] Apart from obtaining basic demographics including age, hand dominance and occupation, history taking should focus on the mechanism and source of injury, position of the hand at the time of injury, evidence of brisk bleeding from the wound and the presence or absence of altered sensation.

The injury can be a result of a sharp or a blunt object, with glass being the most common.[6] If a blade or saw was the agent, details should be sought regarding the size and type and whether it was contaminated. However one should always assume the agent was dirty, if unknown. Occupational injuries involving machinery are likely to result in more extensive injuries or mangled extremities. It should also be documented whether the cut was accidental, alleged assault or deliberate self-harm.

Examination: clinical examination of the injured hand begins with inspection for the presence of an open wound noting its location and pattern. In cases of open fractures, particular attention needs to be paid to any associated sensory deficit as nerve injuries can be easily missed. Pre operative findings should be documented and any areas of altered sensation are marked on