AUTOPSY BASED STUDY OF INCIDENCE OF VERTEBRAL ARTERY INJURY IN FATAL NON PENETRATIVE CERVICAL SPINE TRAUMA

Dissertation submitted in partial fulfilment of
the requirements for the degree

M.D. (Forensic Medicine)
BRANCH - XIV

INSTITUTE OF FORENSIC MEDICINE
MADRAS MEDICAL COLLEGE
CHENNAI – 600 003

THE TAMIL NADU Dr. M.G.R. MEDICAL UNIVERSITY
CHENNAI

APRIL 2017

BONAFIDE CERTIFICATE

This is to certify that the work embodied in this dissertation entitled **"AUTOPSY BASED STUDY OF INCIDENCE OF VERTEBRAL ARTERY INJURY IN FATAL NON PENETRATIVE CERVICAL SPINE TRAUMA"** has been carried out by **Dr. T.Ezhil Kothai, M.B.B.S,** a Post Graduate student under my supervision and guidance for his study leading to Branch XIV M.D. Degree in Forensic Medicine during the period of April - 2016 to September - 2016.

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Madras Medical College &
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DECLARATION

I, **Dr.T.Ezhil Kothai,** solemnly declare that this dissertation titled **"AUTOPSY BASED STUDY OF VERTEBRAL ARTERY INJURY IN FATAL NON PENETRATIVE CERVICAL SPINE TRAUMA"** is the bonafide work done by me under the expert guidance and supervision of Dr.V.Murugesan M.D.,D.A.,F.C.C.P., Professor and Director, Institute of Forensic Medicine, Madras Medical College, Chennai – 3. This dissertation is submitted to The Tamil Nadu Dr. M.G.R Medical University towards partial fulfilment of requirement for the award of M.D., Degree (Branch XIV) in Forensic Medicine.

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Date:

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CERTIFICATE OF APPROVAL

To
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Dear Dr.T.Ezhil Kothai,

The Institutional Ethics Committee has considered your request and approved your study titled **" AUTOPSY BASED STUDY OF INCIDENCE OF VERTEBRAL ARTERY INJURY IN FATAL NON PENETRATIVE CERVICAL SPINE TRAUMA " - NO.17012016.**

The following members of Ethics Committee were present in the meeting hold on **12.01.2016** conducted at Madras Medical College, Chennai 3

1.Dr.C.Rajendran, MD.,	:Chairperson
2.Dr.R.Vimala,MD.,Dean,MMC,Ch-3	:Deputy Chairperson
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7.Tmt.J.Rajalakshmi, JAO,MMC, Ch-3	: Lay Person
8.Thiru S.Govindasamy, BA.,BL,High Court,Chennai	: Lawyer
9.Tmt.Arnold Saulina, MA.,MSW.,	:Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

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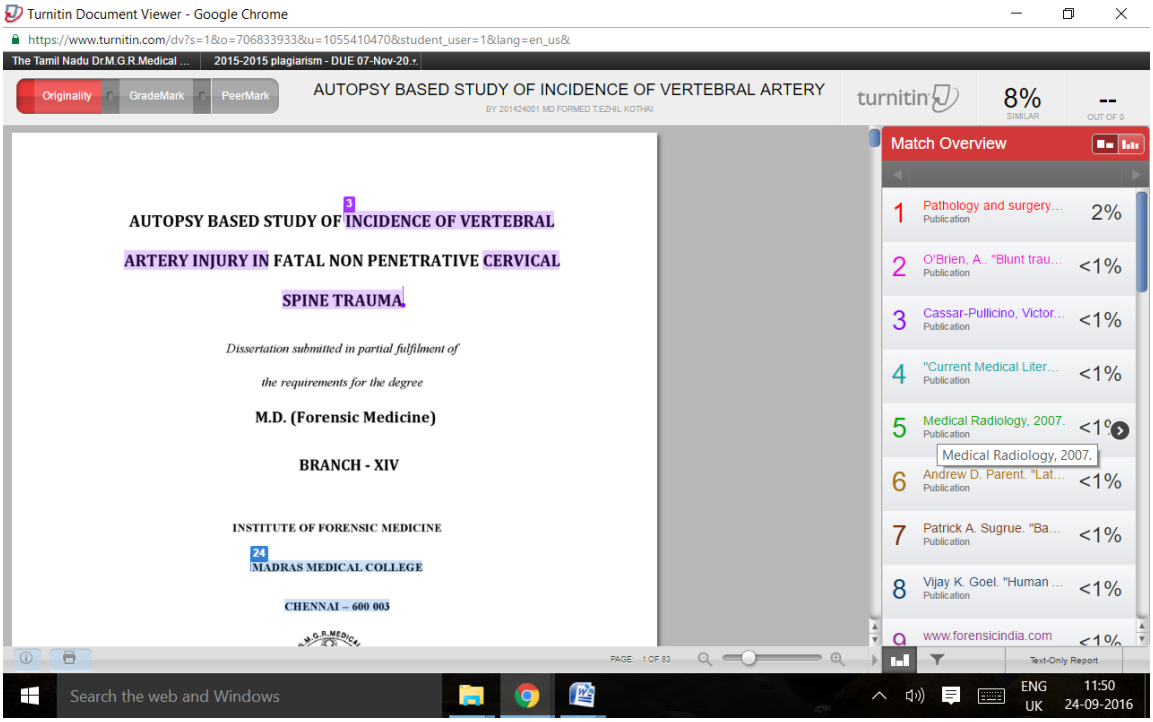
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INDEX

LIST OF TABLES

LIST OF FIGURES

LIST OF CHARTS

ABBREVIATIONS

VA	Vertebra Artery
C	Cervical
CTA	Computed Tomographic Angiography
MRA	Magnetic Resonance Angiography
MRI	Magnetic Resonance Imaging
RTA	Road Traffic Accident
Lt.	Left
Rt.	Right
PM	Postmortem

Introduction

INTRODUCTION

Etymologically, 'Trauma' originates from the Greek language which means 'wound'[1]. Any injury inflicted by force on a living tissue is called as trauma[2]. It could be physical or psychological. Psychological trauma is not physically visible. The word trauma usually means physical trauma which is interchangeable with the word 'injury'. Trauma can occur in any manner – accidental, suicidal or homicidal.

Accidents are the most common manner of injury owing to the increased number of automobiles and industries in this century. It is followed by suicidal injuries which could be penetrating injuries like cut throat and suicidal incision wounds. Trauma related to suicides is possible when it involves road traffic accidents, fall from height and train traffic accidents. Homicidal trauma could be cut throat injury, stab injury, gunshot wounds, lacerations, fractures etc.

About two third of all injury in the world is due to blunt force[3].Of all the causes of trauma, road traffic accidents constitute more than three fourth of the cases. For every 1000 vehicles in India, about 35 vehicles meet with an accident and accidents happen every 2 minutes[4,5]. Injury to the head has higher mortality than injury to other parts of the body due to the damage caused to the brain. Spinal injuries are more common in road traffic accidents

of which cervical spine injuries are of great concern to the Forensic experts owing to its close relationship with head injuries and their increased incidence in this century [6].

Based on the type of injury, it can be classified as blunt trauma and penetrative trauma. Penetrative injuries become fatal when there is damage to any great vessel, vital organ or the airway. Immediate death is mostly due to shock and haemorrhage. Late deaths occur due to infection of the wound, sepsis, multi organ failure etc.

In blunt trauma, the force on the body gets transmitted to various organs along the body surface and there is no breach in the surface. Blunt injury to the body can cause injuries like fractures, intracranial haemorrhages, cerebrovascular injuries, laceration of visceral organs and internal haemorrhage.

Head injuries are the major cause for mortality and severe morbidity in case of blunt injuries. Head injuries are mostly associated with bad prognosis because of the associated brain injury which is almost always present. Any neurological deficit or permanent disability depends on the severity of the injury, duration of the insult and the time interval between injury and its management.

Next to the brain injury, spinal injuries are commonly associated with cranial injury. This is due to the continuity of the bony architecture of the calvarium with the spinal column. The commonest mechanisms causing spinal injuries are hyper flexion, hyperextension and rotation.

The first and second cervical vertebrae are responsible for the rotational movement of the neck while the rest of the cervical vertebrae are responsible for the flexion and extension of neck.[6] Any incident which affects these functions by restriction or exaggeration, results in cervical spinal injury. The injury can be associated with spinal cord injury, nerve injury and vessel injury.

The cervical injuries could be penetrative or non penetrative. When there is a breach in the skin and the platysma beneath, it constitutes penetrative neck injuries.[7] These injuries occur due to missile from fire arm, accidental fall over any sharp objects like iron rods or broken glasses, homicidal or suicidal stab injuries, homicidal or suicidal cut throat injuries.

Road traffic accident is another major cause of penetrating injury to the neck. In such circumstances, the neck structures which are prone to get injured fatally are the superficial neck veins, the carotid arteries, the trachea, the oesophagus and the spinal column.

Injuries to the vessels occur in nearly half of the patients with penetrative neck injuries and any injury to the great vessels results in increased mortality. Nearly one third of the injury affects larynx, trachea and oesophagus and results in bad prognosis and severe morbidity.

Non penetrative injuries to the neck most commonly occur in Road traffic accidents followed by fall from height.[8, 9, 10, 11, 12, 13] The other causes of blunt cervical injury are as follows

- Accidents during games and sports
- Improper or excessive neck manipulation as in manual spinal alignment or chiropractic procedures
- Strangulation and blow to the neck
- Seizures

The blunt injury to the neck can occur due to direct impact of the force on the neck resulting in shearing injury of the vessels and fracture dislocation of the spinal column with spinal cord damage. Sometimes, the injury is due to rapid acceleration or deceleration of the head resulting in the hyper flexion, hyperextension and rotational injuries of the cervical region. The following injuries may occur in blunt trauma neck.

- Thrombosis of the vessels due to shearing force
- Fracture of Basilar part of skull and injury of the carotid artery

- Cervical spine fractures and dislocations
- Disruption of the airway [7]
- Blunt injury to Carotid and Vertebral arteries

The incidence of cervical spine injury in association with head injury is less than 10%. [15,16,17] When there is a cervical spine fracture, the incidence of associated spinal cord injury is as high as 50%.[15, 17] The vertebral artery injury associated with blunt cervical trauma is varying and is increasingly being diagnosed than predicted. [18,19, 20, 21, 22, 23]

The incidence of vertebral artery injury diagnosed in live patients with blunt injury is 0.2% to 0.7%. [19, 21, 24] This incidence increases about 30 fold when the population with blunt injury neck is narrowed down to the population with cervical spine injuries.[18, 21]

All these statistical data about the vertebral artery injury in blunt cervical trauma is in live patients through various imaging modalities like computer tomography, Magnetic Resonance Imaging and Angiographic methods. Some of the vertebral artery injuries which goes undetected in the imaging increases the actual incidence of vertebral artery injuries and could be detected through a complete autopsy.

It is essential to know the incidence and pattern of cervical spine injury and the vertebral artery injury associated with it to identify the high risk

group among the patients and to device a screening protocol. The effects of the blunt vertebral artery injury need to be studied for proper management protocols. In this study, the vertebral artery injury is studied in 25 cases of death associated with blunt injury to the neck most of which are due to fall from height and road traffic accidents.

Aims and Objectives

AIMS AND OBJECTIVES

1. To study the incidence of vertebral artery injury in non penetrative cervical spine trauma by gross and histopathological evaluation.

2. To analyze the types of vertebral artery injury in different types of non penetrative cervical spine trauma.

Review of Literature

REVIEW OF LITERATURE

BLUNT NECK INJURY AND VERTEBRAL ARTERY INJURY:

Voccaro et al conducted a prospective study in 1993 to evaluate the long term effects of the blunt vertebral artery injury associated with cervical spine trauma. The screening modality was Magnetic Resonance Angiography. Of the 61 patients, 12 of them had defective blood flow in one of the vertebral arteries. While follow up study, it was found that 83%, did not reconstitute the flow. Thus the stenosis or occlusion was persisting which should be considered in any future surgeries. [25]

Willis et at studied the vertebral artery injury associated with midcervical spine fracture and subluxation in 1994. Out of the 26 patients studied, 12 of them were diagnosed with vertebral artery injury (46%) and the types of cervical spine injury were subluxation, facet dislocation and fracture extending to foramen transversarium. Of the 12 patients, 9 of them had vertebral artery occlusion and the rest of the 3 had pseudoaneurysm, dissection and intimal flap.[26]

Giacobetti et al conducted a 7 month prospective study in 1997 to detect the incidence of vertebral artery occlusion in blunt neck injuries. 61 patients were studied using MRI and MRA. The incidence of vertebral artery

occlusion was 19.7% (12cases) of which 10 cases presented with cervical spine injury. Thus 83% of patients with vertebral artery occlusion had associated cervical spine injury.[20]

Taneichi et al conducted a similar prospective study to detect the traumatic vertebral artery occlusion associated with blunt cervical spine trauma using MRA. Of the 64 patients in the study, 11 had unilateral vertebral artery occlusion and one case presented with bilateral vertebral artery occlusion. The incidence of vertebral artery occlusion was found to be 17.2%. The occlusion was rarely symptomatic due to collateral formation from the opposite vertebral artery. [22]

Cothren CC et al conducted a study on the pattern of injury in cervical spine which is predictive of an underlying blunt vertebral artery injury. Four vessel angiography was done in all cases of cervical spine fracture. It was found that the incidence of blunt vertebral artery is higher than reported and the patterns of cervical spine injury associated with it are subluxation and fracture extending through foramen transversarium. 18% of the fractures were located in the upper three cervical spines. Thus focussing on these three patterns of injury may increase the diagnosis of blunt vertebral artery injury. [19]

Cothren CC et al conducted a 5 year study starting in 1996 to predict the pattern of blunt cervical spine injury which is more associated with blunt vertebral artery injury. The purpose of the study was to identify the type of cervical spine injury associated with blunt vertebral artery injury, so that the high risk group with such type of injuries can be screened effectively. This also reduces the expense spent in unnecessary diagnostic procedure.

Although only 23 patients presented with the symptoms of blunt cerebrovascular injury, screening angiography revealed blunt vascular injury in 238 cases of which 125 cases had blunt cervical spine injury. The types of cervical fractures associated with this injury were grouped into 3 patterns i.e, subluxation (48%), fracture of upper three cervical vertebra (36%) and fracture of foramen transversarium (16%).

Both carotid and vertebral arteries were evaluated and isolated Carotid artery injury was found in 18 cases while vertebral artery injury was found in 84 cases. Both vessels were injured in 23 cases. 90% of the patients were chosen based on the presence of cervical spine fracture. Based on this prospective angiographic study, the incidence of vertebral artery injury associated with cervical spine fracture is 37%. [27]

Once the occurrence of vertebral artery injury associated with blunt cervical spine injury was established, various studies were conducted to diagnose the injury with sensitivity and specificity.

Jae Won – Jang et al conducted a prospective study to determine the efficacy of computed tomographic angiogram in detecting the blunt vertebral artery injury. 99 patients were screened using CTA to detect any disruption in the flow following cervical spine injury. Complete disruption in unilateral vertebral artery was seen in seven patients. Two cases involved fracture extending to foramen transversarium and two cases involved the lower cervical segment.

This study established that computed tomographic angiography is a very good tool to be used as first level screening in diagnosing blunt vertebral artery injuries. Similar outcomes were recorded in studies conducted by **Berne et al** using helical CTA in which 486 patients with cervical spine injury underwent CTA within 24 hour of the incident. [24]

Biffl et al conducted a study to compare the non invasive modalities (CTA and MRA) to diagnose blunt vertebral artery injury when compared to gold standard arteriography. 46 patients were investigated using CTA and arteriography and the outcomes were compared.

Similarly 26 patients were investigated using both MRA and arteriography. The result revealed that both CTA and MRA are good tools for screening while they missed Grade I, II and III lesions thus arteriography remains as the Gold standard. This result doesn't preclude the use of CTA and MRA in high risk groups of blunt vertebral artery injury. Studies have showed that MRA has better sensitivity than the CTA.

In 2000, **Sim E et al** conducted a study to find the effects of flexion distraction injury on the vertebral arterial flow. Fresh frozen cervical spines were used and their vertebral arterial flow was checked by cannulation. This design provides the static effect of flexion distraction injury on the verterbral artery. Based on this study, Stage 1 injury (flexion within normal physiological range) did not affect the vertebral artery. [28]

Stage 2 injury is unifacet dislocation and Stage 3 injury is bifacet dislocation. Both of them were associated with impaired arterial flow. Stage 4 injuries resulted in complete disruption of the blood flow. It was also found that manipulating a Stage 2 distraction injury also resulted in severe vertebral artery injury.

Biffl et al conducted a study to establish the serious effects of blunt vertebral artery injury. The death rate which was mainly due to the blunt vertebral artery injury was found to be 8%. Although the neurological status

of the patient and occurrence of cerebrovascular accident was not in correlation with the degree of the vessel injury, 24% of the patients had posterior circulation stroke. This study showed that, although blunt injury of vertebral artery are mostly asymptomatic and there is no neurological deficit even in cases of irreversible vertebral artery stenosis, the vertebral artery injuries have a devastating potential to cause fatal brain infarction

Motomura et al conducted an autopsy based study to assess the vertebral artery injury using angioscopy. Of the 28 cases with cervical injury, 61% were associated with vertebral artery injury. This study is done to indicate the advantage of using angioscopy in autopsy to detect blunt vertebral artery injury. [29]

ANATOMY OF NECK STRUCTURES:

Neck is one of the most important part of the body through which many important structures pass through. They are, the carotid vessels, Jugular veins, larynx, trachaea, oesophagus, spinal cord and the Vagus nerve It supports the head and connects it to the rest of the body. The cervical vertebra forms the axial skeleton of the neck and it encloses the spinal cord and the vertebral artery.

The layers of neck are,

- Skin
- Superficial fascia
- Deep cervical fascia
- Deeper neck structures

The skin on neck is firm and is devoid of much subcutaneous fat. In obese people and in children, the subcutaneous fat accumulation causes neck folds which present as deep cleavage line in the anterior of neck. The Langer's line in the neck extends in the form of concentric circles around the neck.

Platysma is the most superficial muscle of neck. It originates from the fibrous covering of the pectoralis major and deltoid muscle. The muscle fiber of platysma goes upwards and inwards, crossing the clavicle. The anterior fibers of platysma of both sides interlace with each other in the midline. Breach of the neck skin along with platysma is considered as penetrative neck injury. The posterior fibers attach the skin and superficial layer of the face with the underlying jaw bone.

The deep cervical fascia form the following layers

- Investing layer
- Pretracheal layer

- Prevertebral layer
- Carotid sheath
- Buccopharyngeal fascia
- Pharyngobasilar fascia

The deep cervical structures includes

- Suprahyoid muscles
- Superficial part of submandibular salivary gland
- Mylohyoid nerve and vessels
- Submental branch of facial artery
- Infrahyoid muscles
- Pretracheal fascia and thyroid gland

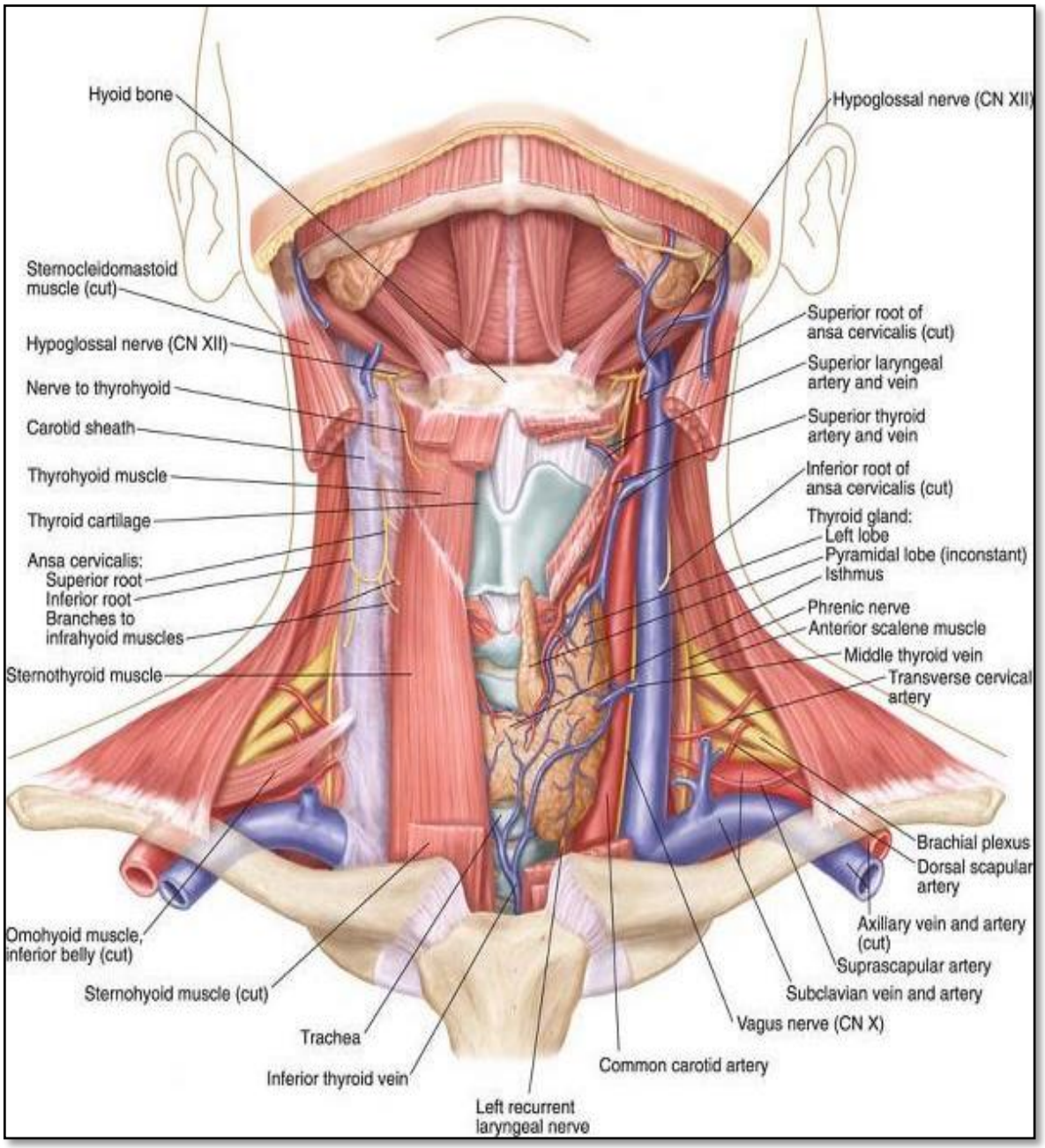
Deep plane of neck contains Larynx, Trachea, Oesophagus, vertebral column containing spinal cord and vertebral artery within the foramen transversarium.[25, 26] The neck is divided into anatomical triangles by the Sternocleidomastoid muscle into Anterior and Posterior Triangle, each of which is further divided into smaller triangles. The anterior triangle is subdivided by the digastric muscle and the superior belly of omohyoid muscle into four triangles.

- Submental triangle – contains submental nodes and submental veins
- Digastric triangle – contains carotid sheath with internal carotid

artery, internal jugular vein, vagus nerve. It also contains submandibular salivary gland, mylohyoid muscles and nerves, submental artery

- Carotid triangle – The common carotid artery and its bifurcation to internal and external carotid artery, Internal jugular vein, Common facial vein, Lingual vein, Vagus nerve, Superior Laryngeal nerve, Hypoglossal nerve ,Spinal accessory nerve and Sympathetic chain
- The posterior triangle is further subdivided by the inferior belly of omohyoid into two triangles
- Occipital triangle – contains occipital artery and spinal accessory nerve
- Supraclavicular triangle – contains the trunks of the brachial plexus, nerve to subclavius, Nerve to serratus anterior, suprascapular nerve, third part of subclavian artery, suprascapular artery and vein and lower part of external jugular vein.

Fig 1. ANATOMY OF NECK



ANATOMY OF VERTEBRAL COLUMN:

Vertebral column or the back bone is the main component of human axial skeleton. It is a link of 33 small bones called vertebra placed one over the other and which supports the back muscle to provide an erect posture. Based on their situation, the vertebral bones are of 5 groups - cervical vertebra, thoracic vertebra, lumbar vertebra, sacrum and coccyx.

There are seven cervical verterbra which are represented as C1 – C7, twelve thoracic vertebra represented as D1-D12, and five lumbar vertebra represented as L1-L5. The 5 sacral vertebra are fused together to form sacrum and the four coccygeal vertebra are fused together to form the tail bone.

The vertebrae have a body which is present anteriorly and an arch posteriorly. Both these parts fuse together and enclose the vertebral canal to lodge the spinal cord. The spinal cord end at the level of lumbar vertebra and there is no vertebral canal in sacrum and coccyx. Two transverse process and a spinous process is present in each vertebra. The spinous process projected backward along the midline of the vertebral arch and the transverse process project on each side of it.

The short bony bridge that connects the vertebral body with the spine and transverse process is called the pedicle. The neural arch forms the

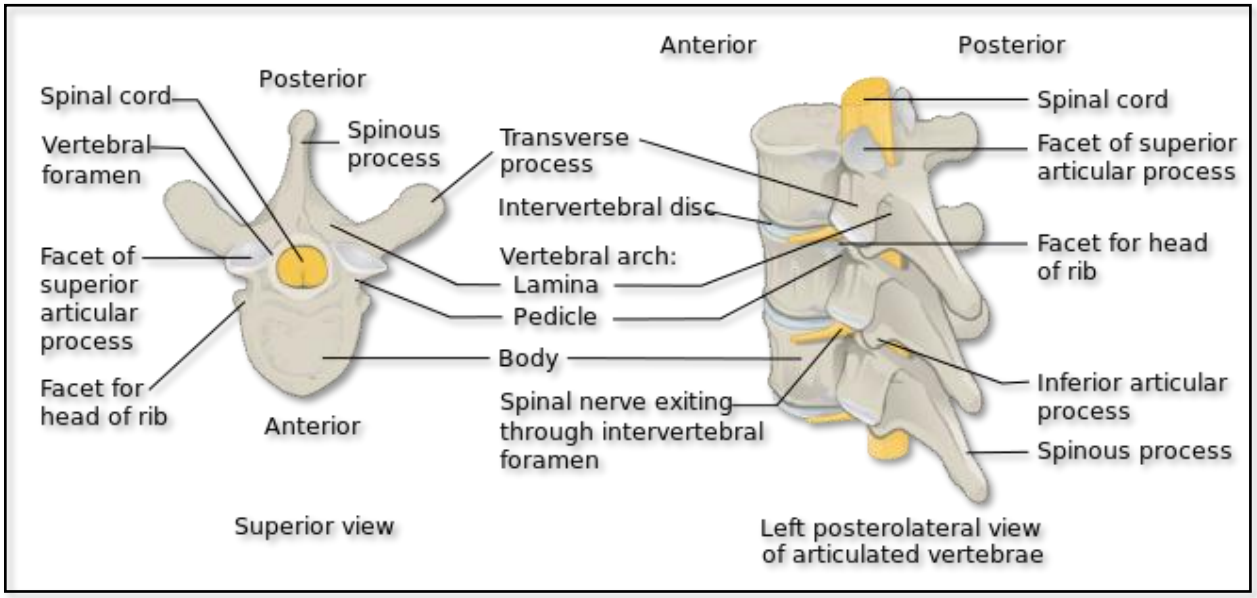
vertebral canal due to the articulation of vertebral bodies with the ones above and below them.

Spinal cord continues from the medulla oblongata through the foramen magnum in the base of the skull and enters the vertebral canal in the first cervical vertebra. The vertebral bodies are separated from each other by a fibrous disc called intervertebral disc. It is absent in between the first and second cervical vertebra.[25] The movement between each vertebra is restricted by facet joints between them.

The vertebral column has its characteristic shape by the following curvatures

- Primary curvature – found in the foetus
  - Thoracic curvature – concave forwards extending from T2 – T12
  - Sacral curvature – concave downward and forward extending from sacrovertebral joint to tip of coccyx
- Secondary curvature – acquired after birth
  - Cervical curvature – convex forwards extending from C2 to T2
  - Lumbar curvature – convex forward extending from L5 to sacrovertebral joint

Fig 2. ANATOMY OF A TYPICAL VERTEBRA



ANATOMY OF CERVICAL VERTEBRA:

There are 7 cervical vertebra and these are the sole bony supporters of the cranial vault and its contents. They differ from other vertebral bodies in so many ways. The third to sixth cervical verterba are called as typical cervical vertebra because the other three vertebrae have distinguishing features of their own.

Their vertebral body is comparatively smaller and broader than the other vertebrae. The anterior surface is a little lower than the posterior surface and the inferior discal margin is such a way to overlap the superior discal margin of the cervical vertebra below. The pedicles are directed outward and posteriorly. The vertebral foramen at this level is larger and

triangular. The vertebral canal contains the cervical enlargement of the spinal cord.

The spine of cervical vertebra is divided into two and each end is slightly enlarged to form tubercles of unequal size. The nuchal ligament is attached to the spinous process of second to the seventh cervical vertebra. The lamina bulges outward to form a lateral mass. It is formed by the fusion of the upper and lower articular process to form the articular pillars.

The transverse process is morphologically a three component structure that encircles the foramen transversarium. The anterior and posterior bars of the transverse process end as tubercles and both these tubercles are joined to each other by the costal lamella which completes the ring of foramen transversarium. The foramen transversarium is present in the upper six cervical vertebrae and the contents are vertebral artery and vein, sympathetic nerve plexus

The anterior margin of the vertebral body gives attachment to the anterior longitudinal ligament and the posterior margin gives attachment to the posterior longitudinal ligament. These ligaments stabilize the vertebral column and enables smooth movement of flexion and extension of the column. The inferior surface of vertebral body has a protruding margin which overlaps the intervertebral disc below. The shape of the superior and

inferior surface of the cervical vertebra is in such a way that any lateral or sliding movement in anteroposterior direction is restricted during articulation.

The anterior portion of the transverse process is equivalent to the of the ribs in the thoracic vertebra and they end in the anterior tubercle of the vertebra. The posterior portion ends in a vertical posterior tubercle and is directed forwards and outwards. The anterior tubercle of the C6 vertebra separates the carotid artery from the vertebral artery at this level. The carotid artery could be palpated against this tubercle which is called as Carotid Tubercle or Chassaignac tubercle.

ANATOMY OF FIRST CERVICAL VERTEBRA:

The first cervical vertebra is also known as Atlas. It supports the cranial vault and connects it to the spinal column. The components of C1 vertebra are anterior arch, posterior arch and two lateral mass connecting both the arches on either side. Thus it has a ring like appearance.

The anterior arch has a small anterior tubercle to which the longus colli muscle and the anterior longitudinal ligament. The posterior surface of the anterior arch contains a facet called fovea dentis in which the odontoid process of second cervical vertebra articulates.

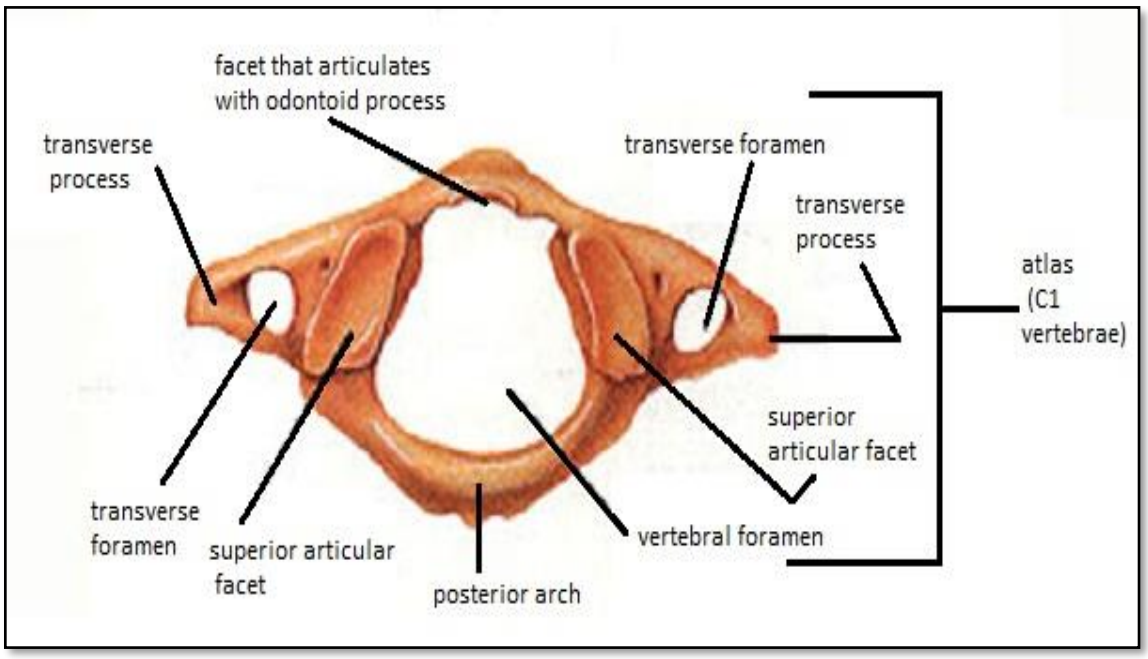
The atlanto – occipital membrane is attached to the superior surface

of atlas. The posterior arch has a posterior tubercle which is the rudimentary spinous process and it gives attachment to the ligamentum nuchae. Sometimes, the superior articular process of atlas present as a foramen through which the vertebral artery enters. It transmits the vertebral artery after it comes out through the foramen transversarium and winds around the lateral mass in backward and inward direction.

The articular facets of Atlas lie on the upper and lower surface of the lateral masses. The superior articular process are slightly depressed and is directed upward, backward and medially to accommodate the condyles of the calvarium. The atlanto occipital joint so formed is responsible for the flexion and extension at this level which is the nodding movement.

The inferior articular facets are oval and directed backwards and medially. It articulates with the axis and is responsible for the rotational movement of the head at the atlanto axial level. The vertebral foramen of the first cervical vertebra is divided into two compartments by transverse atlantal ligament. The anterior compartment lodges the odontoid process of second cervical vertebra and the posterior compartment accommodates the brainstem.

Fig 3. ANATOMY OF ATLAS VERTEBRA



ANATOMY OF SECOND CERVICAL VERTEBRA:

The second cervical vertebra is also called as Axis. It has a characteristic odontoid process which is a vertical projection from the centre of the body. It helps in the rotational movement of the Atlas with the centrum of Axis. The body of Axis is a composite mixture of the body of Atlas and Axis with a rudimentary intervertebral disc between them.

The articular facets are on either side of the odontoid process and the articulate superiorly with the lateral masses of the Atlas. The inferior surface of superior articular facet is very thin on which the vertebral artery grooves. The transverse process is directed downwards and backwards. The

tip of the transverse process is similar to the posterior tubercle in a typical cervical vertebra.

In contrast to the small spinous process of first cervical vertebra, Axis has a thick spinous process that is concave inferiorly. The longus colli, levator scapulae, and scalenus medius are attached to the end of the transverse process. The blood supply of Axis is at the level of odontoid process which is penetrated by the branches of vertebral arteries.

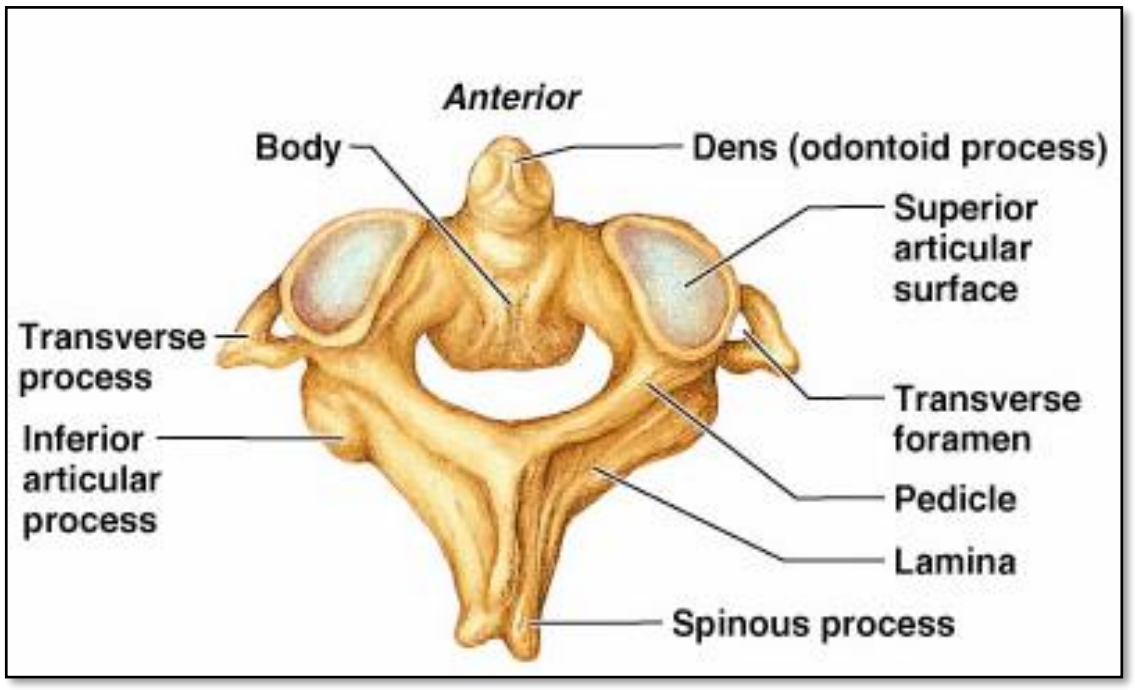
There is also supply from the branches of External carotid artery anteriorly. This extensive network of blood supply protects the Axis from avascular necrosis which is a complication of fracture. The level of morbidity and serious sequelae of C2 vertebra fracture makes it one of the most feared cervical injuries.

The type-I fracture of axis vertebra involves the tip of the odontoid process and the oblique fracture line run across it.

The type-II fracture involves the whole odontoid process and the fracture line run across the junction where it joins the body.

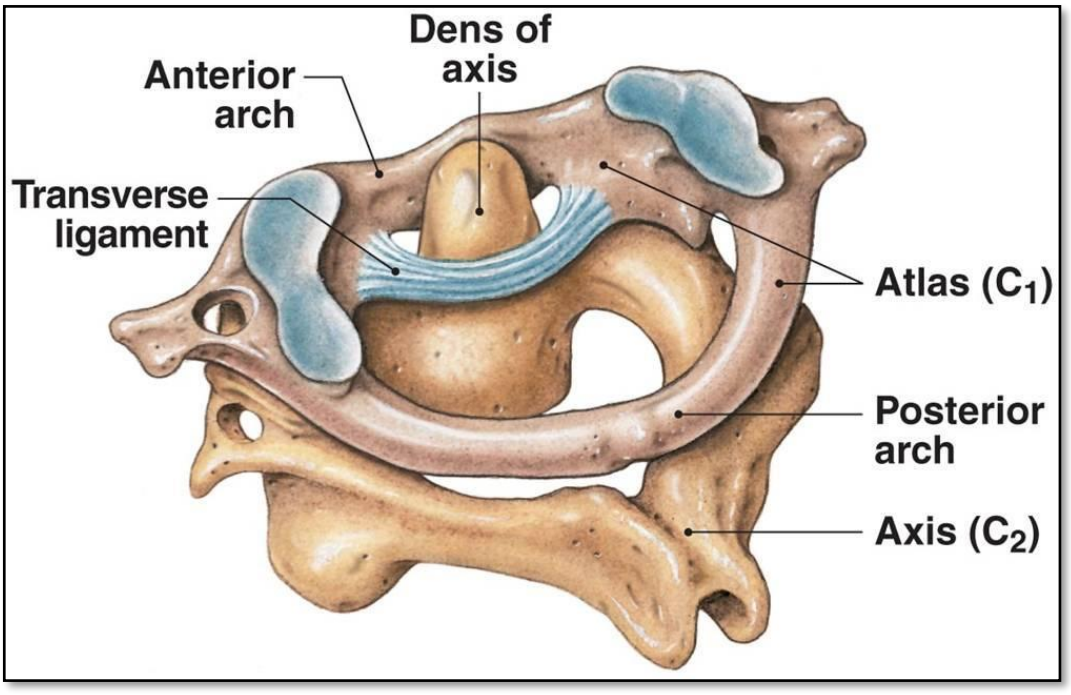
The type-III fracture involves the fracture line extending on to the body of the vertebra.

Fig 4. ANATOMY OF AXIS VERTEBRA



The Atlas and the Axis work together as a complex to bring about the normal rotational movement of the head. While the atlanto occipital joint helps in the nodding movement of the head, the Atlas and Axis complex results in the turning of head to the sides. The Atlas vertebra pivots on the odontoid process of the Axis vertebra. Any disruption to this complex like fracture of body of the vertebra or the odontoid process results in severe cervical injury affecting the brainstem and the vertebral artery.

Fig 5. COMPLEX OF ATLAS AND AXIS

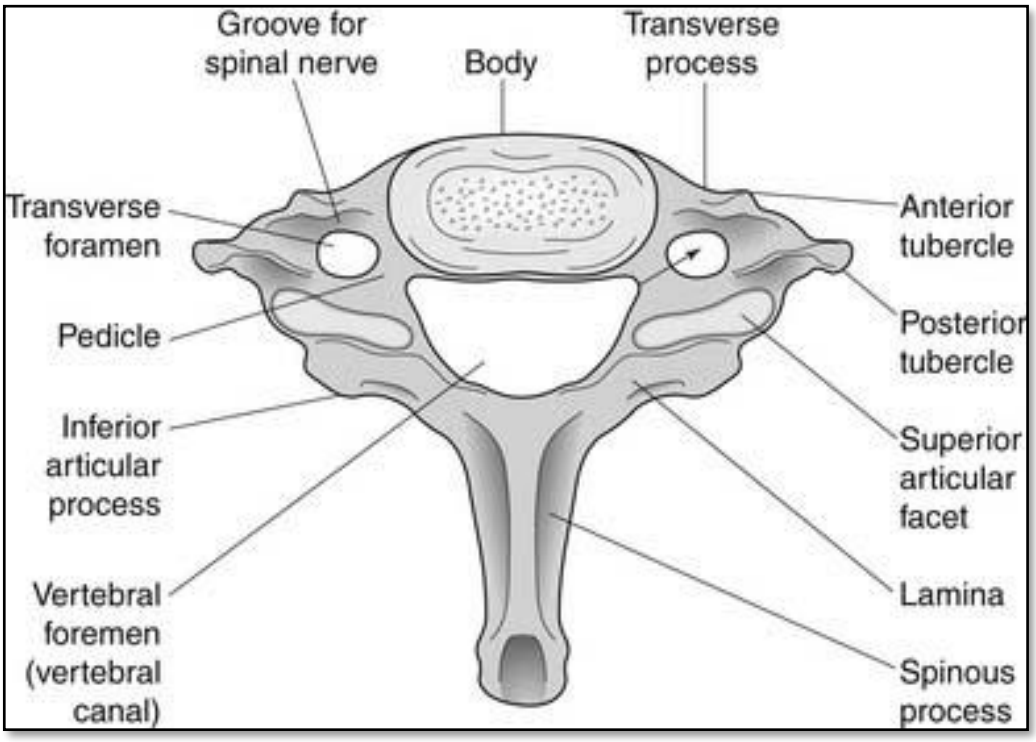


ANATOMY OF SEVENTH CERVICAL VERTEBRA:

The seventh cervical vertebra is also known as Vertebra prominens owing to its prominent spinous process. The ligamentum nuchae is attached to this spinous process. The tranverse process lies behind and laterals to the foramen transversarium. The foramen is different from the foramen of other cervical vertebra in a way that it transmits only vertebral vein and not vertebral artery.

While the posterior tubercle is prominent, the anterior tubercle is inconspicuous. Sometimes the lamella of the transverse process presents as a separate rib called the cervical rib.

Fig 6. SEVENTH CERVICAL VERTEBRA



VERTEBRAL ARTERY AND ITS RELATIONS:

Vertebral arteries are the deep arteries of neck which arise on both side of the neck from the first part of Subclavian Artery. On both sides, the arteries travel posterosuperiorly from the Subclavian Artery and enter the Foramen transversarium of sixth cervical vertebra. But in some anatomical variation, in about 7.5% population, the verterbral arteries enter the Foramen Transversarium at the level of seventh cervical vertebra.

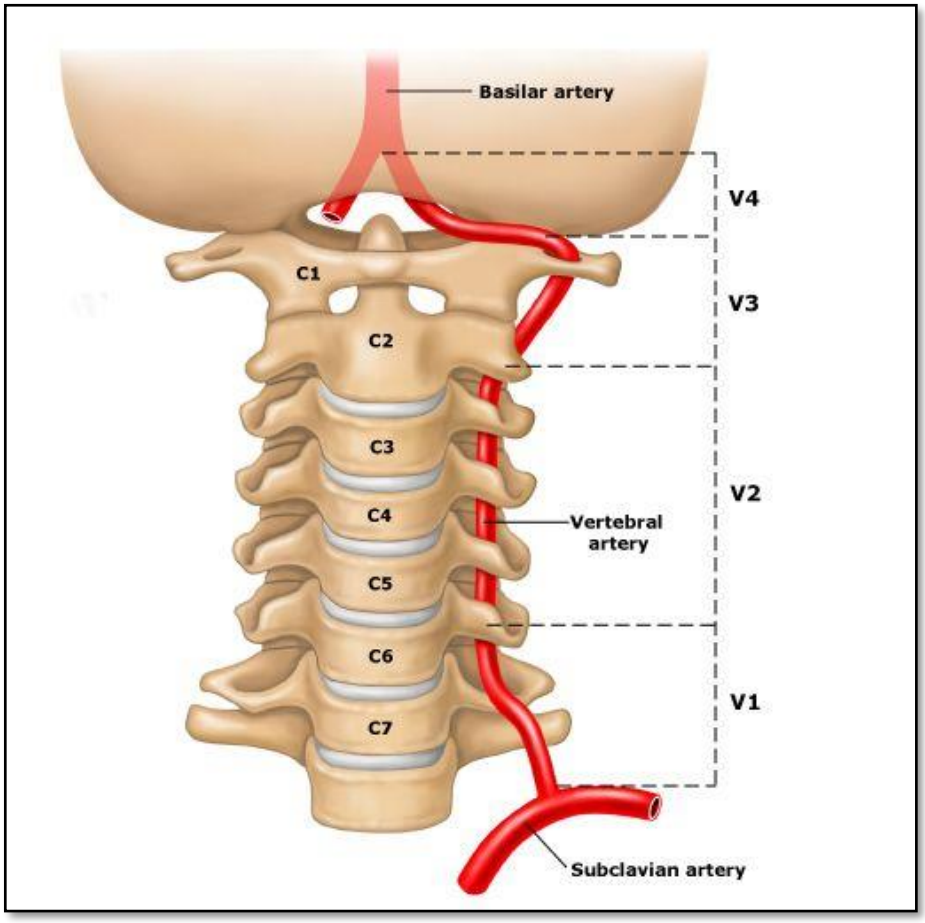
As the arteries emerge through the Foramen Transversarium of the Atlas vertebra, they travel across the posterior arch of Atlas and lie on the

Suboccipital triangle and reach the Foramen Magnum. It lies between the scalenus anterior and the longus colli muscles. As both vertebral arteries enter the skull, they unite together at the inferior border of pons to form a single artery in the midline called the Basilar Artery.

The Vertebral Artery is divided into 4 segments namely,

- First Segment – From the point of origin in Subclavian Artery to the point of entry in the Foramen Transversarium of C6 vertebra
- Second Segment – The segment which run in the Foramen tranversarium of sixth to second cervical vertebra
- Third Segment – From the emergernce through Foramen Transversarium of Axis vertebra to entrance through the Atlanto occipital memberane.
- Fourth Segment – The segment which pierces the Duramater and then fuse to form the Basilar Artery.

Fig 7.COURSE OF THE VERTEBRAL ARTERY



First Segment (Preforaminal V1):

Immediately after its origin, the vertebral artery run posterosuperiorly between the Longus Colli and anterior Scalene muscle. At this point, Internal Jugular vein and the vertebral vein lie on the anterior aspect and is crossed by the inferior thyroid artery. In addition to it, the thoracic duct crosses the left vertebral artery. The posterior relations are the sympathetic nerve trunk, inferior cervical ganglion and the transverse process of C7 vertebra.

Second Segment (Foraminal V2):

This segment is the most vulnerable to injuries. It is surrounded by the nervous and venous plexus. It lies anterior to the cervical nerve trunks and ascends upwards vertically till its exit through foramen transversarium of the second cervical vertebra

Third Segment (Extradural V3):

This segment is divided as V3v which is the vertical subsegment and V3h which is the horizontal subsegment. In V3v, the vertebral artery goes upwards crossing the root of second cervical vertebra and then enters the foramen transversarium of the first cervical vertebra.

The horizontal part curves behind the superior articular process of the C1 by curving inwards and backwards and reach the groove on the superior surface of its posterior arch and then goes through the inferior margin of the posterior atlanto occipital memberane which is attached on the superior margin of Atlas. It then enters the vertebral canal. This segment lies in the suboccipital triangle ad is covered by the semispinalis capitis muscle. The suboccipital nerve lies posterior to this segment.

Fourth Segment (Intradural V4):

This segment curves medially anterior to the medulla oblongata and meets its counterpart in front of the base of pons to form the Basilar artery.

This segment forms the intracranial part of the vertebral artery while the first three segments constitute the extracranial part of the vertebral artery.

Although it originates from the Subclavian Artery, the right vertebral artery sometimes originates from the brachiochephalic artery and very rarely from the Aortic arch. When it originates in the arch, it enters the foramen transversarium at the level of fifth cervical vertebra instead of sixth.[30]

Both vertebral arteries are usually unequal in their caliber. It has an average intaluminal diameter of 2-5mm. The left vertebral artery is usually larger in diameter. In about 15% population, the groove of Atlas gets converted to a foramen by the presence of a bony spur through which the vertebral artery pass through and is called as the Arcuate foramen. [31]

TERRITORIES SUPPLIED BY VERTEBRAL ARTERY:

One fifth of the blood supply to brain is by the vertebrobasilar arteries. Although two third of it is supplied by the carotid arteries, the one third supplied by the vertebral arteries goes to very important territories of brain. They are

- Brainstem
- Cerebellum
- Thalamus and hypothalamus
- Posterior aspect of parietal lobe

- Inferior temporal lobe
- Occipital lobe
- Posterior part of Corpus callosum

Additional to the posterior inferior cerebellar artery, the vertebral arteries gives off anterior spinal branches and posterior spinal branches arise from them. Thus vertebral arteries are the main supply to the spinal cord. The united anterior spinal arteries descend as the single branch supplying the anterior half of the spinal cord while the posterior branches stay divided and descend on either side of the spinal cord.

ANATOMICAL VARIATION IN VERTEBRAL ARTERY:

The following variations can be seen in a very small group of population and these anatomical variations have implications in the probability of injury to the artery and the possible outcome. They are

- Assymmetry in the caliber which is mostly left dominant (45%). It may also be right dominant (30%) and co dominant (25%)
- It can originate from the aortic arch or it can arise from a more lateral aspect on the subclavian artery
- Complete or partial vertebral artery duplication is possible
- The orientation of its ostium may vary – it could be cranial, caudal etc.

VERTEBRAL ARTERY – WHY IS IT PRONE TO INJURY?

The vertebral artery takes a course which involves turns and bends against bony prominences. This results in their susceptibility to injury at these points in its course. The course of the second segment in the foramen transversarium of midcervical vertebra makes it susceptible to injuries which distort the cervical vertebra.

In the third segment, the vertebral artery makes a turn medially and backwards before it enters the foramen transversarium of C1. This segment is susceptible to compression injuries at this point. As it enters the foramen magnum, there is a possibility of compression along the basilar margin of the calvarium. The intracranial part of vertebral artery is prone to injury along the clivus of the skull.

The vertebral arteries are more prone to injury in the following regions even if the site of impact is not the same. They are

- In the canal of the first cervical vertebra
- In the space between the first and second cervical vertebra
- In the space between the first cervical vertebra, just below the foramen magnum
- Intradurally, above the foramen magnum near the confluence to form the basilar artery

MECHANISM OF CERVICAL TRAUMA:

Cervical injury most commonly occur in upper and the lower cervical segments. The upper cervical injuries with involvement of first and second cervical vertebra are more serious as they lodge the brainstem in their vertebral canal. Hence they are highly fatal. About 15% of unconscious patients of a road traffic accident are with severe cervical spine trauma.

This vertical alignment of the small cervical vertebra is maintained in a stable architecture by the ligament systems. Anterior longitudinal ligament and posterior longitudinal ligament stabilize the anterior and midsegment of th cervical vertebra while the ligamentum nuchae, ligamentum flavum and the capsular ligaments maintain the stability of the posterior segment.

When both the supportive systems are disrupted, the spine begins to move as two separate entities. There are various mechanisms that result in fracture and other injuries of cervical vertebra. They are as follows.

Flexion injury:

Any impact that results in exaggeration of the flexion range of the cervical vertebra results in flexion injuries which include the following

- Compression wedge fracture
- Flexion fracture

- Atlantoaxial dislocation
- Anterior subluxation
- Facet dislocation

When there is a pull on the ligamentum nuchae, there is compression of the vertebral bodies resulting in anterior stable fracture with associated anterior paraspinal injury while the posterior segment remains uninjured due to the stability of posterior ligaments.

When the posterior ligaments get ruptures, anterior subluxation results. A severe form of anterior subluxation in which the anterior ligament system also gets damaged results in bilateral facet dislocation. In this condition the superior cervical vertebra slides over on the inferior cervical vertebra.

Flexion Rotation Injury:

When the neck is flexed along with the rotation of the skull, the inferior articular facet of the superior cervical vertebra to slide forward on the superior articular facet of the inferior vertebra resulting in unilateral facet dislocation. This is identified by observing that the line connecting the spinous process has been disrupted. When this unilateral facet dislocations occurs in first cervical verterbra it results in unstable fracture.

Extension Injury:

Most of the hyperextension injuries are seen in victims of road traffic accidents, while it was more common in individuals of judicial hanging in the olden days which gave it the name, Hangman's fracture. The fracture line passes through both the pedicles of the second cervical vertebra. Due to hyperextension, the anterior longituidinal ligament gets pulled which displaces a fragment of the inferior cervical vertebra resulting in an avulsion fracture.

When the hyperextention is sudden and forceful, the occiput and the spinous process of the second cervical vertebra cause a pull on the posterior arch of the first cervical vertebra causing it to fracture.

Compression injury:

The compression fracture is caused by force acting vertically downward causing the occipital condyles to compress the lateral masses of first cervical vertebra. When this compression causes fracture of the arches of C1, it causes Jefferson fracture. Sometimes, all the 4 parts of the ring of Atlas can occur. The fracture fragments then move laterally causing injury to the surrounding paraspinal soft tissues.

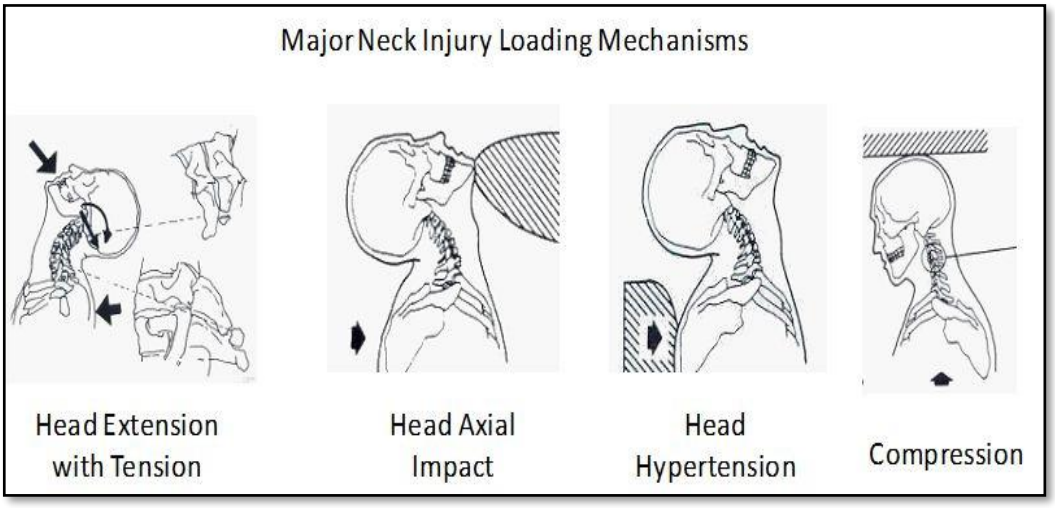
When the compression force is intense, the vertically transmitted force can dislocate the fractured body of the cervical vertebra to move laterally

resulting in a burst fracture. In this condition, the anterior margin of the fractured vertebral body protrudes anteriorly and posteriorly than the other cervical vertebra.

Multiple mechanisms:

In most of the road traffic accidents and fall cases, instead of one of the above said mechanism, a complex of multiple mechanisms occurs. This result in the severe outcomes like the fracture of odontoid process, atlanto occipital dislocation, occipital condyle fracture and fracture of transverse process of second cervical vertebra. Multiple mechanisms can also cause injury in more than one level of cervical vertebra.

Fig 8.TYPES OF CERVICAL INJURY MECHANISM



TYPES OF VERTEBRAL ARTERY INJURIES:

When a blow hits the side of the neck, the neck is tilted sideways with the rotation of head to the same side. There is complex mechanism acting on the atlanto occipital joint at that moment.

Blunt vertebral artery injuries can result in any of the following type of injury. It depends on the mechanism of injury – whether it is hyperextension or hyperflexion, lateral flexion, rotation, compression, flexion – distraction etc.

- Dissection
- Thrombosis
- Occlusion
- Pseudoaneurysm

VERTEBRAL ARTERY DISSECTION:

Dissection means rupture or tears in the internal lining of the vessel wall which results in the seepage of blood from the vessel to the ruptured site which separates the vessel wall from the underlying layer. The seeped blood can form a thrombus at the site or result in weakening of the vessel wall. Non traumatic dissection is caused by diseases affecting the vessel wall and is more common than traumatic dissection.

Traumatic vertebral artery injury is less than 1% in blunt injuries and it cause about 2% of ischemic stroke in total but about 20% in the population of less than 45 years. [32] The vertebral artery dissection can result in thrombus formation which embolises and causes ischemic stroke. Sometimes the Vertebral artery stenosis can occur resulting in the disruption of the flow causing neurological deficit.

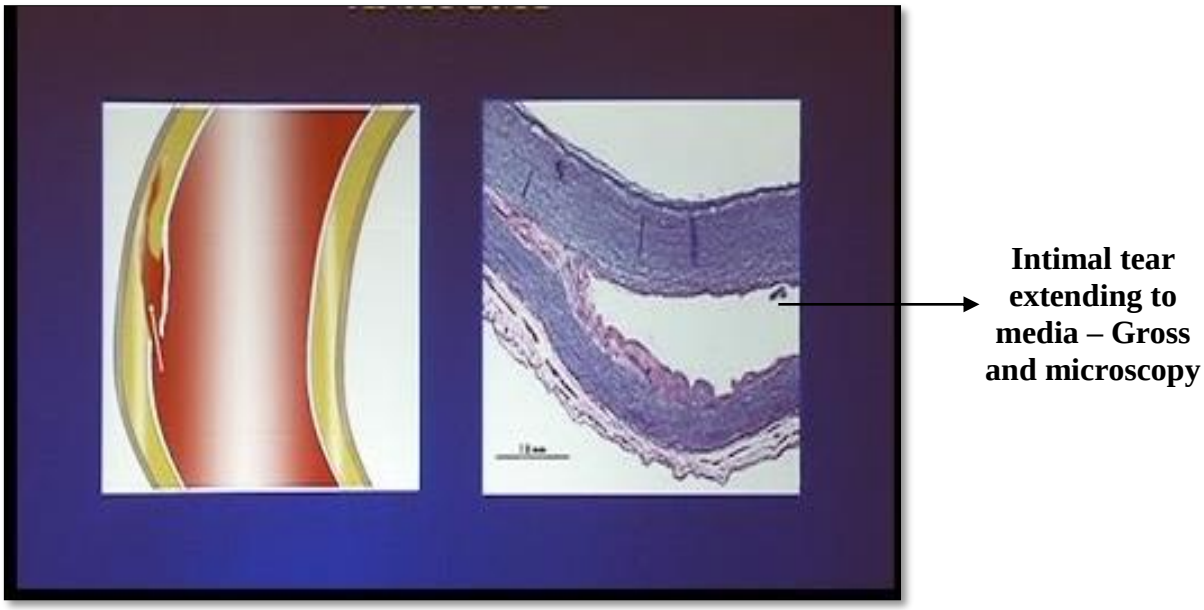
Vertebral artery injury is considered to be associated with CV1 syndrome. In this condition, it was thought that, massive blow to the side of the neck which results in the fracture of the transverse process of the first cervical vertebra results in the rupture of the vessel wall of vertebral artery resulting in a massive subarachnoid hemorrhage which is instantly fatal. Later studies showed that, even without the fracture of the upper cervical vertebra, the mechanical forces are capable of causing vertebral artery dissection and subsequent fatal subarachnoid hemorrhage.

As studies have also indicated that the subarachnoid hemorrhage is possible even with an uninjured vertebral artery, the injury and hemorrhage could be two concomitant effects of the blunt trauma to the neck. But there are also instances in which rupture of the vertebral artery at the level of posterior cranial fossa due to non penetrative trauma to the neck. Thus, dissection of vertebral artery is possible at level distant to the site of injury

The vertebral artery dissection could be identified with postmortem angiography to detect the leakage. But studies show that, there are diffuse leakages that create artifacts in the imaging. In autopsy, vertebral artery injury has to be suspected if there is history suggestive of blunt injury to the sides of neck, the sides and undersurface of jaw and below the ear.

Even if there are no external symptoms, bruise of the subcutaneous tissue may be the only indicator of force of impact and forensic pathologist should proceed with the postmortem examination of the vertebral artery.

Fig 9. VERTEBRAL ARTERY DISSECTION



VERTEBRAL ARTERY THROMBOSIS:

Vertebral artery thrombosis is an effect of any form of injury to the vessel, like dissection, transection etc. The traumatic vertebral artery

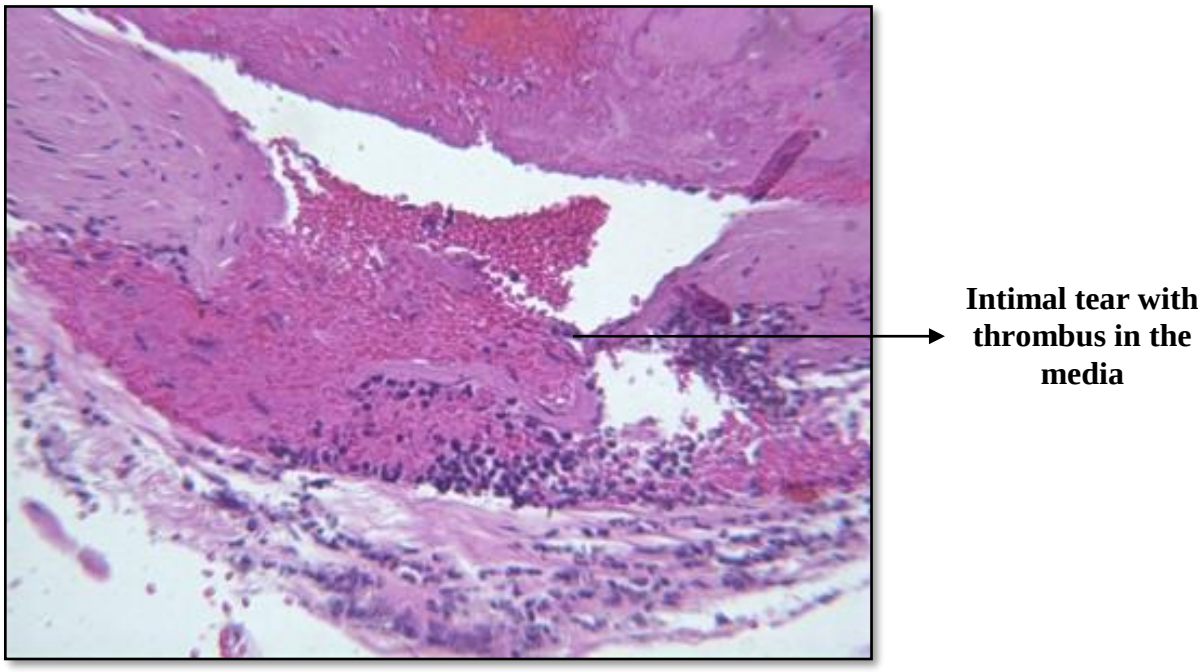
thrombosis is more commonly associated with cervical spine trauma. The effect of vertebral thrombosis is unpredictable. Most of the vertebral artery thrombosis goes undetected as they are asymptomatic.

Studies show that, people who have been detected with vertebral thrombus and stenosis following cervical spine injury remain asymptomatic even if the stenosis does not recanalise eventually. But this is not the case always. There have been cases reported in which the vertebral artery thrombus which has gone undetected due to absence of neurological deficit at the time of incident, has resulted in a fatal cerebellar infarct after a week.

This lack of correlation between the vertebral artery thrombosis and the severity of its effects warranties diagnostic protocols to detect it in the high risk group patients. Also, death due to fatal infarction and stroke due to vertebral artery thrombus which could be immediate or delayed have to be detected in autopsy to fix the exact cause of death.

The treatment for such vertebral artery thrombosis is controversial. While some of the clinicians suggest that anticoagulant therapy could reduce the harmful outcome of the thrombosis, some studies have showed that the outcome of the untreated thrombus has to be weighed with the complications which result from anticoagulant therapy.

Fig 10. DIFFERENTIAL STAINING SHOWING VERTEBRAL ARTERYTHROMBOSIS



VERTEBRAL ARTERY PSEUDOANEURYSM:

When a vessel gets injured, the whole vessel wall may be breached resulting in a hole. When the thrombus extends through this hole and present as a sac like projection in the surrounding space, it is called pseudoaneurysm. It is different from true aneurysm which is dilatation of the vessel wall due to weakening of the medial layer of the vessel due to trauma or elastic tissue defect.

It is also different from the dissection in which the breach in the vessel wall is not through and through and there is an incomplete breach which forms an incomplete track for seepage of blood within the vessel wall. The

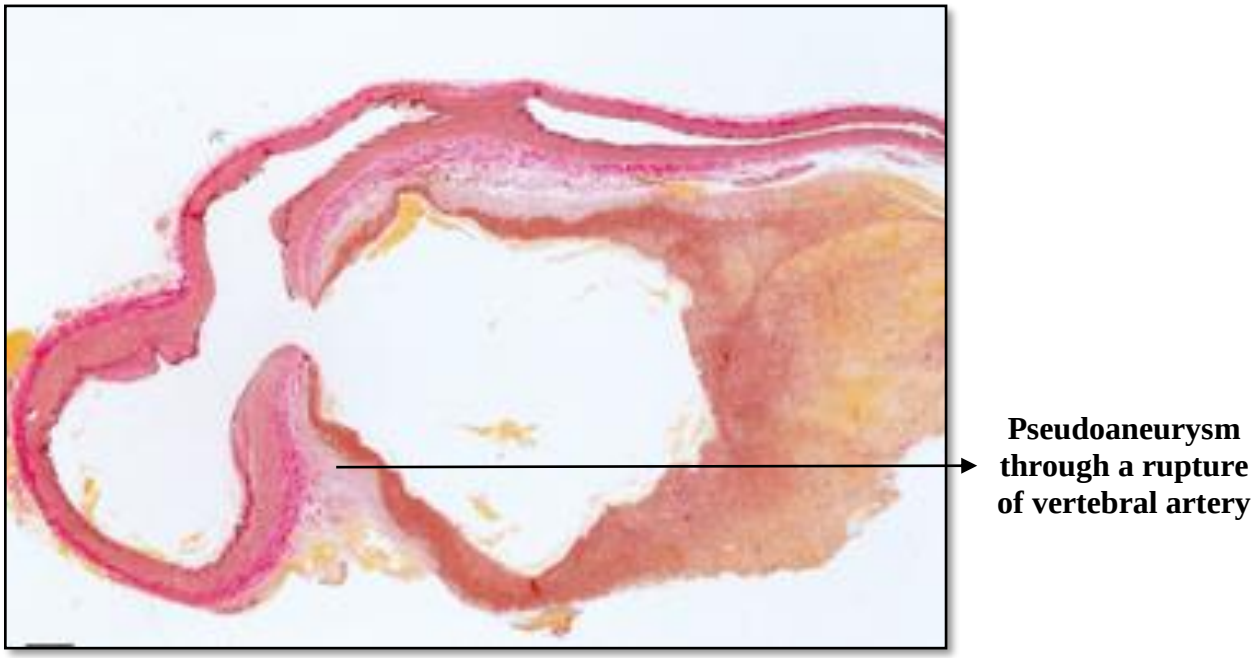
traumatic pseudoaneurysm of vertebral artery is mostly caused by penetrating injuries to the neck than by non penetrating injuries.

The size of the pseudoaneurysm may vary from few mm to few cm. It can present with neurological deficit and may sometimes lead to rupture or thrombosis resulting in fatal infarcts. The advanced angiographic methods help in easy diagnosis of the pseudoaneurysm and could be treated by endovascular procedures.

Studies have shown that the pseudoaneurysm may stay asymptomatic and undetected for over years. Cases have been reported in which a pseudoaneurysm which presented as a pulsatile mass in the side of the neck after an injury sustained in a road traffic accident 5 years ago.

The pseudoaneurysm of vertebral artery present as a pulsatile mass in the side of the neck. Depending of its size and the occlusion it is impinging, neurological deficit may or may not happen. Once it ruptures, compromising the blood flow to brain, it can result in infarction or stroke.

Fig 11. PSEUDOANEURYSM OF VERTEBRAL ARTERY – HISTOPATHOLOGY



Materials and Methods

MATERIALS AND METHODS

This prospective study was conducted in the Institute of Forensic Medicine, Madras Medical College, Chennai-3 for a period of 8 months.

This study analyzed the second part of the right and left vertebral artery from its entry into foramen transversarium at the level of sixth cervical vertebra till it enters the calvarium along foramen magnum, in cases of blunt cervical spine trauma subjected for autopsy by gross and histopathological examination. The study sample consisted of 29 pairs of vertebral arteries taken from cases of blunt cervical injuries due to road traffic accident, fall from height and industrial accidents. Ethical clearance was obtained from the Institutional Ethical Committee (IEC) before starting the study.

In dead bodies with history of blunt injury neck and cervical spine injury subjected for autopsy, after making a Y incision on the skin dissecting out the skin, subcutaneous tissue, fascia and muscle with a BP handle scalpel blade, reflecting out the skin together with the muscles on both side of the chest and the V flap of the neck was reflected as far as the lower border of mandible.

The ribs are cut at the costochondral junction and 2 cm lateral to the sternoclavicular joint on each side which includes the medial half of clavicle,

disarticulating it, the sternum is lifted up. The abdominal and thoracic organs are removed in the usual technique. Before removing the heart, the subclavian artery is identified at the origin of vertebral artery on both sides and is cut proximal to the origin. The brain is removed in the usual way with severing of basilar artery of both sides.

The neck muscles are reflected one by one to check for any bruise and the neck cartilages are checked for fractures. The deep neck structures are freed from the cervical vertebra in the usual way and the longus coli and longus capitis muscles are freed from the anterior surface of the cervical vertebra. The cervical spine is checked for presence of any fractures, subluxation and the paraspinal tissues are checked for the presence of any bruise.

The vertebral artery is traced from its origin and the loose connective tissues are cleared from it till it enters the sixth cervical vertebra. Using a wire cutter, the anterior bony arch of the foramen transversarium is cut till the third cervical vertebra. The vertebral artery is mobilized from the foramen transversarium using a 11 blade in BP handle.

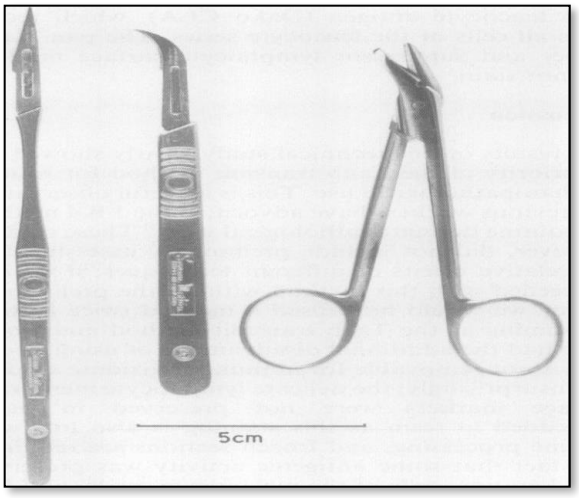
The anterior and the posterior bony arch of the first and second cervical vertebra are cut using wire cutter and the artery is mobilized till it enters the foramen magnum. A 12 blade is used to sweep cut the artery as it

enters the cranium and arteries on both the sides are dissected out similarly.[33]

After removal of the vertebral artery it is visualized grossly for the presence of any injury like intimal tear, thrombosis, dissection etc. If any gross injury is visible, it is sectioned and sent for histopathological examination. If no injury is visible grossly, a section of the vessel wall corresponding to the level of injured cervical vertebra is sent for histopathological examination.

During the neck dissection, the type of cervical injury, the level of cervical injury and the associated paraspinal injuries are noted. In some cases the clinical records have been corroborated to determine the type of cervical injury.

Fig 12. INSTRUMENTS FOR DISSECTION OF VERTEBRAL ARTERY THROUGH ANTERIOR APPROACH



This technique of anterior approach to the vertebral artery is highly efficacious when compared to the conventional time consuming method of decalcifying the entire cervical vertebral column and then removing the vertebral artery which is left behind. Also there is no cosmetic disruption of the deceased and the instruments needed for this method are quite inexpensive. All this technique needs is practice to master it which then could be completed in less than half an hour.

Subject Selection:

The prospective study was conducted on cases coming for Medico Legal autopsy to the Institute of Forensic Medicine, Madras Medical College, Chennai-3.

Inclusion Criteria:

All cases subjected for medico-legal autopsy with diagnosed or suspected cervical spine injury due to non penetrative cervical spine trauma.

Exclusion Criteria:

1. Cases with penetrative neck injury
2. Surgically intervened cervical spine trauma
3. Penetrative interventions like central venous catheterization in neck
4. Postmortem interval more than 36 hours.

These are the factors affecting the outcome of the study. Penetrative neck injuries can result in arterial injuries like pseudoaneurysm, AV fistula and occlusions in both carotid and vertebral arteries. So this result in false

positive values of vertebral artery injuries.[34] There is a possibility of iatrogenic vertebral artery injuries during cervical spine surgeries which are more commonly due to inexperience in the technique. Although the incidence is less than 1%, it still has to be considered to reduce the false positive results.[35]

When central venous catheterisation is done without image guidance there is a possibility of the catheter being misplaced in the vertebral artery and getting injured[36] and vertebral artery pseudoaneurysm is found to be a complication of the procedure. [37]

In the present study most of the cases are brought dead to casualty and the exact time of death is not known to either the investigating officers or the relatives. Therefore the Postmortem interval given in the Master chart is only the approximate time since death derived from the information furnished by the investigating officer and the 36 hour post-mortem interval is to ensure that the vessels are not damaged by autolysis.

This anterior approach to vertebral artery consumes less time and makes it easy to adapt it with the routine autopsy procedure making the assessment of vertebral artery injuries post-mortem as its contribution to the cause of death.

Analysis and Results

ANALYSIS AND RESULTS

Total Number of cases with history of blunt cervical spine trauma = 25

It consists of the following cases

Total number of Cases with History of fall from height =12

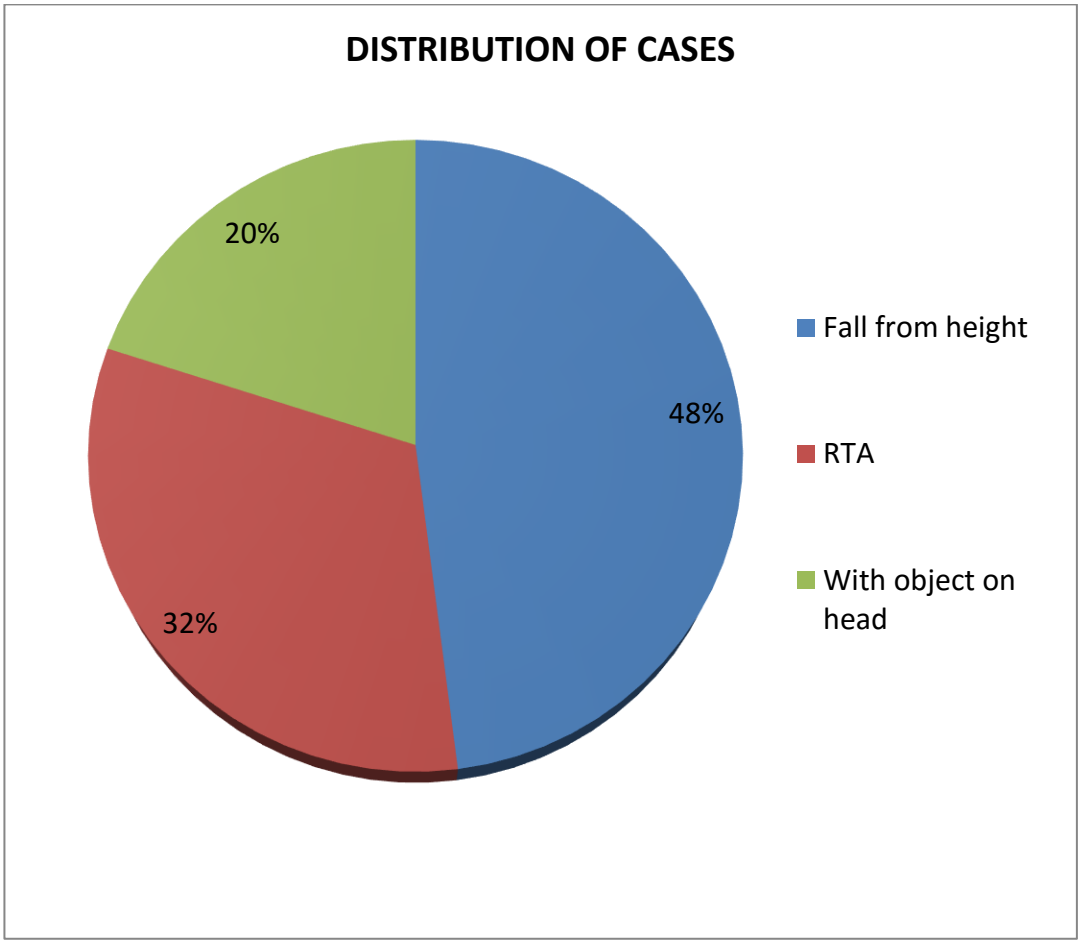
Total number of Cases with History of RTA = 8

Total number of Cases with History of fall with an object on head = 5

Table no.1 Illustrating number of cases in study group

STUDY GROUP	NUMBER OF CASES	PERCENTAGE
Fall from height	12	48 %
RTA	8	32%
Fall with object on head	5	20 %
Total	N = 25	100 %

Chart no. 1 showing the number of cases in the study group



SEX DISTRIBUTION IN STUDY GROUP

Total Number of cases with history of blunt cervical spine trauma = 25

Total number of male = 21

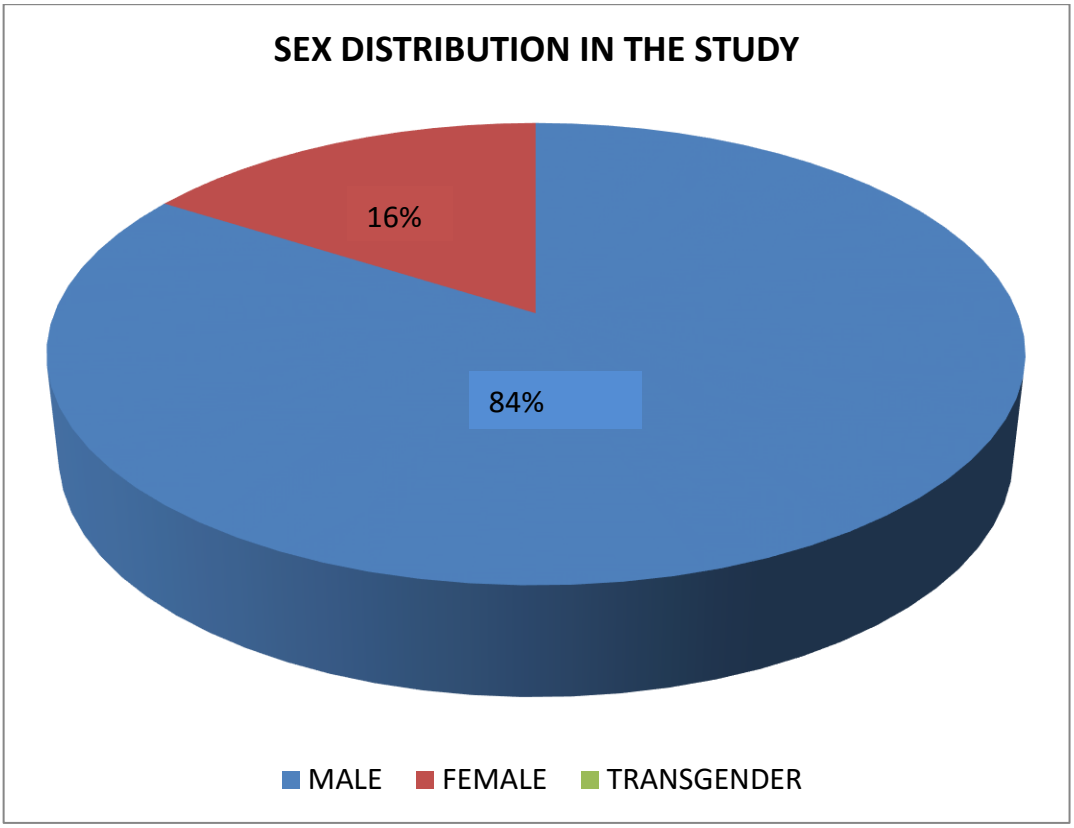
Total number of female = 4

Total number of Transgender = 0

Table No.2 illustrating the sex distribution of cases in study Group

STUDY GROUP	NUMBER OF CASES	PERCENTAGE
Male	21	84 %
Female	4	16 %
Transgender	0	0 %
Total	N = 25	100 %

Chart no. 2 showing sex distribution of cases in the study group



AGE DISTRIBUTION IN STUDY GROUP

Total Number of cases with history of blunt cervical spine trauma = 25

Total number of Case in age group 0 – 20 years = 1

Total number of cases in age group 21 – 40 years = 13

Total number of cases in age group 41 – 60 years = 10

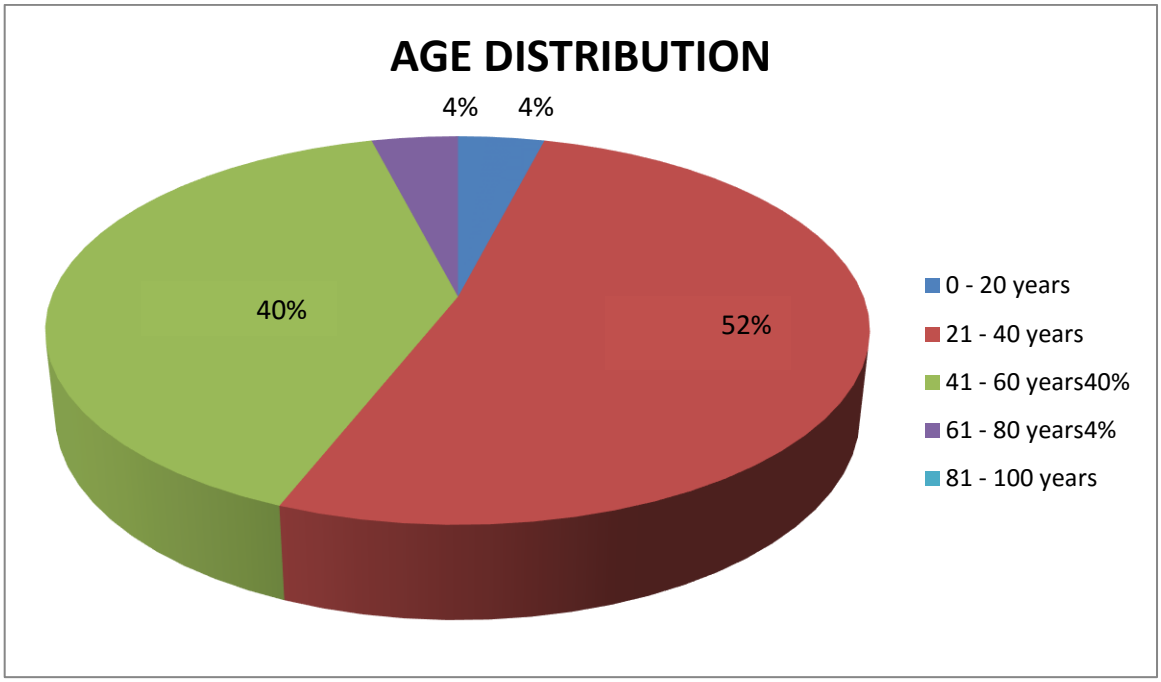
Total number of cases in age group 61 – 80 years = 1

Total number of cases in age group 81 – 100 years = 0

Table No.3 illustrating the age distribution of cases in study group

AGE DISTRIBUTION IN STUDY GROUP	NUMBER OF CASES	PERCENTAGE
0 - 20 years	1	4 %
21 – 40 years	13	52 %
41- 60 years	10	40 %
61 - 80 years	1	4 %
81- 100 years	0	0 %
Total	N = 25	100 %

Chart no. 3 showing age distribution of cases in the study group



TYPE OF BLUNT CERVICAL INJURY FOUND IN THE STUDY GROUP

Total Number of cases with history of blunt cervical spine trauma = 25

Total number of Case with cervical spine fracture = 10

Total number of cases with cervical spine subluxation = 6

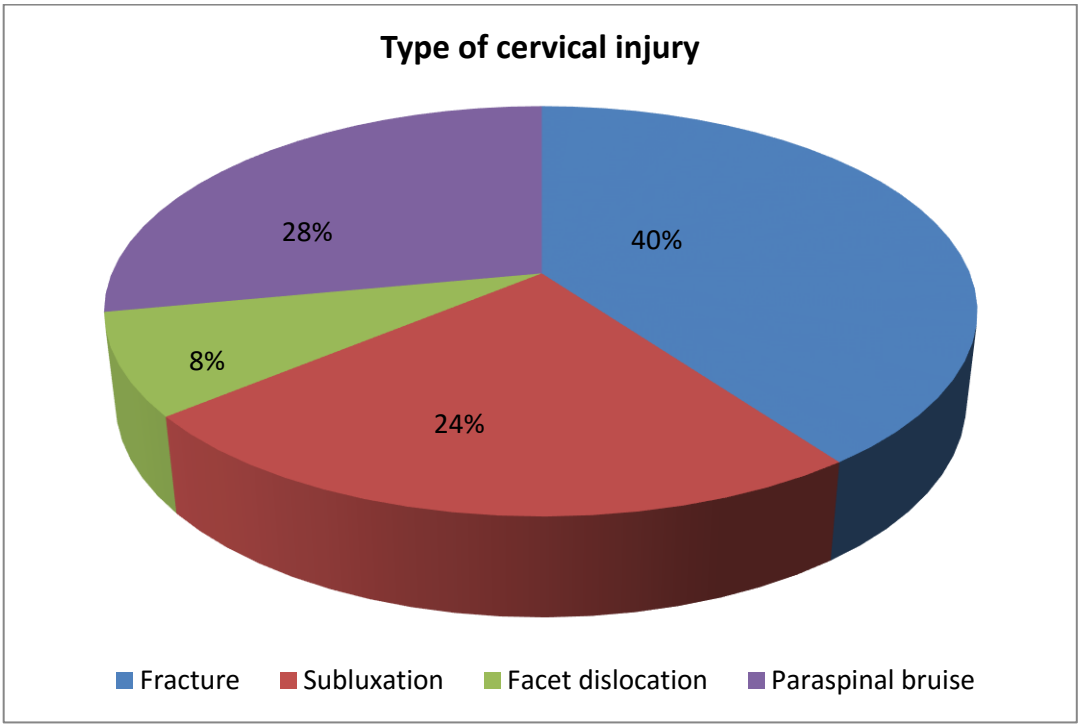
Total number of cases with facet dislocation = 2

Total number of cases with paraspinal muscle contusion = 7

Table No.4 illustrating the type of cervical spine injury in study group

TYPE OF CERVICAL SPINE INJURY IN STUDY GROUP	NUMBER OF CASES	PERCENTAGE
Fracture	10	40%
Subluxation	6	24 %
Facet Dislocation	2	8 %
Paraspinal contusion	7	28 %
Total	N = 25	100 %

Chart no. 4 showing type of cervical spine injury of cases in the study group



VERTEBRAL ARTERY INJURY – GROSS AND HISTOPATHOLOGICAL FINDINGS IN THE STUDY GROUP

Table No.5 illustrating the cases in study group

S.NO	P.M. NO.	CERVICAL INJURY	HISTOPATHOLOGICAL FINDINGS	
			RT	LT
1.	290/16	Fracture at level of C5	Normal	Normal
2.	940/16	Fracture at level of C7	Foci of haemorrhage present	Normal
3.	1011/16	Subluxation of C4 vertebra	Normal	Normal
4.	1065/16	Facet dislocation of C4	Intimal tear present	Intimal tear present
5.	1091/16	Fracture at level of C3, C4, C5	Fibrin thrombi present	Intimal tear and luminal haemorrhage present
6.	1092/16	Fracture at level of C5	Intimal tear present	Foci of haemorhage present
7.	1153/16	Fracture at level of C6,C7	Disruption of intima and media - dissection	Foci of haemorhage present
8.	1166/16	Subluxation of C3 vertebra	Intimal tear present	Intimal tear present
9.	1179/16	Fracture at level of C6	Disruption of intima and media - dissection	Intimal tear present
10.	1208/16	Facet Dislocation at C4	Intimal tear present	Normal
11.	1210/16	Subluxation at the level of C5	Intimal tear present	Intimal tear present Foci of haemorhage present
12.	1247/16	Subluxation at the level of C4	Normal	Intimal tear present Foci of haemorhage present

13.	1262/16	Paraspinal bruise along C3, C4, C5	Intimal tear present Foci of haemorhage present	Intimal tear present Foci of haemorhage present
14.	1273/16	Fracture at level of C3	Normal	Normal
15.	1280/16	Paraspinal bruise along C3, C4	Foci of haemorhage present	Foci of haemorhage present
16.	1281/16	Paraspinal bruise along C5,C6	Normal	Normal
17.	1341/16	Fracture at level of C3	Normal	Normal
18.	1363/16	Fracture at level of C6	Normal	Normal
19.	1364/16	Subluxation of C4 vertebra	Foci of haemorhage present in media	Foci of haemorhage present
20.	1367/16	Subluxation of C3	Luminal haemorrhage, medial hyperplasia, adventitial haemorrhage	Luminal and adventitial haemorrhage
21.	1387/16	Paraspinal bruise along C5,C6	Normal with vessel wall congestion	Normal with vessel wall congestion
22.	1399/16	Paraspinal bruise along C3,C4	Normal with vessel wall congestion	Normal
23.	1409/16	Fracture at level of C6	Normal with vessel wal congestion	Normal with vessel wall congestion
24.	1415/16	Paraspinal bruise along C2, C3, C4	Normal	Normal
25.	1418/16	Paraspinal bruise along C2, C3	Normal	Normal

FRACTURE OF CERVICAL SPINE INJURIES AND THE HISTOPATHOLOGICAL FINDINGS OF VERTEBRAL ARTERY INJURY

Total number of cervical spine fractures = 10

Number of cases with intimal tear = 2 [1 of 2 is bilateral]

Number of cases with foci of luminal haemorrhage = 1

Number of cases with normal vessel = 5

Number of cases with dissection = 2

Table 6. showing correlation of fracture of cervical spine and the histopathological findings of vertebral artery injury

TYPE OF CERVICAL SPINE INJURY	CASES WITH INTIMAL TEAR	CASES OF FOCI OF HAEMORRHAGE	CASES OF NORMAL VESSEL WALL	CASES WITH DISSECTION
Fracture	2	1	5	2
Percentage	20%	10%	50%	20%

CERVICAL SPINE SUBLUXATION AND THE HISTOPATHOLOGICAL FINDINGS OF VERTEBRAL ARTERY INJURY

Total number of cervical spine subluxations = 6

Number of cases with intimal tear = 3 [2 of 3 is bilateral]

Number of cases with foci of luminal haemorrhage = 2

Number of cases with normal vessel = 1

Number of cases with dissection = 0

Table 7 showing correlation of cervical spine subluxation and the histopathological findings of vertebral artery injury

TYPE OF CERVICAL SPINE INJURY	CASES WITH INTIMAL TEAR	CASES OF FOCI OF HAEMORRHAGE	CASES OF NORMAL VESSEL WALL	CASES WITH DISSECTION
Subluxation	3	2	1	0
Percentage	50%	30%	20%	20%

FACET DISLOCATION AND THE HISTOPATHOLOGICAL FINDINGS OF VERTEBRAL ARTERY INJURY

Total number of facet dislocation = 2

Number of cases with intimal tear = 2 [1 of 2 is bilateral]

Number of cases with foci of luminal haemorrhage = 0

Number of cases with normal vessel = 0

Number of cases with dissection = 0

Table 8 showing correlation of facet dislocation and the histopathological findings of vertebral artery injury

TYPE OF CERVICAL SPINE INJURY	NO OF CASES WITH INTIMAL TEAR	NO OF CASES OF FOCI OF HAEMORRHAGE	NO OF CASES OF NORMAL VESSEL WALL	NO OF CASES WITH DISSECTION
Facet dislocation	2	0	0	0
Percentage	100%	0%	0%	0%

FRACTURE OF PARASPINAL BRUISE AND THE HISTOPATHOLOGICAL FINDINGS OF VERTEBRAL ARTERY INJURY

Total number of paraspinal bruise = 7

Number of cases with intimal tear = 1

[1 of 2 is bilateral]

Number of cases with foci of luminal haemorrhage = 1

Number of cases with normal vessel = 5

Number of cases with dissection 0

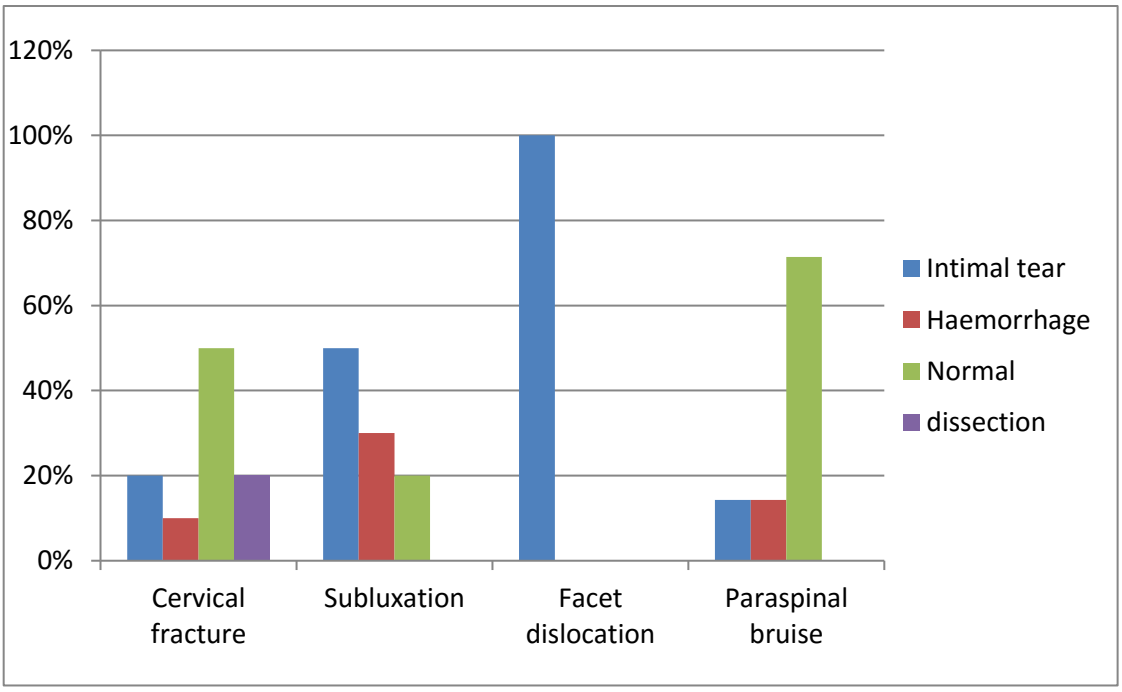
Table 9 showing correlation of paraspinal bruise and the histopathological findings of vertebral artery injury

TYPE OF CERVICAL SPINE INJURY	CASES WITH INTIMAL TEAR	CASES OF FOCI OF HAEMORRHAGE	CASES OF NORMAL VESSEL WALL	CASES WITH DISSECTION
Paraspinal bruise	1	1	5	0
Percentage	14.3%	14.3%	71.4%	0%

Table 10 showing the percentage of vertebral artery injury and the type of cervical spine injury

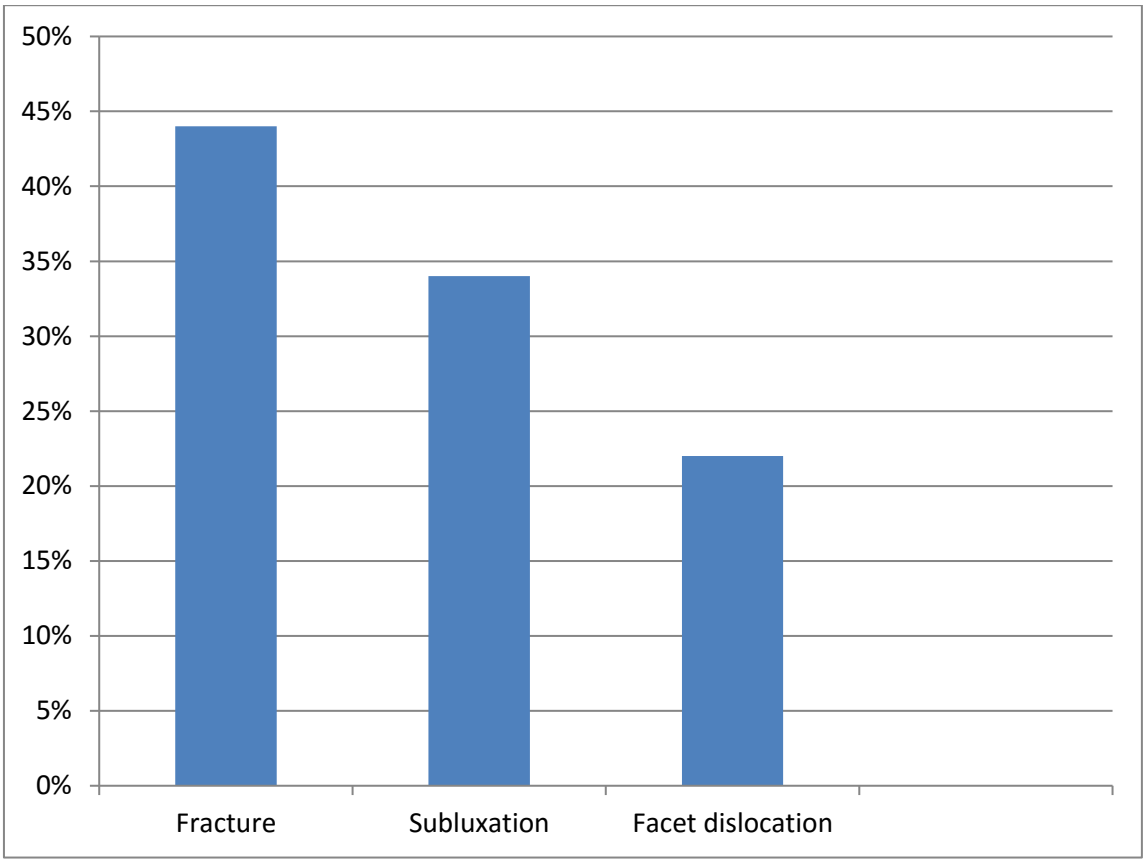
TYPE OF CERVICAL SPINE INJURY	PERCENTAGE OF INTIMAL TEAR	PERCENTAGE OF FOCI OF HAEMORRHAGE	PERCENTAGE OF NORMAL VESSEL WALL	PERCENTAGE OF DISSECTION
Fracture	20%	10%	50%	20%
Subluxation	50%	30 %	20%	0%
Dislocation	100%	0 %	0%	0%
Paraspinal contusion	14.3%	14.3 %	71.4%	0%

Chart 5 showing the percentage of different types of vertebral artery injury and the type of cervical spine injury



Out of different types of cervical injuries, the facet dislocation was associated with the vertebral artery injury with increased incidence. When there is a blunt neck injury which is not associated with any bony injury, the associated vertebral artery injury decreases drastically.

Chart 6 showing the incidence of vertebral artery intimal tear and the type of cervical spine injury



RESULT

This is a prospective study conducted with the aim of establishing the incidence of vertebral artery injury in cases of blunt cervical spine trauma in medicolegal autopsy cases and to assess the type of cervical spine injury resulting in the vessel injury. It is done by histopathological examination of the vertebral arteries.

The medicolegal autopsy cases which fall under the inclusion criteria are dissected to assess the type of cervical spine injury and the vertebral arteries of both sides are studied using eosin and haemotoxylin staining of the tissue. The dissected out vertebral arteries are looked for any gross injury and that section is sent for histopathological study. The study group consists of 25 cases of death associated with a history of blunt cervical spine injury or autopsy finding of the same.

Out of the 25 cases, 12 cases belongs to death due to fall from height (48 %), 8 cases of death due to RTA (32 %) and 5 cases of death due to fall with an object on the head (20 %). The third category consist of heavy weights of >80 kg being carried on the head at the time of accident. Of these cases, three of the deceased where carrying sandbag, cement bag while one of them was working under an auto.

In one case of industrial accident, a 300 kg weighing iron trolley fell on the back of the shoulder of the deceased resulting in subluxation of the cervical vertebra.

In the study group, 21 cases are male (84 %), 4 cases are female (16%) and there were no transgender in the study group. In study group, 1 case was in 0 -20 age category(4%), 13 cases were of 20 - 40 age category(52 %), 10 cases were in 40 -60 age category(40 %), 1 cases was in 60 -80 age category(8%) and there were no case in the 80 -100 age category . The mean age was 43.36

Of the 25 cases, cervical spine fracture was present in 10 cases (40%), vertebral body subluxation was present in 6 cases (24%), and unilateral facet dislocation was present in 2 cases (8%) while 7 cases (28%) had only paraspinal muscle contusion along the cervical column without any gross bony injury.

In the 10 cases in which cervical spine fracture was detected, the microscopic study of vertebral arteries demonstrated intimal tear with foci of hemorrhage, tear in the intima and media, presence of fibrin thrombi, congestion. The histopathological examination shows that intimal tear was present in 2 cases (20%), foci of hemorrhage in 1 case (10%) and 5 cases (50%) did not have any vertebral artery abnormality. Two cases (20%) were

found to have tear in the intima and media with hemorrhage in the media (Vertebral artery dissection).

Well formed fibrin thrombi was present in 1 case of fracture involving the third and fourth cervical vertebra and bilateral intimal tear was present in 1 case of cervical spine fracture. The two cases which presented with tear extending to the media, the cervical spine fracture was at the level of sixth and seventh cervical vertebra. In one case of dissection, the contralateral vertebral artery presented with foci of hemorrhage. In the second case of dissection, the contra lateral vertebral artery presented with tear in the intima.

Of the 6 cases of cervical vertebra subluxation, intimal tear was present in 3 cases (50%) of which 2 cases presented with bilateral intimal tear and 1 case with unilateral intimal tear. Foci of hemorrhage was present in 2 case (30%) and 1 case (20%) did not have any vertebral artery injury. The subluxation which resulted with a heavy weight falling o the back presented with luminal hemorrhage, medial hyperplasia and adventitial hemorrhage

Of the 2 cases with facet dislocation, intimal tear in vertebral artery was present in both cases (100%). One case presented with bilateral intimal tears and one case presented with intimal tear on the side opposite to the

facet dislocation with foci of hemorrhage on the vertebral artery of the same side.

Of the 7 cases with paraspinal bruise, no gross bony injury was detected. The segment of Vertebral artery corresponding to the level of bruise was sent for histopathological examination. One case presented with bilateral vertebral artery intimal tear (14.3%) and one of the cases (14.3%) had foci of haemorrhage. In 5 cases (72%) no injury to the vertebral artery could be detected. Out of different types of cervical injuries, the facet dislocation was associated with the vertebral artery injury with increased incidence. When there is a blunt neck injury which is not associated with any bony injury, the associated vertebral artery injury decreases drastically.

Discussion

DISCUSSION

The main objective of this study is to estimate the incidence of vertebral artery injury in non penetrative cervical spine trauma in medicolegal autopsy cases. Injury to the vertebral artery in cases of blunt injury to the cervical spine has been underreported. [38, 39, 40] The mechanisms which are attributed to the blunt cervical spine injuries are hyperextension, hyperflexion, distraction and rotation. [41, 42]

Most of the studies were done in live patients with history of cervical spine injury using various modalities like Substraction Arteriography,[43] Computed Tomographic Angiography,[22,43] Magnetic Resonance Angiography [44, 45] and some of the studies were done retrospectively based on hospital records.

In this study, facet dislocation has resulted in 100% intimal tear which is similar to the increased incidence documented in the study conducted by Prabhoo et al [46] which is attributed to the rotational aspect of the injury. Of the 2 cases, one case presented with bilateral vertebral artery injury. As the other studies used the angiographic methods for detection of injury, vertebral artery occlusion was detected. But this study used histopathological examination of the vessel wall after gross examination, occlusion could not be identified.

Vertebral artery dissection has been reported in cases of blunt neck injury which has resulted in the fatal cerebellar infarction. [47] But there was no incidence of vertebral artery dissection in the current study. As the studies to find the incidence of vertebral artery injury in blunt neck trauma and to find its correlation with cervical spine injury is done in live patients using imaging studies, it is comparatively low than the values in which autopsy findings of intimal tears were also included. This study provides the autopsy data regarding the vertebral injury in non penetrative neck injury which might have been undetected in the live patients.

The incidence of blunt vertebral artery injury associated with non penetrative cervical spinal injury varies widely in the literature.[48]Their incidence is low due to late presentation of symptoms which leads this entity to go undetected. The detection is based on the patient selection based on the risk factors, the imaging modalities used, the symptomatology, the mechanism of injury and the type of injury present. These are the factors which affect the outcome of various studies.

When the study group is chosen with a bias, i.e, patients with cervical spine trauma, the incidence is higher than that in general population with history of trauma. The result of various studies range from 13% to 88% [18, 43,46, 48,49,50] The deleterious and fatal effects of blunt vertebral artery injury

make it important to screen them at the earliest. They could result in a range of effects from transient neurological deficit to fatal cerebellar infarction.

The study by Prabhoo et al conducted in 47 patients with cervical spine trauma showed an incidence of vertebral artery injury 26% using Magnetic Resonance Angiography while Willis et al showed an incidence of 35% in a study with 26 patients. A similar prospective study by Friedman et al using MRA showed an incidence of 24% of blunt vertebral artery injury.

The injury which is mostly associated with vertebral artery injury is fracture or dislocation of the cervical vertebra in the studies conducted by Biffl et al , There was no correlation between the vertebral artery injury and the neurological deficits in the cases studies by them. Studies which focus on specific cervical injuries like facet dislocation or fracture of foramen transversarium report the highest incidence of vertebral artery injury. [43, 50]

Although the neurological outcome varies in different types of vertebral artery injury, it's devastating potential is undeniable. Cerebrovascular accident has been reported [18] especially posterior circulation stroke in blunt vertebral artery injury. The treatment of vertebral artery thrombosis using anticoagulants is controversial. While some studies have indicated no beneficiary effect of anticoagulants [51 ,52] some studies have indicated severe side effects of the anticoagulant treatments. So,

studies have to be done to establish the frequency of cerebral damage caused by blunt vertebral artery injury, sensitivity and specificity of diagnostic tools that could be used for screening of the high risk group and the necessity, complication and the outcomes of treatment protocol used.

Conclusion

CONCLUSION

The aim of the study is to determine the incidence of vertebral artery injury in fatal non penetrative cervical spine trauma to imply its increased occurrence than being reported in clinical set ups and to establish the type of cervical spine injury that has more probability of an associated vertebral artery injury which would help the clinician to screen the high risk patients. This is evident on analyzing the results of the study when the autopsy study shows the incidence of vertebral artery injury are way higher than the incidence reported by antemortem studies using imaging techniques.

The result of the study shows that vertebral artery injury is more associated with cervical spine injury than with paraspinal muscle bruise without bony injury. It also shows that facet dislocation have high incidence of vertebral artery injury than with cervical fracture and subluxation. Although neurological deficit was not detected in most cases, transient neurological symptoms are not uncommon.

Studies have shown that unilateral vertebral artery injury have no effects on the brain in most cases due to establishment of collateral circulation. To get more information about the effect of this vertebral artery injury, corresponding histopathological examination of the brain tissue need to be done in any future studies.

The clinician must be meticulous in ruling out cerebrovascular injury in patients with cervical spine injury and any neurological deficits in patients with head and spine injury should be identified if it was due to the direct head injury or due to the vertebral artery injury due to cervical spine damage.

Prospective studies should be combined with autopsy studies to establish the actual incidence of vertebral artery injury and to establish screening and treatment protocols that should be followed routinely in patients presenting with non penetrative cervical spine trauma.

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Annexure

Fig 13. Showing autopsy neck dissection

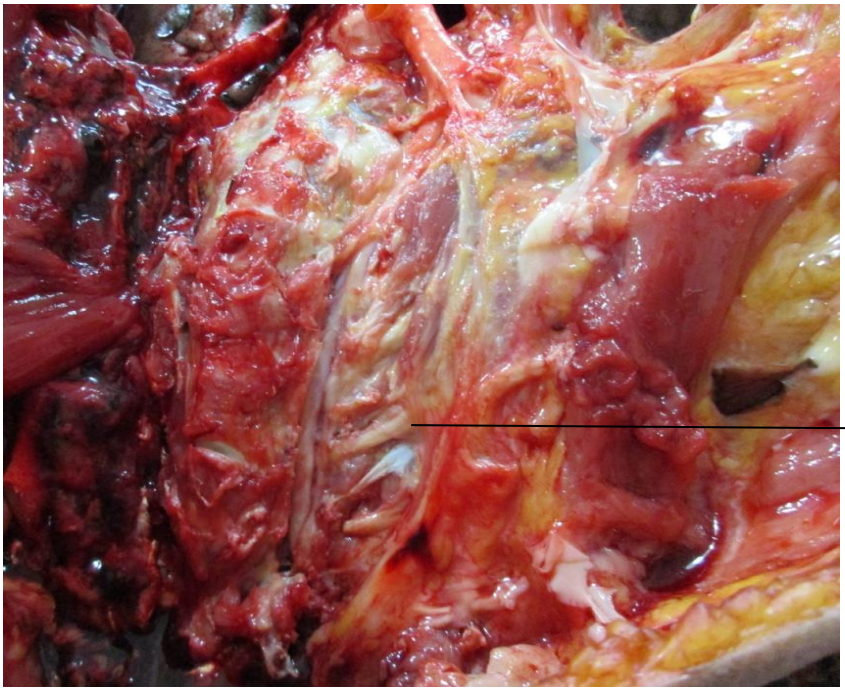


Fig 14. Showing dissection of vertebral artery

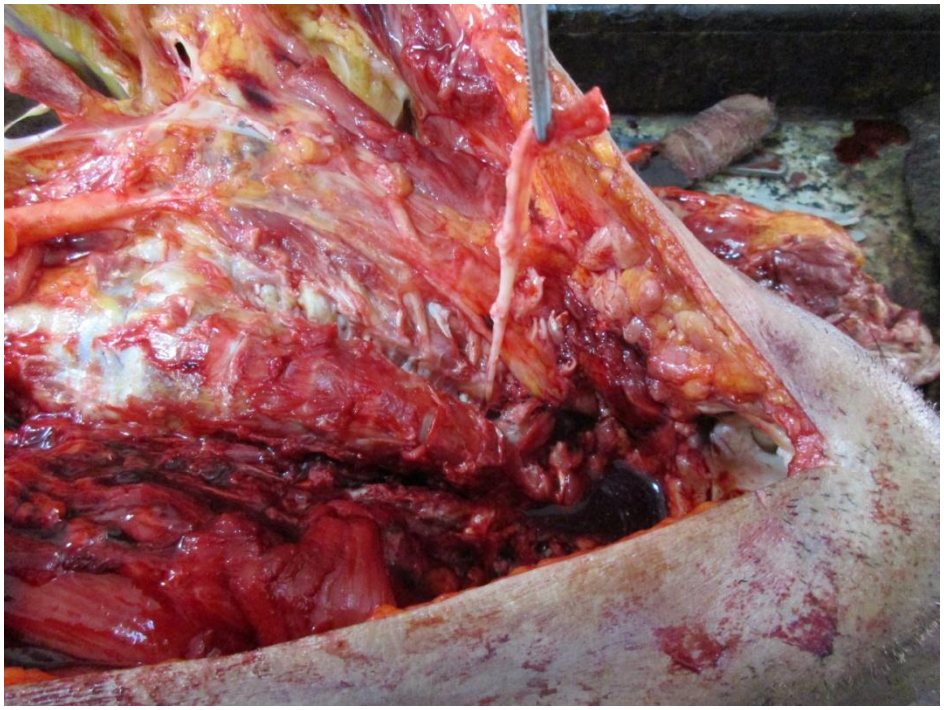


Fig 15. Showing fracture of C5 vertebra

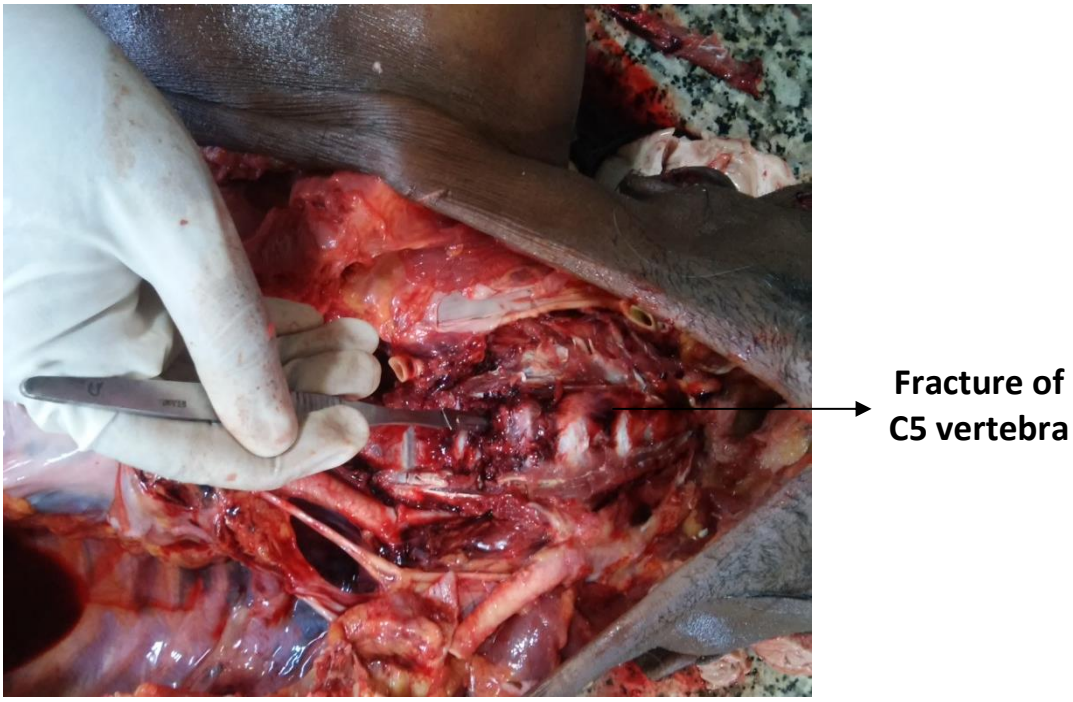


Fig 16. Showing vertebral artery thrombosis in gross examination

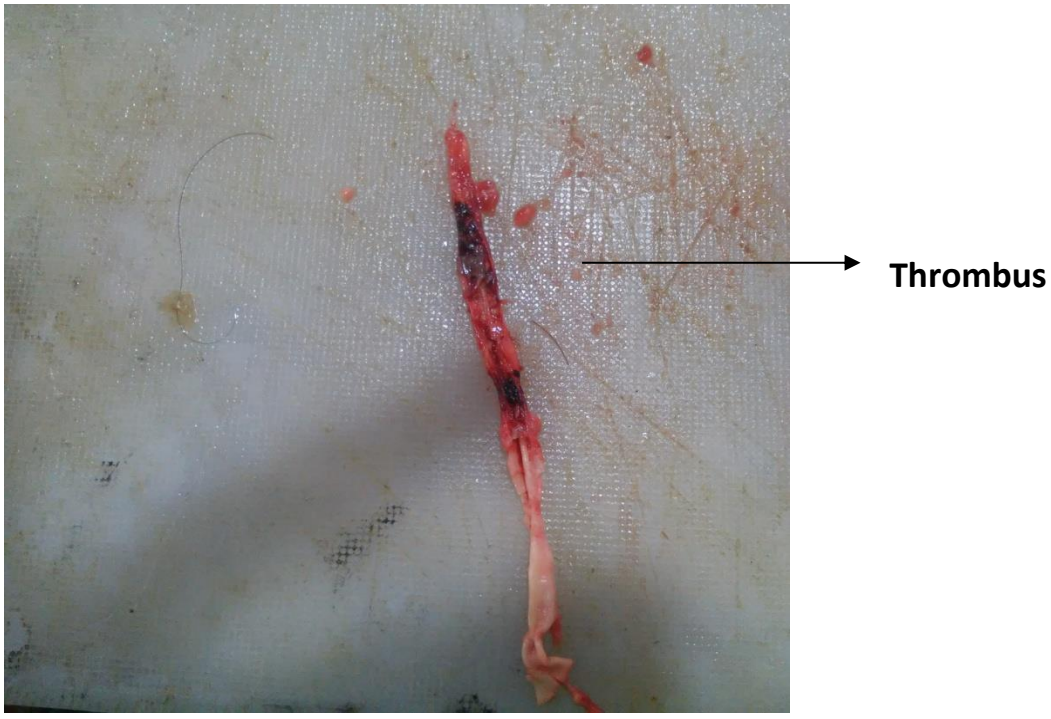


Fig 17. Showing histopathology of vertebral artery intimal tear

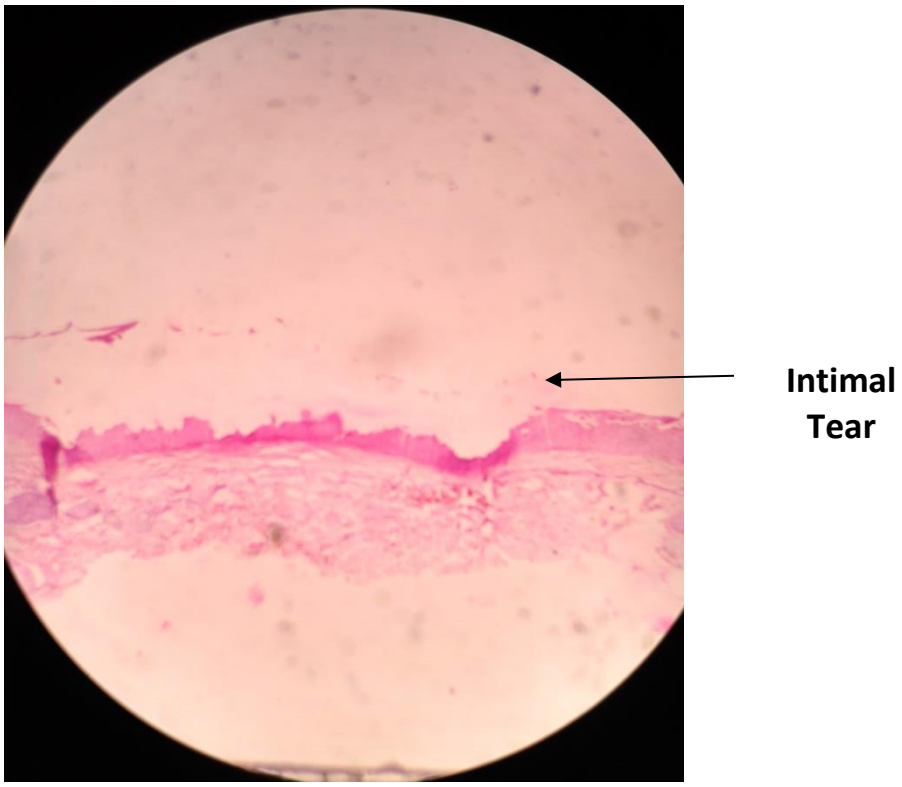
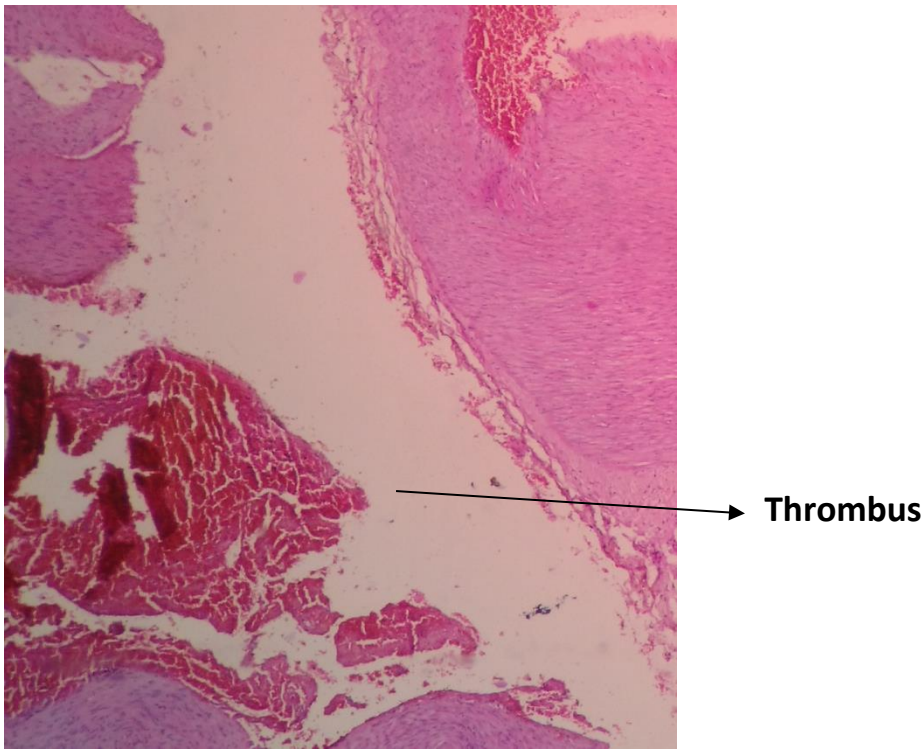


Fig 18.Showing histopathology of intimal tear and thrombus



MASTER CHART

S. NO	PM. NO	AGE	SEX	HISORY	CERVICAL INJURY	HISTOPATHOLOGICAL FINDINGS	
						RIGHT	LEFT
1	290/16	36	M	fall from height	Fracture at level of C5	Normal	Normal
2	940/16	45	M	carbamazepine poisoning and fall	Fracture at level of C7	Foci of haemorrhage present	Normal
3	1011/16	48	M	RTA,	Subluxation of C4 vertebra	Normal	Normal
4	1065/16	40	F	slipped from conveyer belt	Facet dislocation of C4	Intimal tear present	Intimal tear present
5	1091/16	60	F	rice bag slipped from head	Fracture at level of C3, C4, C5	Fibrin thrombi present	Intimal tear and luminal haemorrhage present
6	1092/16	40	M	cement bag fall on head	Fracture at level of C5	Intimal tear present	Foci of haemorhage present
7	1153/16	50	M	slipped with sand bag	Fracture at level of C6,C7	Disruption of intima and media - dissection	Foci of haemorhage present
8	1166/16	34	M	fall from 2 wheeler	Subluxation of C3 vertebra	Intimal tear present	Intimal tear present
9	1179/16	33	M	fall from 2 wheeler	Fracture at level of C6	Disruption of intima and media - dissection	Intimal tear present
10	1208/16	32	M	auto fell over face	Facet Dislocation at C4	Intimal tear present	Normal
11	1210/16	40	M	fall from 30 feet	Subluxation at the level of C5	Intimal tear present	Intimal tear present Foci of haemorhage present
12	1247/16	25	M	fall from height	Subluxation at the level of C4	Normal	Intimal tear present Foci of haemorhage present
13	1262/16	26	F	fall from height	Paraspinal bruise along C3, C4, C5	Intimal tear present Foci of haemorhage present	Intimal tear present Foci of haemorhage present
14	1273/16	30	M	fall from 30 feet	Fracture at level of C3	Normal	Normal
15	1280/16	19	M	fall from 2 wheeler	Paraspinal bruise along C3, C4	Foci of haemorhage present	Foci of haemorhage present
16	1281/16	45	M	pedestrian	Paraspinal bruise along C5,C6	Normal	Normal
17	1341/16	60	M	fall from construction site 20 ft	Fracture at level of C3	Normal	Normal
18	1363/16	30	M	RTA	Fracture at level of C6	Normal	Normal
19	1364/16	80	F	fall unconscious	Subluxation of C4 vertebra	Foci of haemorhage present in media	Foci of haemorhage present
20	1367/16	44	M	accidental fall of iron trolley chain on back of neck at workplace	Subluxation of C3	Luminal haemorrhage, medial hyperplasia, adventitial haemorrhage	Luminal and adventitial haemorrhage
21	1387/16	45	M	pedestrian v 4 wheeler	Paraspinal bruise along C5,C6	Normal with vessel wall congestion	Normal with vessel wall congestion
22	1399/16	37	M	fall from height	Paraspinal bruise along C3,C4	Normal with vessel wall congestion	Normal
23	1409/16	45	M	fall from height	Fracture at level of C6	Normal with vessel wal congestion	Normal with vessel wall congestion
24	1415/16	35	M	fall unconscious	Paraspinal bruise along C2, C3, C4	Normal	Normal
25	1418/16	60	M	fall unconscious	Paraspinal bruise along C2, C3	Normal	Normal