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ANAESTHESIA FOR SURGICAL FIXATION OF CLAVICLE FRACTURE AND INNERVATION OF CLAVICLE - A RETROSPECTIVE ANALYSIS

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ABSTRACT

INTRODUCTION

Clavicle or collar bone is an organ of multiple and variable innervation. Being commonest fracture in childhood, it accounts for upto 10% if all fractures.[1]

1. Clavicle is the only osseous link between the upper extremity and the trunk. The thinnest segment without any ligamentous attachments is the mid segment of clavicle which is henceforth frequently fractured.
2. Alman classification divides clavicular fracture into three classes:

Class 1 is midshaft, Class 2 is lateral 1/3, Class 3 is medial 1/3. Revised Neers classification distinguishes three subdivisions: Type 1 is undisplaced and fractures are lateral to coracoclavicular ligament and managed conservatively. Type 2 involves a separated medial fragment from coracoclavicular ligament. Type 3 is undisplaced fracture extending into acromioclavicular joint. Thus type 2 alone needs surgical intervention.

3. Crucial vessels and nerves are related to clavicle which are both advantageous and sometimes not. The structures serve easy identification but risky injury. The clavicle and the clavicular joints are innervated by subclavian, lateral pectoral and supraclavicular nerves. These nerves have wide anatomic variations in branching relations and levels. Knowledge of innervation of clavicle is needed for effective blockade of nerves for anaesthesia or analgesia. Though interscalene approach of brachial plexus block is a plan A block for shoulder surgeries, it has variable results for clavicular fractures.

This study examines the nerve supply of clavicle and reterospects the nerve blocks which have failed to come under Plan A block category and probes the need for elaboration in regional anaesthesia for fractures of clavicle.

AIMS AND OBJECTIVES

1. To analyse the effect of interscalene block in fractures of clavicle.
2. To examine variable innervation in different types of clavicle fractures.

MATERIALS AND METHODS

Study: Retrospective analysis.

Study Preparation: All patients who underwent surgical correction for clavicle fractures as recommended by Orthopedic surgeon.

Study Period: Jan 2024 to Jan 2025.
Study Place: DSMCH, Siruvachur, Perambalur.
Methods: All the patients are presented for surgical repair and fixation of clavicle, underwent surgery under ultrasound guided interscalene block followed by general anaesthesia. All procedures were uneventful and post-operative hemodynamics and pain relief were optimal and adequate for 8 hours in the post-operative period. The age, gender of the patients, the location and nature of the fractures of clavicle, the probable nerve supply of the fracture site and those needed for reduction of displaced fractures were all noted to support the need for general anaesthesia in all our cases of fracture clavicle, which were isolated fracture. Fractures of multiple bones or polytrauma were excluded from the case series.
RESULT
The case series consists of 23 patients with displaced isolated clavicular fracture. All of them underwent open reduction and internal fixation. Of 23 only 5 were females, most of them belonged to 30-35 years age group, 11 were fractures of left clavicle and 12 were that of right, 16 were fracture of middle third, 6 were lateral 1/3rd of clavicle that was affected of the 23 two were communuted. The pull of muscles and strong ligaments namely trapezius, sternocleidomastoid, pectoralis major and lattismus dorsi and the sternoclavicular ligament all of different innervation necessitated general anaesthesia to reduce and fix the fracture of clavicle.
CONCLUSION
The interscalene approach to brachial plexus block resulted in reliable and predictable anaesthesia of shoulder, upper arm and clavicular region. The supraclavicular branches of cervical plexus supplying skin over the acromion and clavicle are also blocked due to proximal and superficial spread of local anesthetic. Considerations for superficial plexus block and infraclavicular approach to lateral and medial pectoral nerves and posteriorly the suprascapular block may contribute to toal nerve blockade if judiciously performed considering the type of fracture of clavicle. Thus analgesis serves useful where general anaesthesia would not be feasible in specific situations futher studies including cadaveric studies are needed to confirm the variable levels of innervation.

KEY WORDS
Fracture Clavicle, Interscalene Block, Supraclavicular Block, Clavicular Innervation.

Abbreviations- LCL- Left Clavicle, **LCF**- Left Clavicle Fracture, **SCA**- Scalenus Anterior, **SCM**-Scalenus Medius, **SCM**- Sternocleidomastoid, **SCT**-Superior Trunk, **INT**- Intermediate Trunk, **IT**-Inferior Trunk , **MPN**- Medial Pectoral Nerve , **PMAG**- Pectoralis Major, **PMIN**- Pectoralis Minor, **Cl** – Clavicle, **LC**- Lateral Cord, **MC**-Medial Cord, **AV**- Axillary Vessels, **SCM**- Superior Clavicular Nerve, **T**- Trachea, **L**- Lung.

INTRODUCTION

Fracture of the clavicle are frequent injuries and are responsible for 2 to 10% of all the fractures of the human body and 33% to 45% of the injuries affecting the scapular belt.[2] Clavicle fractures occur in young active individuals with high speed falls or violent collisions or sport accounting for 2.6-4% of all fractures, 80-85% of clavicular fractures occur in the midshaft of bone where bone is thin and curved lacking muscular and ligamentous attachments that protect the lateral ends of the bone. More elderly patients with simple falls account to 15-20% presenting as fracture of lateral one third while medial 1/3rd fracture is very rare about 0-5% partly due to difficulty in identifying in plain radiographs.

Surgeries of shoulder and upper limb are commonly done under brachial plexus block. The superior trunk of brachial plexus consistently found accessible and reliable is situated between scalenus anterior and scalenus medius and the local anaesthetic spread due to interscalene block expectantly spreads superficially and proximally to block the supraclavicular nerves as well. The later are found to supply the entire clavicle in most cases.

In this case series we intend to analyse the effects of a well performed ultrasound guided interscalene block which still proved clinical difficulty in reducing the fracture and also in most of the lateral third and all the medial third fractures, necessitating prophylactic general anaesthesia.
Though the nerve blocks provide better post-operative pain relief than in surgeries done under general anaesthesia alone, the interscalene block which is grouped as a plan A block now stepped down to plan B or C block. This case series provoked the idea and need to find answers by examining the innervation of clavicle and the types of fractures which derive nerve supply from variable main branches.

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Figure 1: Operarive Picture of Fracture clavicle

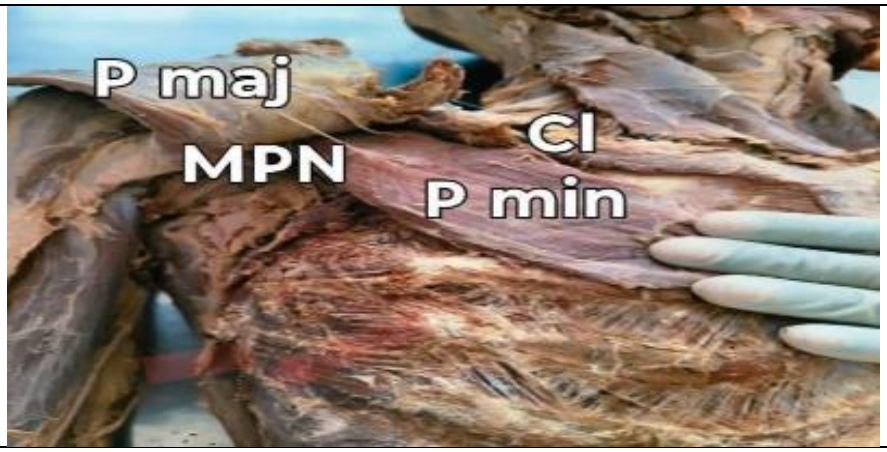

Figure 2: Supraclavicular nerves supplying superolateral portion of clavicle

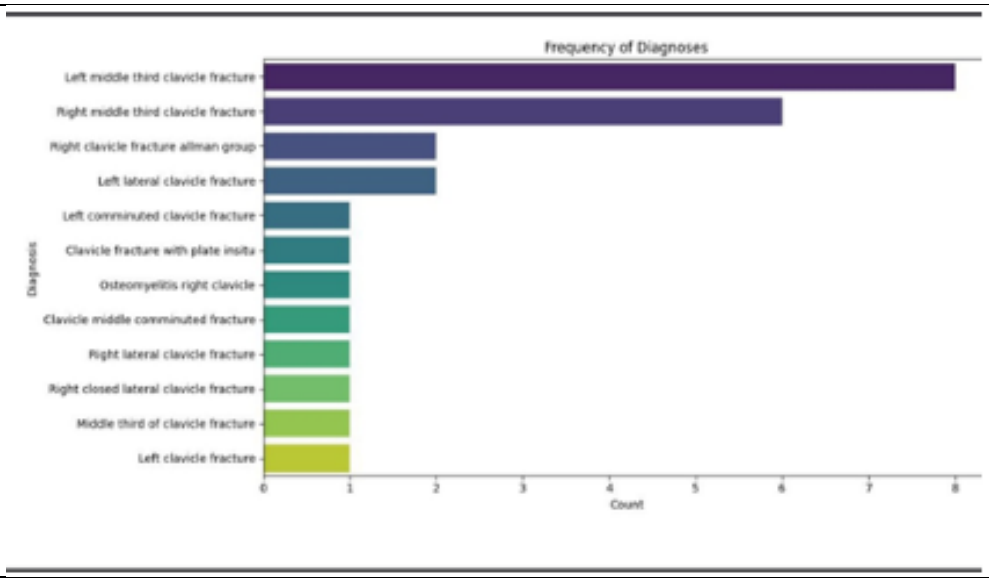

Figure 3: Frequency of diagnosis

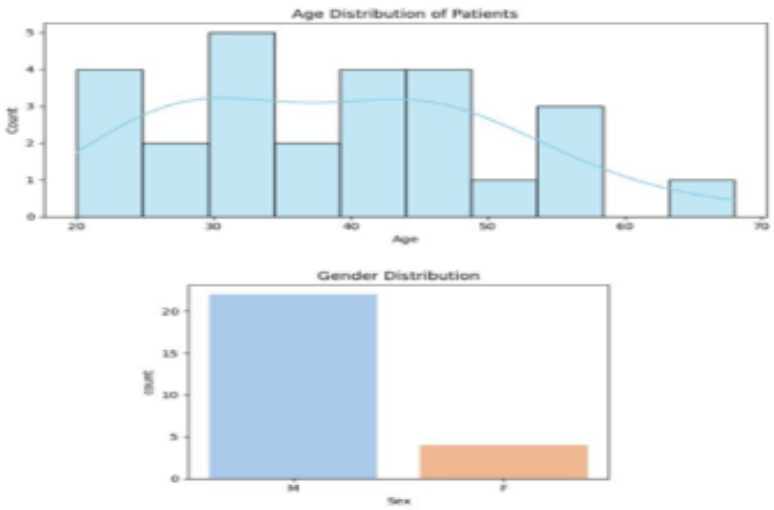

Figure 4: Age, gender distribution

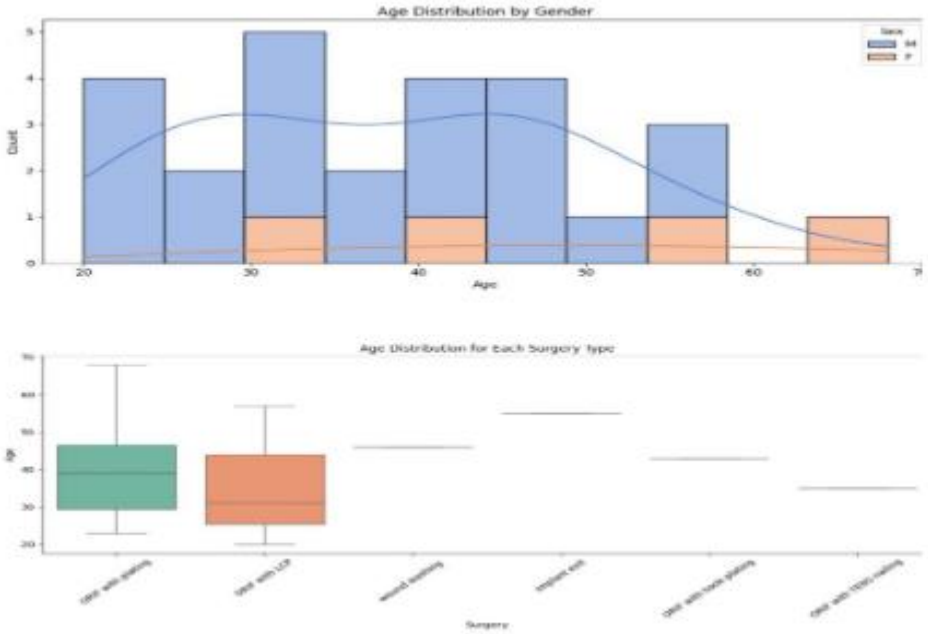

Figure 5: Distribution for type of surgery

DISCUSSION

Clavicle Fractures History

Hippocrates in 400 BC said clavicle being a spongy bone develops early callus and henceforth heal on its own. In 1960s Neer et al said displacement may lead to deformity and set up figure of 8 bandage shoulder brace and sling which prevented malunion. In 2007 Canadian Orthopaedic Trauma Society compared retrospective treatment for clavicular fracture with surgical treatment and inferred nil malunion with the latter.[3] Patient characteristics and fracture morphology should guide the nature of surgery.

Clinical Features

History of nature of injury and associated after injuries or deformities must be noted. A completely displaced midshaft fracture causes shoulder ptosis or drooping of the shoulder.

Allman classification of fracture of clavicle

Group 1: Middle 1/3rd fractures

Group 2: Distal 1/3rd fractures

Group 3: Proximal 1/3rd fractures

Classification influencing treatment and outcome focus on fracture pattern, displacement, communition and shortening. Nordquist et al examined over 2035 fractures of clavicle over 10 years period and expanded on Allmans original scheme.[4]

Robinsons classification defended on prognostic variables from analysis of over 1000 patients.[5] This classification is at present preference as it helps predict outcome and guide treatment.

Robinsons Classification

Neer divided distal clavicle fractures into 3 subgroups based on ligamentous attachments and degree of displacement. Rockwood modified this further as follows:

- **Type 1:** Distal clavicle fracture with intact CC.
- **Type 2:** CC detatched from medial fragment with trapezoidal fragment attached to distal fragment.
- **Type 2A:** (Rockwood) coroid and trapexoid ligaments attached to distal fragment.
- **Type 2B:** Coroid detatched from medial fragment.
- **Type 3:** Distal clavicle fracture with extension into the AC ligament.

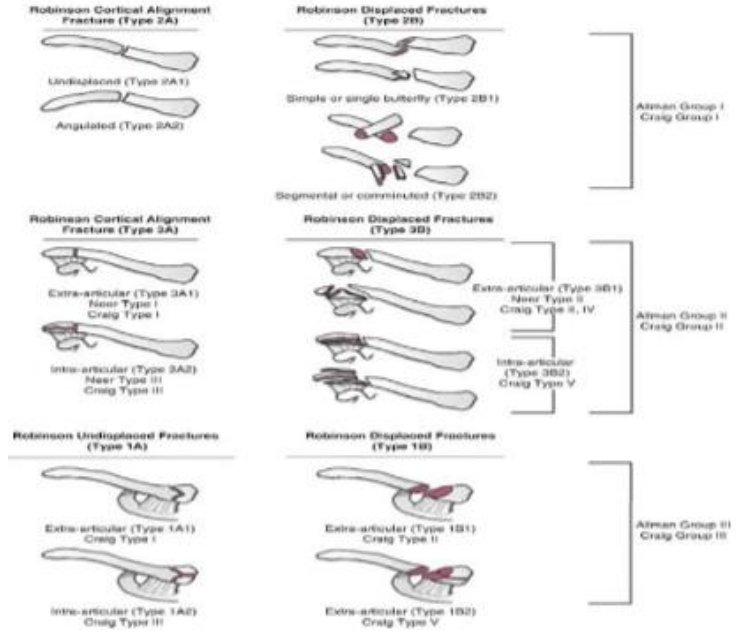

Figure 6: Robinson classification

Pathoanatomy of Clavicle

Clavicle is the only trye connection between torso and arm. It is the first bone to ossify after 5 to 6 weeks of gestation and last to reach complete ossification at 27 years of age.[6] The clavicle is a relatively thin bone, widest at its medial and lateral expansions where it articulates with sternum and acromion respectively. It has two distinct curves: the larger obvious curve is in the coronal plane giving it the S shape- medial end convex anterior, lateral and concave anterior.

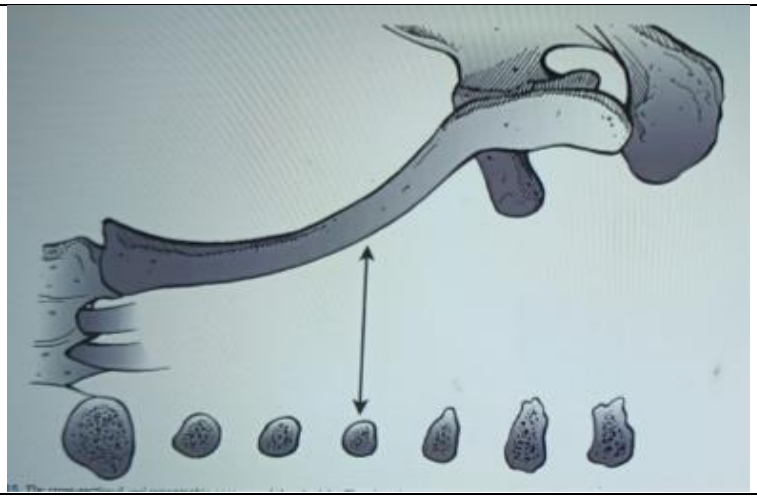

Figure 7: Cross section of clavicle

Cross Sectional Anatomy of Clavicle

Ligamentous Anatomy of Clavicle

Medial Ligaments: Medially the clavicle is secured by the sternoclavicular capsule with the sternum. The thickening of the posterior capsule offers the single soft tissue constraint for the anterior and posterior translation of the medial clavicle. The interclavicular ligament acts as a tension wire at the base of the clavicle and prevents inferior angulation or translation of clavicle.

Lateral Ligaments: The coracoclavicular ligaments are the trapezoid (more lateral) and coroid (more medial) which are stout ligaments that arise from the base of the coracoid and insert into the small osseous ridge of the inferior clavicle (trapezoid) and the clavicular coroid tubercle (coroid). These ligaments are very strong and provide the primary resistance to superior displacement of the lateral clavicle. Clavicle fractures in this locat ion have an avulsed inferior fragment and surgical fixation including these fragments enhances the stability of operative repair. The capsule of the acromioclavicular joint is thickened superiorly and is responsible for resisting is ligament is essential while operating on the distal end fractures of the clavicle.[7]

Muscular Anatomy of the Clavicle: Clavicle serves attachment sites to several large muscles. Medially the pectoralis major muscle originates from clavicular shaft anteroinferiorly, and sternocleidomastoid originates superiorly. The pectoralis origin emerges with origin of anterior deltoid laterally while the insertion of trapezius blends superiorly with the deltoid origin at the lateral margin.

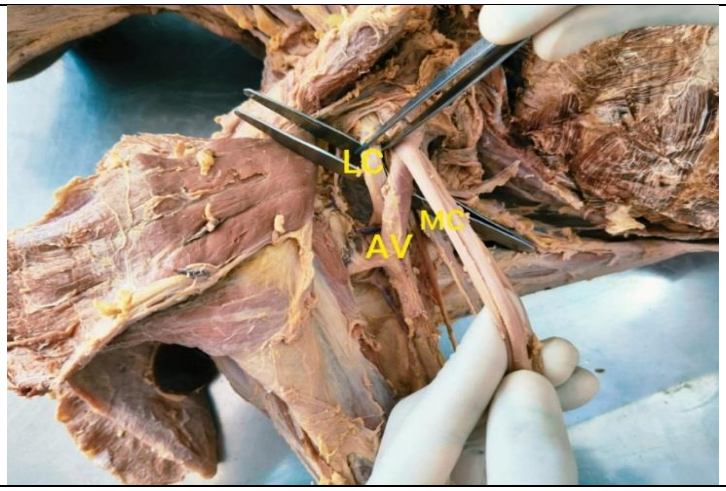

Figure 8: Axillary vessel separating medial and lateral cord

The medial clavicular fragments of a fracture is elevated by the unopposed pull of the sternocleidomastoid while the distal fragment is held inferiorly by deltoid and medially by pectoralis major. Thus the nerves that supply these muscles also play a role in causing traction pain while reducing the fracture. The under surface of the clavicle is the insertion site of subclavius muscle which serves as a soft tissue buffer in the subclavicular space superior to the brachial plexus and subclavian vessels. The platysma envelopes the anterior and superior aspects of clavicle.

Neurovascular Anatomy of Clavicle

The supraclavicular nerves originates from cervical roots c3 and c4 and exit from a common trunk behind the posterior border of sternocleidomastoid muscle. There are three major branches namely anterior, middle and posterior that cross clavicle superficially from medial to lateral. The subclavian vein runs directly below the subclavius muscle and the first rib where it is accessible for central vein cannulation. More posteriorly lie subclavian artery and brachial plexus separated from vein and clavicle by scalenus anterior muscle medially, subclavian vessels are closest to the clavicle at the medial end, but lie 2cm posteroinferior in the middle third of clavicle.

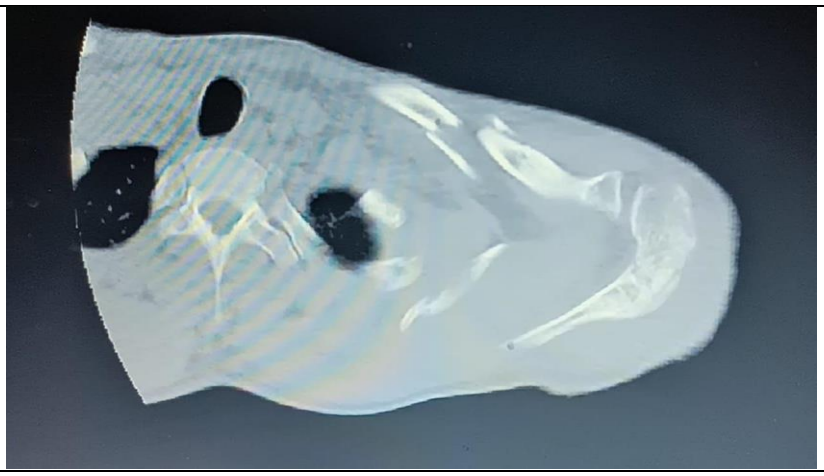

Figure 9: CT scan of fragmental fracture mid third of clavicle

Clavicular Fractures and Nerve Blocks

A systematic review of regional anaesthesia for clavicle fractures by Xuequin Ding of Cleveland Medical centre, Ohio in 2022 describes the sensory innervation of clavicle still remained controversial.

A cadaveric investigation or innervation of clavicle by Prangmalee et al revealed that supraclavicular, suprascapular, lateral pectoral nerves all contributed to the nerve supply and clavicular bone and joints.[8] The supraclavicular nerves innervated the scaphoid and ventral aspects of the clavicular bone. The caudal and dorsal aspects of clavicle were innervated by subclavian nerve, the lateral pectoral nerve supplied the caudal aspect of the clavicle. The sternoclavicular joint derived its innervation from supraclavicular nerves whereas the acromioclavicular joint was supplied by supraclavicular and lateral pectoral nerves.

The supraclavicular nerves are branches of the cervical plexus within the root of the neck and clavicular region. The middle third of the posterior border of sternocleidomastoid gives a common trunk. The trunk is formed by the ventral rami of C3 and C4 spinal roots. This common trunk divides into medial, intermediate and lateral branches. These pierces the deep fascia above the clavicle to run in the subcutaneous plane, providing sensory branches to skin.

The medial branch crosses the external jugular vein and sternocleidomastoid to innervate the skin overlaying medial head of clavicle. The intermediate branch crosses the clavicle to innervate the skin overlying pectoralis major and deltoid. The lateral branch passes over trapezius muscle to innervate the skin of superior and posterior shoulder.

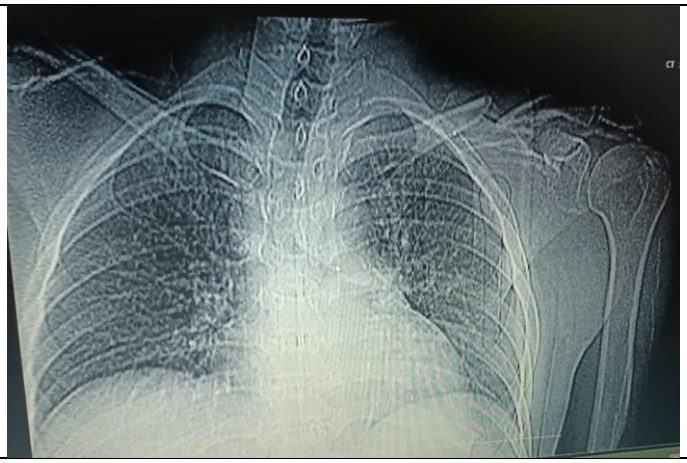

Figure 10: X ray chest with fracture left clavicle

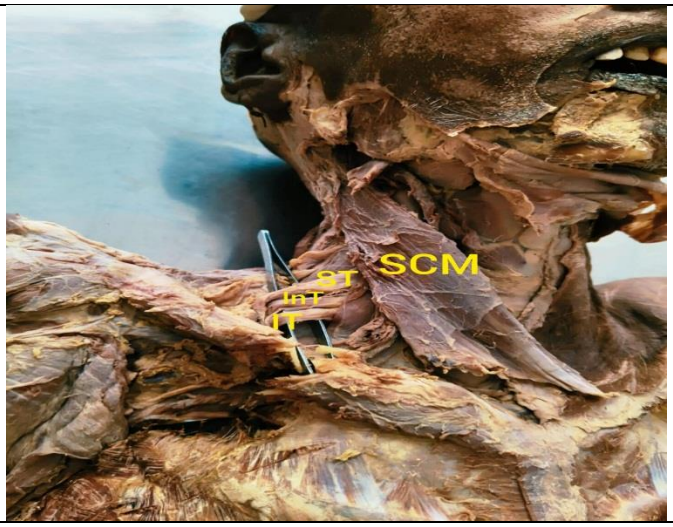

Figure 11: Interscalene groove

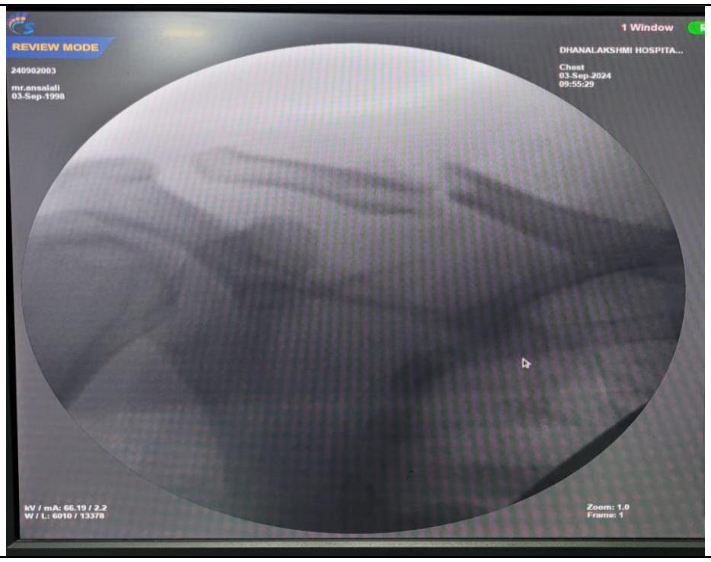

Figure 12: Fracture clavicle mid third

The three main sensory branches of supraclavicular nerves are medial intermediate and lateral. The medial supraclavicular nerves supply the sternoclavicular joint and skin overlying the medial head of clavicle. Intermediate branches supply skin over pectoralis and deltoid. The lateral branches supply the skin of superior and posterior shoulder.

The lateral pectoral nerves showed a constant course on 8 female cadavers which were dissected to perform vascular and radiologic studies.[9] The lateral pectoral nerve coursed infero medially on the deep surface of pectoralis major, under the fascia. The medial pectoral nerves showed two main patters of branching which correlated with the extent of costal attachments of pectoralis minor muscle. In pattern A of about 56% the nerve pierced the deep aspect of pectoralis minor as a single trunk ramified the muscle and gave some branches that appeared on the superficial aspect to enter pectoralis major. In pattern B 44% the nerve divided before entering pectoralis minor and its branches passed through the muscle or round its lower border to each pectoralis major. The most medial branch of medial pectoral nerve emerged from pectoralis minor at the third intercostal space in the midclavicular line. This course of medial pectoral nerve which travels from infero lateral area of clavicle to supply costal attachment of pectoralis major along the sternal fibres travelling medially towards sternocostal region and also giving branches to the sternoclavicular joint. A meta-analysis of the available literature showed the lateral pectoral nerve arises most frequently with two branches from the anterior divisions of the upper and middle trunk or as a single root from the lateral cord. The medial pectoral nerve arises from medial cord, anterior division of the lower trunk or lower trunk.[10]

The two pectoral nerves are usually connected immediately distal to the thoracoacromial artery by ansa pectoralis. The medial pectoral nerve shows communications with intercostobrachial nerve.The interscalene block offers blockade of the superior trunk of the brachial plexus between the scalenus medius and the spread of the local anaesthetic proximally and superficial ensures blockade of supraclavicular nerves as well. Ultrasound guided interscalene block visualises the spread of the local anaesthetic and allows reduction in the volume of the drug when injected under vision to about 50% compared to by landmark guided technique.

The brachial plexus at interscalene level is seen lateral to carotid artery and internal jugular vein between anterior and middle scalene muscles. The prevertebral fascia, superficial cervical plexus and the sternocleidomastoid muscle are seen superficial to the plexus.

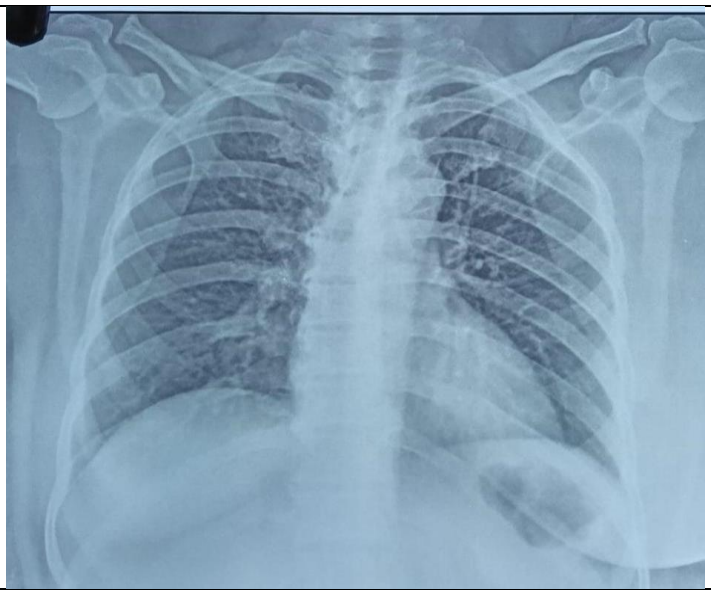

Figure 13: Fracture of right lateral third of clavicle

The approach from lateral to medial insertion of the needle avoids phrenic nerve anterior to the anterior scalene while the dorsal scapular and long thoracic nerve course through the middle scalene. C6 and C7 root nerves split proximally; hence care must be taken to inject between C5 and C6. In some variations C5 root may travel through the anterior scalene for part of its course. The suprascapular and subclavius nerves branch out superiorly and inferiorly respectively just proximal to the anterior and posterior divisions of the superior trunk. The posteroinferior surface of the clavicle and the muscle attachments there derive nerve supply from the above nerve.

The lateral pectoral nerve comes from proximal portion of lateral cord receives few fibres from posterior cord (C7) from the point proximal to the medial pectoral nerve from medial cord (C8T1)which receive nerve fibres from posterior division of superior trunk and anterior division of inferior trunk proximal to the level of cords.

Thus fractures that are not displaced or distorted of the middle third of clavicle need an adequate interscalene block while a displaced and distorted fragmented clavicle needs additional nerves to be blocked for reducing the fracture due to the strong muscle pull of pectoralis major, trapezius and subclavius. Interclavicular placement or approach of local anaesthetic may be needed for a fracture of medial third of clavicle though rare to block medial pectoral nerve which pierces pectoralis minor from lateral end of clavicle to supply sternal fibres of pectoralis major and sternoclavicular joint. The fractures of lateral third of clavicle if also displaced and comminated need an good superficial and proximal spread of local anaesthetic from the interscalene plane to block the supraclavicular, medial and lateral pectoral nerves.

A posteriorly displaced fracture of lateral third with or without involvement of the acromioclavicular joint with or without manifestation of winging of scapula needs suprascapular block as well.

Figure 14: Scalene muscles

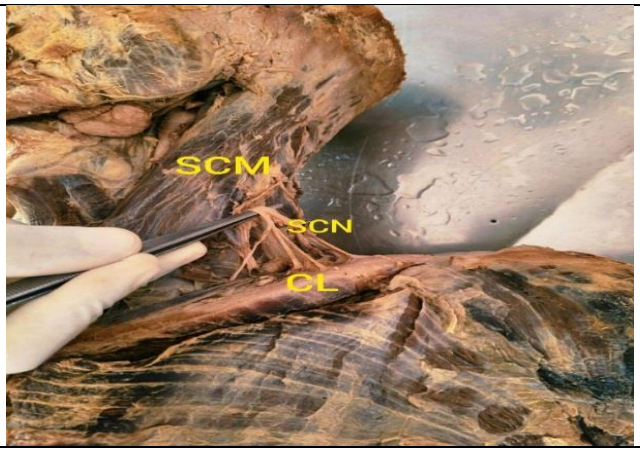

Figure 15: Supraclavicilar nerves

CONCLUSION

Clavicle is the only bone connecting upper limb and the torso fractures of clavicle with sterno to acromio clavicular joint distance has a shortening of more than or equal to 8cm when compared to normal side need surgical correction and fixation. Brachial plexus block at interscalene level is plan A block which can individually provide surgical anaesthesia. This block proves only better post operative analgesia and general anaesthesia is needed in 100% of cases for surgical management. This case series of 23 different fracture sites of clavicle over a one year period examines the reasons for need of general anaesthesia in the perview of innervation of clavicle.

Clavicle and the two joints and powerful muscle attachments derive nerve supply from all directions medially, superiorly, laterally and inferiorly. Depending on the type of clavicle fracture, whether

simple complex, communited, fragmented with the degree of displacement and shortening, drooping of shoulder or winging of scapula, apart from local anaesthetic block to superior trunk of brachial plexus(interscalene), supraclavicular branches for the superolateral and middle third clavicle fracture, medial pectoral for medial third fractures lateral pectoral nerve to subclavius for lateral third clavicle fractures and suprascapular nerve block for posteriorly displaced fractures.

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