Review Article

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Brachial Plexus Injury: A Review Article

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Abstract

The increase in the frequency of car accidents in the previous century was associated with significant increase in injuries to shoulder interference. Currently, new visualization research is available to evaluate nerve shoulders injuries. Myelography, CT myelography, and magnetic resonance imaging (MRI) are indicated in the evaluation of the brachial plexus. Furthermore, a number of specialized electrodiagnostic and neuroconduction studies, in combination with clinical findings during the neurologic examination, can provide information about the location of the lesion, the severity of the injury, and the expected clinical outcome. Improvements in diagnostic approaches and microsurgical techniques have radically changed the prognosis and functional outcomes of these injuries.

Keywords: Brachial plexus injury; Brachial plexus; Injury.

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INTRODUCTION

High energy trauma with upper limbs and neck can cause various lesions in the upper arm plexus. Towing injuries are the most common, and the head and neck are intensely far from the same side shoulder. Injuries can be caused by compression, penetrating trauma, or direct hitting between the collarbone and the first coast. Other lesions, especially those in the spinal cord or head, may delay recognition.[1,2]

Treatment of brachial plexus injuries has evolved since World War II from shoulder immobilization, elbow bone locks, and finger tenodesis to better functional restoration made possible by advances in nerve repair and microsurgery.

The natural history of becoming\"one-handed\" within 2 years has been replaced by early exploration, neurolysis, nerve grafting, neurotization, and free muscle transfers, as well as tendon transfers, for shoulder and elbow function and for wrist or hand prehension. Advances in diagnostic imaging, nerve transfers, electrophysiologic testing, nerve root repair, nerve rootlet replantation, and free muscle transfers have made this a dynamic but highly specialized field.[3-5]

Because the topic is a complex one, this article focuses primarily on traction injuries, the most common type in adults. Such injuries are usually fatal to the injured party, and loss of useful function of the upper limb is common, but early repair and reconstruction can allow for a much greater recovery than previously possible.

ANATOMY

The brachial plexus is formed by the spinal nerves or roots, which are the union of the ventral (motor) and posterior (sensory) roots as they pass through the vertebral foramen. The dorsal root ganglion contains the cell bodies of the sensory nerves. The cell bodies of the ventral nerves are located in the spinal cord. Typically, the brachial plexus is formed from C5-T1; in some cases, there is a contribution from C4 (prefixal, 28-62%) or T2 (postfixal, 16-73%). All innervation of the upper limb passes through this plexus. The cable nerve plexus starts with a rock and ends with an X-horn in a course under the collarbone. Usually, it is composed of five roots, three trunks, six categories (two from each trunk), three chords, and terminal branches.

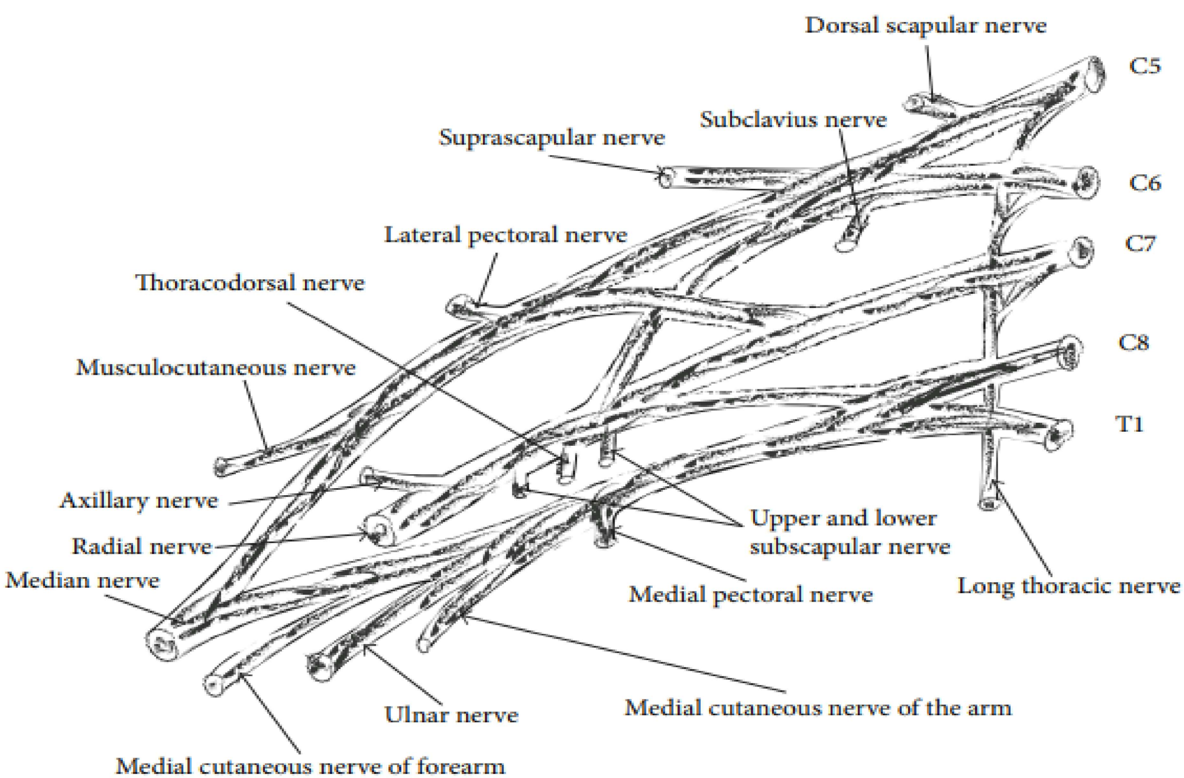

Fig. 1: Anatomy of brachial plexus

The five roots are named according to the level with which they correspond. The C5-7 roots give off branches to form the long thoracic nerve, and the C5 root gives branches to form the dorsal scapular nerve. C5 and C6 give branches to form the superior trunk, C7 the middle trunk, and C8 and T1 the inferior trunk.

Each of the three trunks divides into two parts, with one part of each trunk forming the posterior chordae. The anterior part of the upper trunk and the anterior part of the middle trunk form the lateral cord. The anterior part of the lower trunk forms the medial cord. The names medial, lateral, and posterior cords refer to the relationship of these structures to the axillary artery.

The suprascapular and subclavian nerves arise from the upper trunk. The posterior cord includes the superior and inferior subscapular nerves, with the thoracodorsal nerve located between them. The lateral pectoral nerve arises from the lateral funiculus and the medial pectoral nerve arises from the medial funiculus, but with a connection between the pectoral nerves. The posterior columns then give rise to the axillary and radial nerves.

The lateral cord continues as the musculocutaneous nerve. Branches from the medial and lateral cords become the median nerve. Branches from the lateral branch then join the continuation of the medial cord as the ulnar nerve after the medial cutaneous nerve forearm and medial cutaneous nerve forearm emerge from the medial cord.

The canals and branches are located distal to the clavicle. The roots and trunks are located nearby. The nerve plexus is very close to the X-horny artery between the front and central areas (Fig. 2). This anatomical knowledge allows for the position of the lesion of physical function.

Many different approaches to the brachial plexus have been used. Surgeons' preferences are largely shaped by their training and by the goals of a particular procedure. In any approach, the clavicle can be a barrier to visualization.

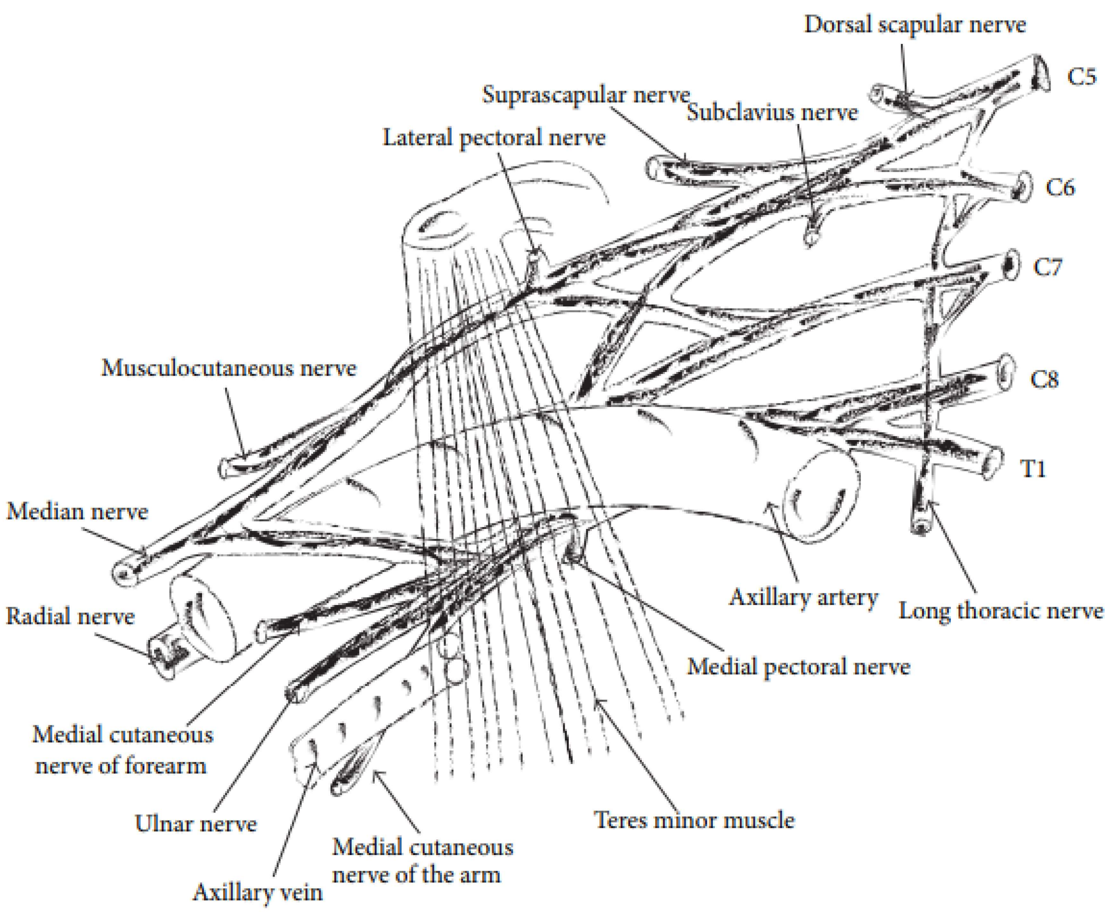

Fig. 2: Relation of brachial plexus with axillary artery

Millesi described an approach that uses three anterior incisions with the patient in the supine position.[6] In this approach, a sagittal incision is made on the lower neck and two transverse incisions are made more distally, following skin tension lines. By moving the clavicle and looking at the plexus from both a cephalad and a caudad direction, the operator can visualize the upper, middle, and lower trunks of the brachial plexus and avoid osteotomy of the clavicle. The spinal nerves of the upper plexus can also be visualized with this approach.

PATHOPHYSIOLOGY

In the wounds of the nerve plexus on the shoulder, the traction head and the neck of the head are strongly removed from the shoulder of the brain axis. Since the first RIB bone functions mainly as a point that indicates the traction according to the upper nervous plexus, damage to high output (C5 and C6) is generally prioritized when the hand is touching. When the hand moves with force and is removed on the head, the low element (C8-T1) is generally injured because the power is pointed according to the C7. Since Cocoid functions as a support point for similar mod[7], increasing hands will increase damage to low power. Inferior plexus injuries may be more common due to the well-formed transverse root ligaments that help resist tension at C5, C6, and C7, whereas at C8 and T1, these ligaments are absent (Table 1).

Traction forces can result in preganglionic or postganglionic lesions. Preganglionic lesions refer to lesions located near the dorsal root ganglia and foramina, which are located within the spinal canal. They may be centrally located or arise directly from the spinal cord or within the dura.[8] Preganglionic lesions do not lead to Wallerian degeneration or neuroma formation because the axons remain in continuity with the cell bodies of the dorsal root ganglion. Postganglionic lesions are defined as lesions distal to the spinal ganglion and are physiologically similar to other peripheral nerve injuries.

Historically, peripheral nerve injuries have been described by the classification system of Seddon and Sunderland[9]. The classification proposed by Seddon describes three groups: neuropathy, neuroparesis, axotomy, and neurotomy.[10,19] Neuroparesis is defined as the presence of nerve dysfunction without gross nerve damage. The transmission of nerve impulses is interrupted at the site of injury for a short period of time, from a few hours to a few months, depending on the extent and severity of the injury. Tinel's sign cannot be detected by physical examination. Nerve conduction studies reveal that conduction is absent at the site of injury but normal conduction distal to the injury site, a characteristic feature of nerve palsy.[11,20] During axotomy, the axial continuity of some individual nerve fibers is interrupted, but the perineurium and epineurium are preserved. Neurotmesis is defined as a complete severance of the axon as well as all parts of the connective tissue of the peripheral nerve.[12]

Spontaneous recovery of the affected nerve axon cannotbe expected. Without surgical intervention, this kind ofinjury may lead to the creation of a nonfunctional neuroma.[13]

In the classification described by Sunderland, the groupof axonotmesis is graded in three degrees, suggesting that different anatomic disruption leads to correspondingly differentprognosis.[14,21] (Table 1).

Table 1: classification of nerve injuries

Sunderland	Seddon	Histopathology
1	Neurapraxia	Functional but not anatomical disorganization
2	Axonotmesis	Intact endoneurium and perineurium
3	Axonotmesis	Intact perineurium
4	Axonotmesis	Intact epineurium
5	Neurotmesis	Disruption of all layers

Factors that affect prognosis of brachial plexus injury (table 2) are based on various factors such as age, pain time of surgery etc.

Table 2: Factors that affect prognosis of brachial plexus injury

Factor	Result
Mechanism of injury	• High energy injuries have worse prognosis. • Avulsion injuries have worse prognosis than acute ruptures • Worse prognosis with concomitant vascular injury.
Age	Better prognosis in young patients
Type of nerve	Exclusively sensory or motor nerves have better functional recovery than mixed nerves
Level of injury	Supraclavicular lesions have worse prognosis than infraclavicular Upper trunk lesions have the best prognosis
Pain	Patients with persistent pain for more than 6 months after traumatic BPI have less possibilities for recovery
Time of surgical intervention	Fibrosis and degeneration of target organs at the time of surgical intervention are related to poor prognosis
Other factors	Concomitant diseases (infections, etc.) are related to worse prognosis

HISTORY

The index of suspicion for a brachial plexus injury is much higher for severe shoulder girdle injuries, particularly motorcycle accidents and motor vehicle accidents (MVAs). The mechanism of injury should be considered; these injuries may occur in the setting of polytrauma. The presence of other injuries necessitating sedation indicates that detailed follow-up examination of the upper extremity may be needed.

The patient may present with the following symptoms:

- Pain, especially of the neck and shoulder - Pain over a nerve is common with rupture, as opposed to lack of percussion tenderness with avulsion
- Paresthesias and dysesthesias
- Weakness or heaviness in the extremity
- Diminished pulses - Vascular injury may accompany traction injury

PHYSICAL EXAMINATION

Standard Trauma Life Support (ATLS) protocols should be followed: Abrasions to the head, helmet, or extremities of the shoulders indicate a supraclavicular injury. Ptosis (drooping eyelids), ptosis (sinking of the eye socket), anhidrosis and miosis (small pupils), or Horner's syndrome suggest damage to the T1 sympathetic ganglion (see image below). Located near the brachial plexus.

Trauma to the brachial plexus. The patient has OSIS and miso of the right eye to complete the lower lesion of the leopard portrait. The swelling of the shoulders is dramatic. A decreased or absent pulse suggests vascular injury, and special attention should be paid to rupture of the subclavian vessels. Clavicle fractures are often palpable. Careful inspection and palpation of the axial skeleton may reveal associated injuries. Each cervical root should be examined individually to determine its motor and sensory function as soon as circumstances permit. Certain special considerations are justified for a neurological examination. Sensory examination is extremely important. The sensation of deep pressure may be the only indicator of nerve continuity without motor function or other sensation. The deep pressure test involves pinching the nail completely at the base and pulling the patient's finger outwards. All burns mean the continuity of the tested nerves. If the burn is not detected, the results of these examinations are not very useful because the nerve root axis may last more than 6 months. Testing sensation in the wrist and fingers as well as movement relative to the median, ulnar, and radial nerves can help localize the brachial plexus injury. Motor examination is also useful. Significant variations occur among the spinal nerves within the cordand account for most of the anomalous patterns of innervation. These variations may make identifying the levels involvedchallenging. In addition, C4 may contribute a branch to the plexus up to 60% of the time. When C4 makes a significantcontribution to the plexus, the plexus is called prefixed. A prefixed cord can explain recovery in the distribution of a nerveroot clinically presumed to be avulsed.

Trauma wound on the nerve shoulder. The death of a human death of the human portrait indicates that the collarbone and a specific soft tissue are reserved. The nerve roots emerge from the corresponding foramina on the right border. The most superior nerve root observed is C5, with C6, C7, and C8 also observed. Cords of plexus can be observed at left-hand margin.

Elbow flexion and extension determine musculocutaneous and high radial nerve function. Shoulder abduction tests the axillary nerve, which comes off the posterior cord. The posterior cord can also influence deltoid function via the radial nerve. The latissimus dorsi is innervated by the thoracodorsal nerve in the posterior cord and can be tested by palpating the muscle while the patient is coughing. If the patient exerts his arm against resistance, the pectoralis muscles can be palpated (the medial thoracic nerve in the sternal head arises from the medial cord, and the lateral thoracic nerve in the clavicular head arises from the lateral cord). The long thoracic nerve innervates the serratus anterior, and the dorsal scapular nerve innervates the rhomboids. Thus, the pterygoid scapularis can help localize the injury.

Clinical findings suggestive of a root avulsion injury are

1. Reported constrictive or caustic pain in an otherwiseinsensitive upper limb.
2. When scapular muscles, serratus anterior, and rhomboid are not functioning, dorsal scapular as well aslong thoracic nerve is formed just distally to roots.
3. Horner syndrome-lid ptosis, meiosis

(constricted pupil), enopthalmos, and loss of hemifacial sweating (anhidrosis) (T1 root is in proximity to T1 sympathetic ganglion and avulsion injuries occur frequently toboth these two structures). Moreover, preganglionic lesions are seldom accompanied by serious vascular injuries, fractures of cervical spine, and dysfunction of spinal cord

All the muscles of the upper extremity and shoulder girdle innervated by the brachial plexus mustbe examined and graded on a scale from 0 to 5 by the manual muscle tests according to the Medical Research Council scale on a brachialplexus chart (Alnot 1995, Boome 1997a) (Fig. 3).

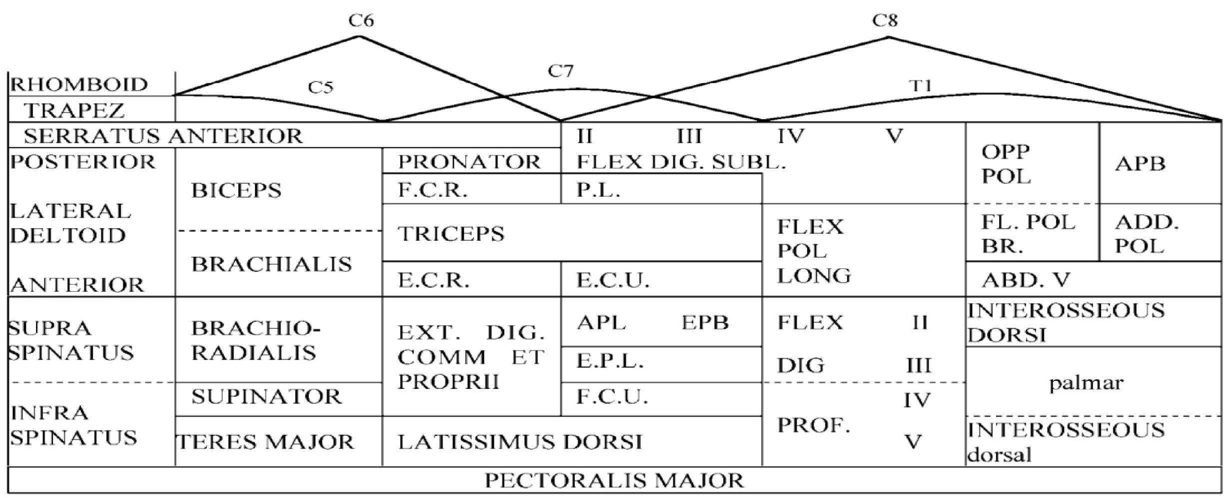

Fig. 3: Brachial plexus muscle test chart

WORK UP

Laboratory Studies

Laboratory studies generally are not helpful for diagnosis of traumatic brachial plexus injury, though they may be indicated inthe routine evaluation of any trauma patient. Electrophysiologic studies are crucial in the management of these injuries, buttiming (eg, for wallerian degeneration to occur) must be considered.

Imaging Studies

Plain radiography

In X-Ray from the chest to the front (AP), you need to pay special attention to the distance between the chest spine and the troublesome process of the shovel. If X-ray shooting is not a drawback, the increase at this distance from the opposite side may indicate the dissection of Spatatata therapy (see the image below). Trauma to the brachial plexus. Initial anteroposterior chest radiograph of a patient involved in an accident with an 18-wheel truck. The clavicle fracture found on the initial chest radiograph was significant as it indicated the need for further evaluation of the injury as the patient was intubated and unresponsive from blunt head trauma.

CT scan

Careful examination of the chest CT scan suggested a scapulothoracic dissociation and a brachial plexus injury was noted as soon as the patient became responsive. AP and lateral axillary views of the shoulder show the clavicle fracture, most of the scapular fracture, and the most proximal fracture of the humerus. Cervical spine radiographs, including AP, lateral, and odontoid views, are helpful.

Computed tomography

Adequate plain radiographs, especially of the odontoid and the cervicothoracic junction, may be difficult to obtain. Computed tomography (CT) of the neck can often be obtained in conjunction with the CT evaluation received by many trauma patients.

Plain CT is very helpful in evaluating any cervical fractures and should be obtained if fractures are suspected on the basis of plain radiographic findings. Chest CT may reveal subclavian vessel injuries, scapular fractures, humeral fractures, andthoracic spine fractures.

Plain myelography

The most reliable indicator of root avulsion is an absent root shadow on plain myelography.[13] A common sign of a rootavulsion is a meningocele at the affected level; hence, myelography may best be delayed for 4 weeks so that any blood clotwill not be dislodged by the study and the meningocele can be allowed to form.

CT myelography

CT myelography (CTM) has grown in popularity as compared with standard myelography.[14] CTM is capable of detectinglower concentrations of contrast medium than standard myelography can. Burge stated that CTM may be better able toreveal small meningoceles, but artifact from surrounding soft tissues may be problematic at the lower cervical levels.[15]

Magnetic resonance imaging

Magnetic resonance imaging (MRI) is the current criterion standard for visualizing spinal cord injuries (SCIs), but there havebeen fewer reports of its utility in evaluating traumatic lesions of the brachial plexus.

A systematic review and meta-analysis by Wade et al showed that the mean sensitivity of MRI for detecting root avulsionwas 93%, with a mean specificity of 72%.[16] MRI offers modest diagnostic accuracy for traumatic brachial plexus rootavulsion. It is also the only technique that can be used to visualize the postganglionic brachial plexus.

A study by Elsakka et al found that MRI myelography utilizing three-dimensional (3D)-T2-turbo spin echo (TSE) with 90°flipback pulse ("DRIVE") was highly accurate in evaluating preganglionic traumatic brachial plexus injuries.[17] It is likely that MRI will continue to play a growing role in evaluation of the brachial plexus and in surgical decision-making for traumatic brachial plexus injury.[18]

Angiography

Both conventional angiography and magnetic resonance angiography (MRA) are valuable tools in evaluating any suspected vascular disruption. Concurrent subclavian or axillary vascular injury is frequent in brachial plexus injury and can makereconstructive surgery more challenging.[19]

Other Tests

Sensory nerve action potentials

Sensory nerve action potentials (SNAPs) are very useful in distinguishing preganglionic from postganglionic lesions (Table 3). If the injury is proximal to the dorsal root ganglion (DRG), the sensory axons remain intact and therefore Wallerian degeneration does not occur. Thus, SNAPs observed in the nerve on anesthetized dermatomes confirm a preganglionic injury. SNAP is not useful in evaluating C5 because it does not contribute significantly to the major peripheral sensory nerves.

Electromyography

During the first week after injury, electromyography (EMG) cannot be used to rule out complete nerve transection unless voluntary motor unit action potentials are observed. If the paralyzed muscles show no signs of denervation within 3 weeks after injury, EMG can be used to confirm nerve paresis. A study by Impasto et al. aimed to determine the prognostic value of needle EMG in traumatic brachial plexus injuries.[20] The lack of potential for voluntary motor unit recruitment within 1–9 months predicted a poor prognosis for spontaneous recovery. A high percentage of patients who underwent discrete recruitment did not achieve strength improvement of 3/5 or greater.

Table 3: Neurophysiological findings in traumatic peripheral nerveinjuries, in each category, respectively, according to Seddon classification

	Neurapraxia	Axonotmesis	Neurotmesis
Conduction velocity	Usually normal	Normal/mild reduction	Absent
CMAP frequency	Normal/reduced	Reduced	Absent
SNAP frequency	Reduced	Reduced	Absent
Abnormal spontaneous potentials in EMG	Absent	Probably present	Present

Intraoperative somatosensory evoked potentials (SSEPs) are useful in brachial plexus surgery. The presence of SSEPssuggests continuity between the peripheral nervous system and the central nervous system via the DRG. SSEPs are absentin postganglionic or combined pre and postganglionic lesions.

Combined electrodiagnostic techniques like nerve actionpotentials (NAPs), somatosensory evoked potentials (SSEPs), and compound muscle action potentials (CMAPs) may give adequate additional information in order to help the surgeon in decision making

Treatment

Approach Considerations

Previously, most brachial plexus injuries were treated conservatively: patients were followed for 12 to 18 months until they regained significant voluntary motor control, and any residual disability was declared permanent. Leffert suggested that residual shoulder defects are considered permanent after 9–12 months.[21] However, recovery of more distal function may be observed more than a year after injury. Common treatments have been shoulder fusion, elbow fusion, wrist and finger tenodesis, and transhumeral amputation. Currently, brachial plexus surgery is a highly specialized field that is restricted to a relatively few tertiary care centers. There are many variations in how these injuries are surgically treated. The availability of subspecialists experienced in the surgical treatment of these lesions is essential if surgical treatment is considered.

In general, current surgical options consist of the following:

- Nerve transfers (neurotization)
- Nerve grafting
- Muscle transfers
- Free muscle transfers
- Neurolysis of scar around the brachial plexus in incomplete lesions

Given that these injuries are very complex and vary widely, patient selection is key. Other preoperative considerations aretiming of intervention, which can be critical, and planning of the repair versus reconstructive nature of specific procedures.[22] The timing of and indications for surgical treatment are addressed in more detail below .

Contraindications for surgical treatment include the following:

- Joint contractures
- Severe edema
- Advanced patient age
- Lack of patient motivation or lack of patient understanding of surgical goals

The future may bring further advances in nerve rootlet replantation for preganglionic injuries and in free muscle transfertechniques. Research into growth factors that promote nerve regeneration may make nerve grafting and transfers moreappealing in the future.

Medical Therapy

The operable treatment of the lesion of the shoulder plexus is complicated, and it is best to consider the integrated team, including qualified orthodists, specialized therapists, physiotherapists, and doctors. Brace often plays a role in preventing contracts, but people are waiting for recovery after surgery or hoping to recover from the nerve exhibition. There have been reports in the literature assessing cellular therapy as a potential therapeutic modality after traumatic brachial plexus injuries, suggesting augmented clinical benefits with the combination of cellular therapy and rehabilitation.[23]

Surgical Therapy

Surgical options (see below) include nerve (primary) and soft-tissue (secondary) procedures. Primary procedures are reparative in nature; secondary procedures are reconstructive.

The three crucial factors in restoration of upper-arm function after brachial plexus injury are as follows:

- Patient selection
- Timing of surgery
- Prioritization of restoration
- Patient selection and evaluation

Initial evaluation focuses on examination, particularly sensory and residual motor function, while electrodiagnostic studies and imaging are an essential part of planning the proposed procedure.

Nerve action potentials (NAPs) can demonstrate preserved axons and significant regeneration, as well as the potential for further recovery. Neuroparetic lesions, unlike axonometric lesions (NAP positive), do not demonstrate NAPs.

roots directly into the spinal cord. [29] This was a dramatic advance, as preganglionic lesions were previously thought to be irreparable. In addition, it was reported that the radial sensory to the median nerve transfer.[30]

Ali et al. Enlightened articles published since 1990 to assess the relative efficiency (1) of nervous transplantation, (2) nerve translations and (3) combinations of two for the treatment of shoulder interference injuries.[31] They included only articles in their research. This was reported about the results with the participation of 10 or more cases. They came to the conclusion that during injuries of the shoulder plexus of the upper court in adults,

The Oberlin procedure and nerve translations are more successful in restoring the flexion of the elbow and abduction of the shoulder, respectively, compared with nervous transplantation or combined methods. Sousa et al. We conducted a study comparing the front approach with the rear approach when transferring a reliable nerve with the suprascapular nerve in patients with traumatic injuries of shoulder plexus in their study were 20 patients with men; The Narakas \ 'scale was used to evaluate the abduction of the arms and rotation of the shoulder. The researchers concluded that a posterior approach provides better results for external rotation of the arm.[32]

Timing of surgical intervention

Open injuries from a sharp object may benefit most from immediate exploration and, if possible, direct, end-to-end repair.

Unfortunately, blunt force injuries and avulsion injuries are more common. In open blunt trauma, the contours of the damaged nerve endings can be clearly seen after a 3-4 week recovery period following initial treatment and marking. Low-velocity gunshot wounds can cause nerve paralysis and may be observed. High-velocity gunshot wounds require early evaluation to detect significant soft tissue injury. Open wounds, particularly high-velocity gunshot wounds, require immediate debridement and repair when possible or nerve tagging for delayed repair. External neurolysis should be performed for intraoperative monitoring and electrical studies, or only neurolysis for nerves in continuity with NAP. The extended injury is the most difficult problem. The conditions are inconsistent with such injuries, but spontaneous recovery periods should be generally allowed. Early surgery may eliminate the possibility of spontaneous recovery; however, delaying surgery Otherwise (without intraoperative NAP), nerve grafting can be performed in cases of postganglionic neuroma or nerve rupture. Somatosensory evoked potentials (SSEPs) indicate continuity between the central and peripheral nervous systems via the dorsal root ganglion (DRG). Postganglionic lesions do not have SSEP.

Physiotherapy may be important to prevent contractures during preoperative follow-up. However, surgery may proceed without observation if examination and imaging demonstrate no potential for spontaneous healing.

Surgical options

Open injury, especially high-speed damage, is treated by equipment and restoration. External nerve dissolution must be performed only for surgery and electrical research, or only the nervous dissolution of only continuity nerves. Neuromas or postganglionic ruptures may benefit from nerve grafts. Typically, these grafts include C5 for shoulder abduction, C6 for elbow flexion, and C7 for elbow and wrist extension. Nerve grafting or nerve transfer (neurotization) may be performed in cases of preganglionic injury (i.e., intact cell bodies in the DRG) or to reduce reinnervation time.[24] Such procedures, ideally performed within 6 months, reduce reinnervation time by shortening the distance to the site of nerve injury. Transfer sources include the spinal accessory nerve, intercostal nerves, and medial thoracic nerve.[25,26] They improve shoulder abduction and external rotation in common but devastating high plexus injuries (C5, C6).[27] The Oberlin transfer uses the functional ulnar nerve bundle, but in special cases the median nerve or others may also be used. Kim et al is recovered by recovering elbow flexion in a systematic review and meta analysis that evaluates different donor nerves for nerve movement. We have demonstrated that COST interconnections and pleural nerves are statistically excellent. M3 or higher.[28] Neuro oxidation using the top-closed patient, shaku, median, or double-faciled nervous migration has obtained similar functional results.

The patient's age is also an important consideration. The ability of nerve transfers to restore functional strength decreases dramatically with patient age. Therefore, many of the surgical options are reserved for younger patients.

Advances in this field are expected to lead to more surgical options in the future. For example, Karlstedt has had promising early results repairing preganglionic lesions by transplanting nerve too long may result in failure of the motor nerve end plates and reinnervation. Suspected avulsions can be examined at 3–6 weeks, and failure of adequate reinnervation can usually be examined at 3–6 months. There is no clear consensus on the timing or indications for surgery, but sural nerve grafting has been shown to be superior to denervation, and surgery over a 3 to 6-month period is more common and preferred, with better outcomes. Recruiting large numbers of comparable patients can be difficult in some cases, and further studies are needed to demonstrate the effectiveness of most currently available procedures.

Prioritization of restoration

Reconstruction details are really a matter of planning; the variety of procedures is large, and reconstruction may have to bestaged. Many surgeons prioritize the elbow and then the shoulder for reconstructive procedures. The principal considerations are the root level involved and the specific deficits, particularly hand sensibility, wrist extension, finger flexion, wrist flexion, finger extension, and intrinsic function of the hand.[33]

Postoperative Care

Expectations after surgery are not for immediate recovery but, instead, for a slow process requiring significant patient andfamily education and involvement. Physical therapy is critical for safely maintaining joint motion and suppleness, inconjunction with supports for protection.

Electrical stimulation has been controversial but may at least have psychological benefit. A small study (N = 19) by Pulos etal found that the use of a myoelectric orthosis yielded improved elbow flexion strength, increased function, and reduced painin the majority of patients with brachial plexus injury and inadequate elbow flexion after observation or surgicalreconstruction.[34-36]

CONCLUSION

Knowledge of topographic anatomy (rooting, course, and relationship related to adjacent anatomical elements, and peripheral and peripheral nerves, and the connections of the target organs, the connections, and nerves. Not only those relationships, but also repeatedly recorded clinical tests, sensory nervous domination is the key to diagnosis evaluation of the lesion of the upper arm nerve plexus.

Regardless of whether there is a contrast, whether or not, the simple X-ray photograph, computer fault shooting, CT bone marrow contrast, and magnetic resonance images have their own sensitivity and peculiar, and are exquisite and diagnostic. A valuable accessory tool for evaluation and diagnostic approach to sexual wounds. Each of these techniques plays an important role in intra- and post-operative diagnosis and evaluation. To optimize expected outcomes, it is paramount to use each diagnostic method within an appropriate time frame.

REFERENCES

1. Akita S, Wada E, Kawai H. Combined injuries of the brachial plexus and spinal cord. J Bone Joint Surg Br. 2006 May. 88 (5):637-41.
2. Webb JC, Munshi P, Saifuddin A, Birch R. The prevalence of spinal trauma associated with brachial plexus injuries. Injury. 2002Sep. 33 (7):587-90.
3. Shin AY, Spinner RJ, Steinmann SP, Bishop AT. Adult traumatic brachial plexus injuries. J Am AcadOrthop Surg. 2005 Oct. 13(6):382-96.
4. Blaauw G, Muhlig RS, Vredeveld JW. Management of brachial plexus injuries. Adv Tech Stand Neurosurg. 2008. 33:201-31.
5. Rovak JM, Tung TH. Traumatic brachial plexus injuries. Mo Med. 2006 Nov-Dec. 103 (6):632-6.
6. Millesi H. Brachial plexus injuries. Chapman MW, Szabo RM, Mann RA, et al, eds. Chapman's Orthopedic Surgery. Philadelphia:Lippincott Williams & Wilkins; 2001. 1703-20.
7. Goldie BS, Coates CJ. Brachial plexus injury: a survey of incidence and referral pattern. J Hand Surg Br. 1992 Feb. 17 (1):86-8.
8. Hong TS, Tian A, Sachar R, Ray WZ, Brogan DM, Dy CJ. Indirect Cost of Traumatic Brachial Plexus Injuries in the UnitedStates. J Bone Joint Surg Am. 2019 Aug 21. 101 (16):e80.
9. Narakas AO. The treatment of brachial plexus injuries. Int Orthop. 1985. 9 (1):29-36.
10. Doi K, Muramatsu K, Hattori Y, Otsuka K, Tan SH, Nanda V, et al. Restoration of prehension with the double free muscletechnique following complete avulsion of the brachial plexus. Indications and long-term results. J Bone Joint Surg Am. 2000 May.82 (5):652-66.
11. Kandenwein JA, Kretschmer T, Engelhardt M, Richter HP, Antoniadis G. Surgical interventions for traumatic lesions of thebrachial plexus: a retrospective study of 134 cases. J Neurosurg. 2005 Oct. 103 (4):614-21.
12. Landers ZA, Jethanandani R, Lee SK, Mancuso

CA, Seehaus M, Wolfe SW. The Psychological Impact of Adult TraumaticBrachial Plexus Injury. J Hand Surg Am. 2018 Oct. 43 (10):950. e1-950.e6.

13. Boome RS. The hand and upper extremity. Boome RS, ed. The Brachial Plexus. Philadelphia: WB Saunders; 1997. Vol 14: 1-18.

14. Amrami KK, Port JD. Imaging the brachial plexus. Hand Clin. 2005 Feb. 21 (1):25-37.

15. Burge P. Diagnostic investigations. Boome RS, ed. The Brachial Plexus. Philadelphia: WB Saunders; 1997. Vol 14: 19-29.

16. Wade RG, Takwoingi Y, Wormald JCR, Ridgway JP, Tanner S, Rankine JJ, et al. MRI for Detecting Root Avulsions in TraumaticAdult Brachial Plexus Injuries: A Systematic Review and Meta-Analysis of Diagnostic Accuracy. Radiology. 2019 Oct. 293(1):125-133.

17. Elsakka TO, Kotb HT, Farahat AA, Semaya AE, Deif OA, Bastawi RA. Axial T2-DRIVE MRI myelography is highly accurate indiagnosing preganglionic traumatic brachial plexus injuries: why pseudomeningoceles should not be used as a primarydiagnostic sign. Clin Radiol. 2022 May. 77 (5):377-383.

18. Szaro P, Geijer M, Ciszek B, McGrath A. Magnetic resonance imaging of the brachial plexus. Part 2: Traumatic injuries. Eur JRadiol Open. 2022. 9:100397.

19. Ferris S, Chan M, Miller G. Incidence of brachial plexus injury with concurrent subclavian or axillary vascular injury and itsinfluence on reconstruction. ANZ J Surg. 2022 Feb 28.

20. Impastato DM, Impastato KA, Dabestani P, Ko JH, Bunnell AE. Prognostic value of needle electromyography in traumaticbrachial plexus injury. Muscle Nerve. 2019 Nov. 60 (5):595-597.

21. Leffert RD. Green's Operative Hand Surgery. 4th ed. New York: Churchill Livingstone; 1999. 1557-87.

22. Jivan S, Kumar N, Wiberg M, Kay S. The influence of pre-surgical delay on functional outcome after reconstruction of brachialplexus injuries. J Plast ReconstrAesthet Surg. 2009 Apr. 62 (4):472-9.

23. Sharma A, Sane H, Gokulchandran N, Badhe P, Pai S, Kulkarni P, et al. Cellular Therapy for Chronic Traumatic Brachial PlexusInjury. Adv Biomed Res. 2018. 7:51.

24. Rohde RS, Wolfe SW. Nerve transfers for adult traumatic brachial plexus palsy (brachial plexus nerve transfer). HSS J. 2007Feb. 3 (1):77-82.

25. Moiyadi AV, Devi BI, Nair KP. Brachial plexus injuries: outcome following neurotization with intercostal nerve. J Neurosurg. 2007Aug. 107 (2):308-13.

26. Suzuki K, Doi K, Hattori Y, Pagsaligan JM. Long-term results of spinal accessory nerve transfer to the suprascapular nerve inupper-type paralysis of brachial plexus injury. J ReconstrMicrosurg. 2007 Aug. 23 (6):295-9.

27. Bhandari PS, Deb P. Dorsal approach in transfer of the distal spinal accessory nerve into the suprascapular nerve:histomorphometric analysis and clinical results in 14 cases of upper brachial plexus injuries. J Hand Surg Am. 2011 Jul. 36(7):1182-90.

28. Kim RB, Bounajem M, Hamrick F, Mahan MA. Optimal Donor Nerve to Restore Elbow Flexion After Traumatic Brachial PlexusInjury: A Systematic Review and Meta-Analysis. Neurosurgery. 2022 Jan 1. 90 (1):39-50.

29. Carlstedt TP. Spinal nerve root injuries in brachial plexus lesions: basic science and clinical application of new surgicalstrategies. A review. Microsurgery. 1995. 16 (1):13-6.

30. Leechavengvongs S, Ngamlamiat K, Malungpaishrope K, Uerpairotkit C, Witoonchart K, Kulkittiya S. End-to-side radial sensoryto median nerve transfer to restore sensation and relieve pain in C5 and C6 nerve root avulsion. J Hand Surg Am. 2011 Feb. 36(2):209-15.

31. Ali ZS, Heuer GG, Faught RW, Kaneriya SH, Sheikh UA, Syed IS, et al. Upper brachial plexus injury in adults: comparativeeffectiveness of different repair techniques. J Neurosurg. 2015 Jan. 122 (1):195-201.

32. Souza FH, Bernardino SN, Filho HC, Gobbato PL, Martins RS, Martins HA, et al. Comparison between the anterior and posteriorapproach for transfer of the spinal accessory nerve to the suprascapular nerve in late traumatic brachial plexus injuries. ActaNeurochir (Wien). 2014 Dec. 156 (12):2345-9.

33. Ahmed-Labib M, Golan JD, Jacques L. Functional outcome of brachial plexus reconstruction after trauma. Neurosurgery. 2007Nov. 61 (5):1016-22; discussion 1022-3.

34. Pulos N, van den Berg C, Kaufman KR, Shin AY. Application of myoelectric elbow flexion assist orthosis in adult traumaticbrachial plexus injury: a retrospective clinical study. ProsthetOrthot Int. 2021 Dec 1. 45 (6):521-525.

35. Parry CB. Management of deafferentation pain. Boome RS, ed. The Brachial Plexus. Philadelphia: WB Saunders; 1997. Vol 14:165-8.

36. Thomas DG, Sheehy JP. Dorsal root entry zone lesions (Nashold's procedure) for pain relief following brachial plexus avulsion. JNeurolNeurosurg Psychiatry. 1983 Oct. 46 (10):924-8.