"EVALUATION OF ANATOMICAL RELATIONSHIP OF INTERNAL JUGULAR VEIN AND THE COMMON CAROTID ARTERY USING COMPUTED TOMOGRAPHY: A ONE YEAR OBSERVATIONAL STUDY AT KLES DR. PRABHAKAR KORE HOSPITAL & MEDICAL RESEARCH CENTRE"

By

REGISTRATION NO: BE0120009

Dissertation

Submitted to

KLE Academy of Higher Education and Research,

Belagavi, Karnataka

In partial fulfilment

of the requirements for the degree of

MASTER OF SURGERY
IN
OTORHINOLARYNGOLOGY AND HEAD AND NECK SURGERY

DEPARTMENT OF OTORHINOLARYNGOLOGY AND

HEAD AND NECK SURGERY,

JAWAHARLAL NEHRU MEDICAL COLLEGE,

BELAGAVI, KARNATAKA

JUNE/JULY – 2023

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Dr. B.P. BELALDAVAR M.S (ENT), D.L.O, Ph.D,
Professor & Head of Department
Department of Otorhinolaryngology
and Head & Neck Surgery,
J.N.Medical College,
Nehru Nagar, Belagavi -590010

Date: 31/12/22
Place: Belagavi

KAHER BELAGAVI J.N.MEDICAL COLLEGE

Dr.(Mrs)N.S.MAHANTASHETTI M.D.(Paeds)
Principal
J.N.Medical College,
Nehru Nagar,
Belagavi -590010

J.N. Medical College, BELAGAVI- 590 010

Date:
Place: Belagavi

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BE0120009

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(Recognized by Medical Council of India, New Delhi)
Accredited 'A+' Grade by NAAC (3rd Cycle) Placed in Category 'A' by MHRD (GoI)
Nehru Nagar, Belagavi- 590 010, Karnataka, INDIA
0831 - 2471350 0831 - 2470759 www.jnmc.edu principal@jnmc.edu

Ref No: MDC/PG/ Date: 29-11-2022

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Postgraduate Student,
2020-21 Batch,
Department of ENT,
J. N. Medical College, Belagavi.

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K.L.E. ACADEMY OF HIGHER EDUCATION AND RESEARCH
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Accredited 'A' Grade by NAAC (2nd Cycle) Placed in Category 'A' by MHRD (GoI)
JAWAHARLAL NEHRU MEDICAL COLLEGE,
NEHRU NAGAR, BELAGAVI-590010 (KARNATAKA-INDIA)
Website: http//www.jnmc.edu
E-Mail : dome@jnmc.edu
Phone: (+ 91-(0)831 Office : 2472550
Principal: 2471701
Fax No. +91 (0)831 – 2470759

Ref: MDC/DOME/ 69 **Date: 25/01/2021**

To,

PG student in Otorhinolaryngology and Head & Neck Surgery,
J.N.Medical College,
BELAGAVI.

Sub: Institutional Ethical Clearance for the study.

With reference to the above, we wish to inform you that your proposed research project titled **"EVALUATION OF ANATOMICAL RELATIONSHIP OF INTERNAL JUGULAR VEIN AND THE COMMON CAROTID ARTERY USING COMPUTED TOMOGRAPHY: A ONE YEAR OBSERVATIONAL STUDY AT KLES DR. PRABHAKAR KORE HOSPITAL & MEDICAL RESEARCH CENTRE",** is ethical and justifiable. The proposed research project has been cleared by the JNMC Institutional Ethics Committee on Human Subjects Research.

(Dr. Smita Sonoli)
Member Secretary
JNMC Institutional Ethics Committee
on Human Subjects Research,
J.N.Medical College, Belagavi.

(Dr. Harsha Hegde)
Chairman,
JNMC Institutional Ethics Committee
on Human Subjects Research,
J.N.Medical College, Belagavi.

ABSTRACT

Title: Evaluation of anatomical relationship of internal jugular vein and the common carotid artery using computed tomography: A One year observational study at KLES Dr. Prabhakar Kore Hospital & Medical Research Centre.

Objective: To evaluate the intervarying relationship of IJV and CCA at supine and after simulating rotation to 15, 30 and 45 degrees respectively.

Methods: A one year study was undertaken and 104 IJVs were evaluated at supine and after simulating 15-, 30- and 45-degree neck rotation to the contralateral side.

Results: The study had a male predilection of 68.63% over 33.33% females. Prior to simulating rotation, the IJV was Anterolateral (42%), Lateral (39%), Posterolateral (22%), Posterior (1%) and with subsequent rotation it assumed a more anterior relationship. The mean overlap of IJV and CCA was 27.7 at 0 degree, 32.93 at 15 degrees, 37.73 at 30 degree and 37.81 at 45-degree neck rotation and 26.7 at 0 degree, 29.24 at 15 degrees, 35.58 at 30 degree and 31.52 at 45-degree neck rotation on left; thereby showing increasing overlap with rotation.

Conclusion: Special attention should be paid to anterior shifting of IJV relative to CCA induced with neck rotation. Taking this knowledge into account in the operative field can minimize surgical errors and intra operative complications.

Keywords: internal jugular vein, common carotid artery, simulated rotation, computed tomography

LIST OF ABBREVIATIONS

IJV	**Internal Jugular Vein**
CCA	**Common Carotid Artery**
SR	**Simulated Rotation**
USG	**Ultrasonography**
CT	**Computed Tomography**
CECT	**Contrast Enhanced Computed Tomography**
SD	**Standard Deviation**

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INTRODUCTION

Head & Neck cancers have come across in the 21st century as one of the most pertinent public health problems in India due to the demographic profile, lifestyle habits, and paucity of health resources. It has been documented in the literature that 57.5% of Head & Neck cancers (HNC) occur in Asia out of which India attributes to 30% of it.

Neck dissection is an operation performed in patients with HNC such as the oral cavity, oropharynx, laryngopharynx, thyroid, etc. The purpose of neck dissection is to remove the draining lymph nodes in the neck. There are many important anatomical structures in the neck, such as Internal Jugular Vein (IJV), Common Carotid Artery (CCA), spinal accessory nerve (SAN), vagus nerve, hypoglossal nerve, submandibular gland, thyroid gland, various muscles, etc. These structures need to be carefully identified and preserved during operation.[2] Hence their relationship with each other is vital information. The CCA and IJV are the two main vascular structures in the neck.

The anatomical variations of relationship between IJV and CCA may lead to a puncture of the artery while performing a dissection of the neck or central venous access. It has been seen that operators performing cannulation find difficulty for the same without ultrasound due to the anatomic unreliability of the external landmarks. IJV is often used to place central venous catheters.[3] The anatomical variations of the vein may lead to unsuccessful cannulations or iatrogenic injuries to the artery.

Ultrasound scanning is used in difficult cannulations but in settings with a paucity of resources it cannot be performed for each patient and for intervention.

Therefore, one has rely on the knowledge of landmarks and palpation of the CCA when there is no ultrasound, but this is based on our standard literature which describes IJV as being lateral to CCA. Whereas to do cannulation successfully physicians rotate the head which increases the risk for CCA puncture in cases where the IJV overlies the carotid artery. Plus, the principle of ultrasound usually follows lateral scanning as the probe must be coupled as anterior to posterior scanning is not possible in a round neck. Thus, even though scans are adequately performed IJV shown to be more anterior to CCA falsely than anatomically present.[5]

It has been documented that at the supine position IJV is on lateral side of CCA. On rotating to opposite side to cannulate the IJV, the artery it moves anteriorly and medially such that it occupies an anterior position to the CCA.[6]

Therefore, a detailed study of the intervarying relationship of IJV and CCA is deemed fit to find out the varying relationships between them and to take this knowledge into account in the operative field to minimize surgical errors and intraoperative complications.

A novel study was undertaken at our centre using virtual simulation for neck rotation and intervarying relationship of the IJV and CCA was studied not only at midline but also after neck rotation to 15, 30 and 45° angle using CT. Along with it the overlap of IJV and CCA was also evaluated at each of the angles.

OBJECTIVES

- **Primary Objective:** To evaluate the anatomical relationship and degree of overlap between Internal Jugular Vein and Common Carotid Artery using computed tomography (CT) in patients.
- **Secondary Objective:** To evaluate the changes that occur in these elements after simulating 15-degree (SR15), 30-degree (SR30) and 45-degree (SR45) neck rotation to the contralateral side.

REVIEW OF LITERATURE

ANATOMY

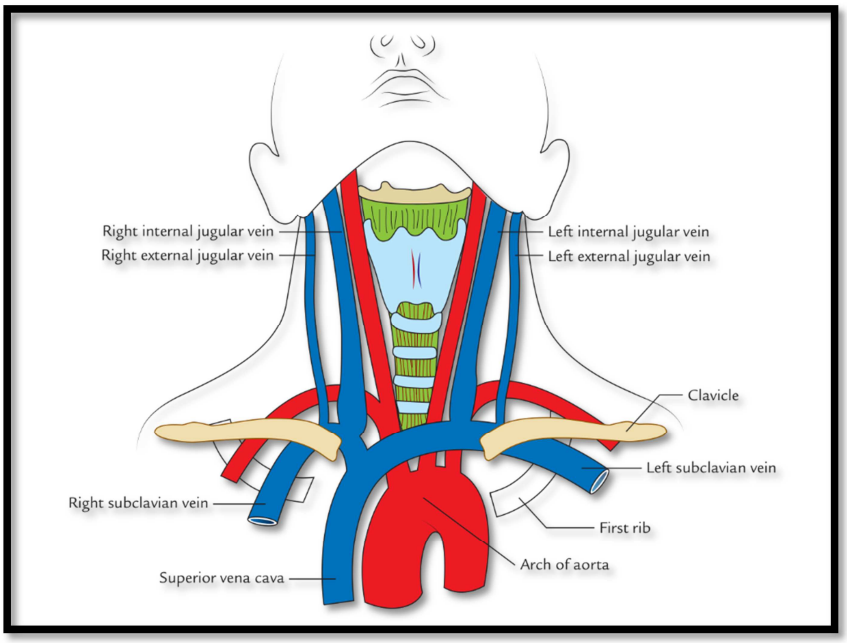


Figure 1[25]: Anatomy of head and neck showing major vessels and structures.

The vascular anatomy of head and neck is extremely complicated. Several blood vessels run through this area, supplying all the vital structures of the head and neck. This anatomical knowledge is important for surgeons dealing with HNC as well as reconstructive surgeons.

The variations in anatomy of IJV are not commonly enumerated. The literature documented till date is mostly sourced from the ones documented by anaesthesiologists and puts cost of imaging as the basis of study. Whereas 'surgical literature' is mostly the variations in anatomy as seen by surgeons or anatomists while performing surgeries and anatomical dissections.

ANATOMY OF NECK

The neck is the anatomical part of human body which separates head from the rest of the body or can also be defined as a part connecting head to rest of the body. It extends from anteriorly located cervix and goes on till the posteriorly located nucha. Superior extent being the line connecting occiput to the chin and inferior extent parallels the course of the first rib at the thoracic inlet.

Surface Anatomy

Antero-superiorly bordered by inferior border of mandible and mylohyoid muscle, postero-superiorly by the base of skull, posteroinferiorly by the scapulae and on the inferior aspect it is bounded by the thoracic inlet.

Muscles of Neck

Muscles of the neck can be divided into superficial and deep muscles. Superficial muscles being Platysma, Sternocleidomastoid muscle, and Trapezius muscle whereas the deep muscles are Suboccipital, Suprahyoid, Infrahyoid and Scalene muscles.

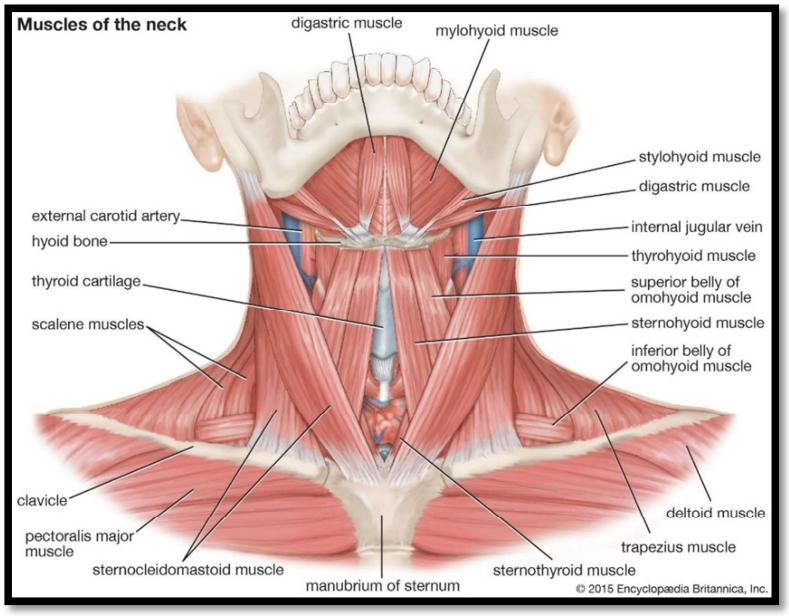


Figure 2[26]: Muscles of the neck.

TRIANGLES OF NECK

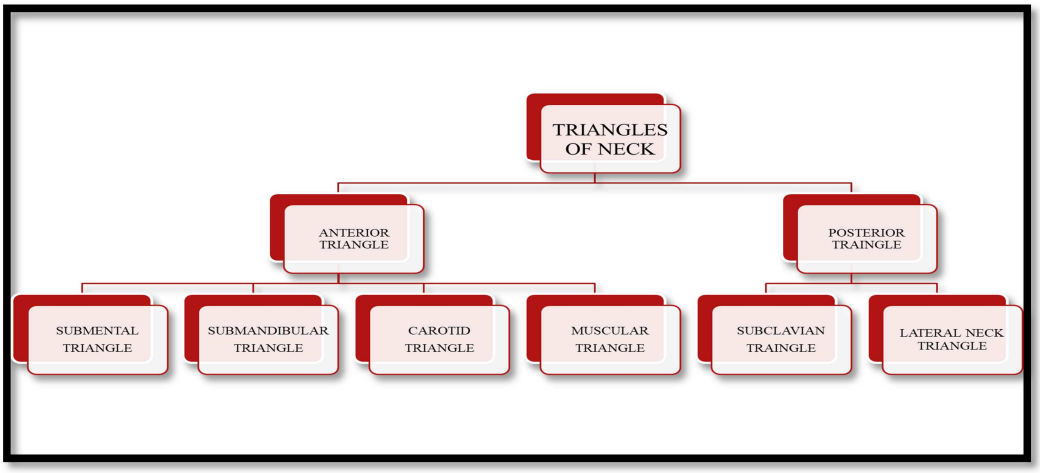


Figure 3: Chart showing divisions of the triangles of neck.

ANTERIOR TRIANGLE

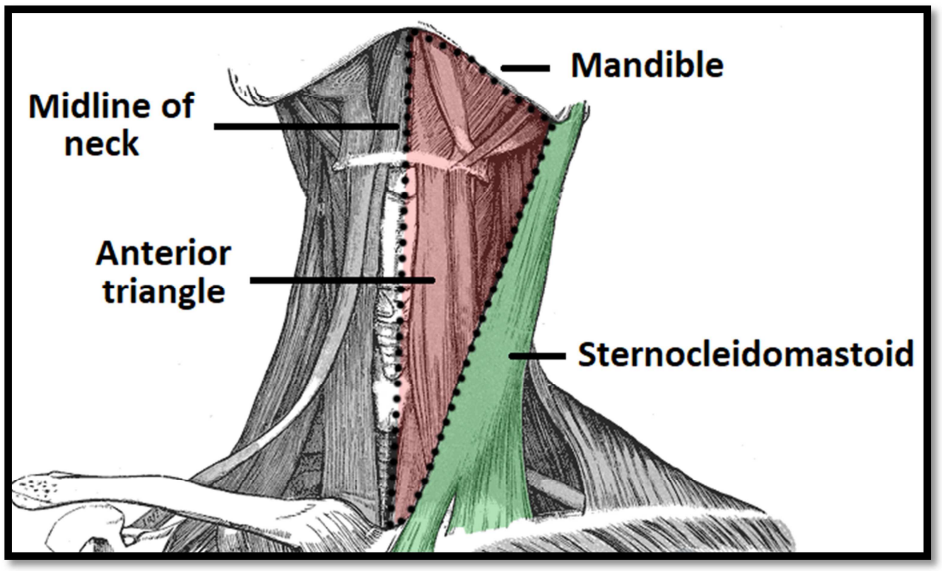


Figure 4[27]: Image showing boundaries of anterior triangle of the neck.

The Anterior triangle of neck as shown in Fig 4 is laterally bound by the posterior border of Sternocleidomastoid muscle, medially by midline of the neck and superiorly by the inferior ramus of the mandible.

SUBDIVISIONS:

- Submental triangle
- Submandibular triangle
- Carotid triangle
- Muscular triangle

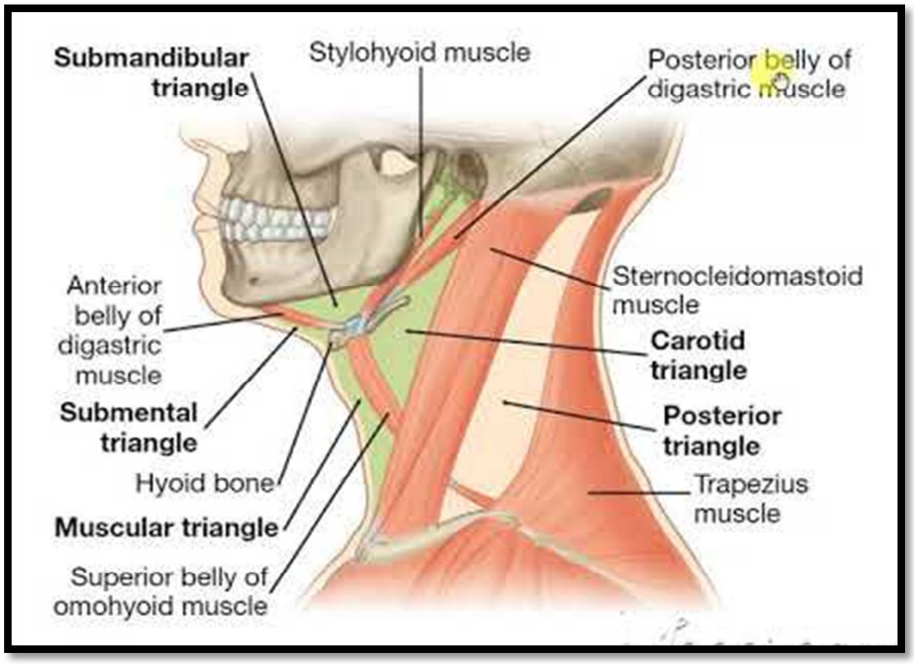


Figure 5[25]: Divisions of anterior triangle

SUBMENTAL TRIANGLE

The submental triangle is bounded laterally by the anterior belly of the digastric, medially -by the midline of the neck, inferiorly by hyoid bone and the floor is formed by mylohyoid muscle. Its contents are level IA lymph nodes and the submental salivary gland

SUBMANDIBULAR TRIANGLE

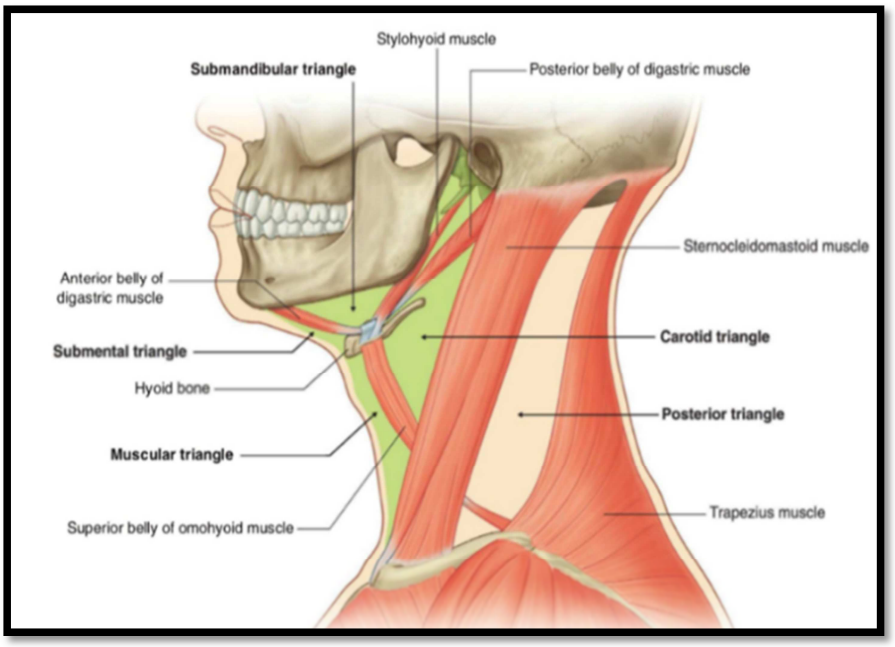


Figure 6[25]: Submandibular triangle

The submandibular triangle is bounded superiorly by the Body of mandible, anteriorly by anterior belly of Digastric and posteriorly by posterior belly of Digastric. The contents of submandibular triangle are submandibular salivary gland, deep fascia, lymph nodes, anterior facial vein, facial artery, marginal mandibular branch of the facial nerve.

CAROTID TRIANGLE

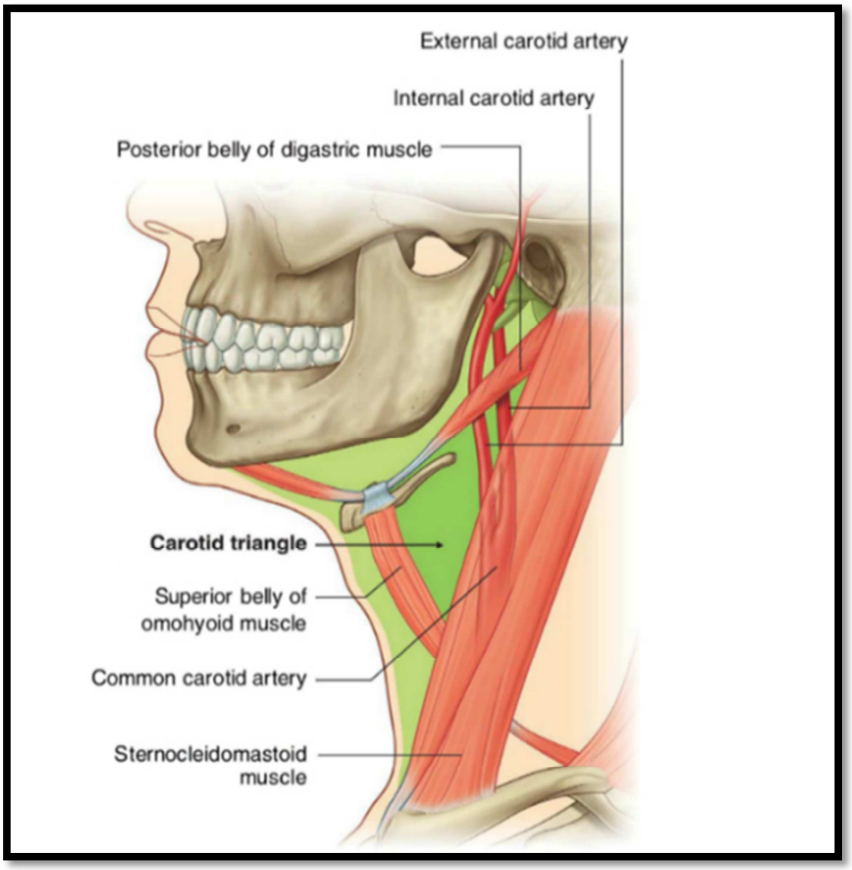


Figure 7[25]: Carotid triangle

The carotid triangle is bounded laterally by posterior border of Sternocleidomastoid muscle, superiorly by posterior belly of Digastric and medially by Superior belly of Omohyoid. The contents are upper Carotid sheath, lymph nodes and bifurcation of Carotid into internal and external branches.

CAROTID SHEATH

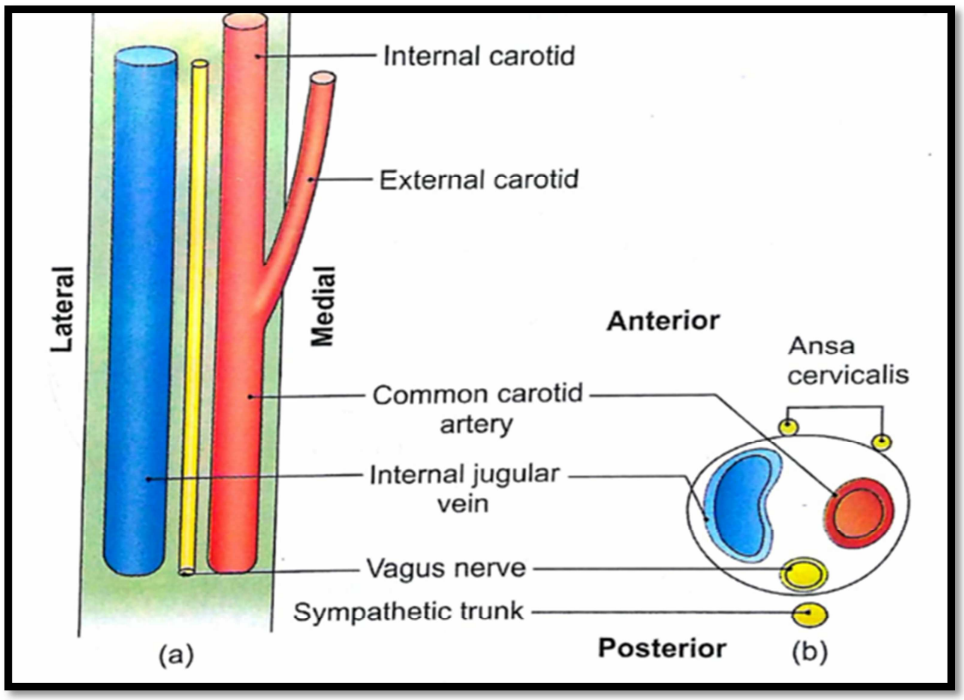


Figure 8[25]: Carotid Sheath

This is derived from the superficial layer of deep cervical fascia medial to the sternocleidomastoid muscle.

MUSCULAR TRIANGLE

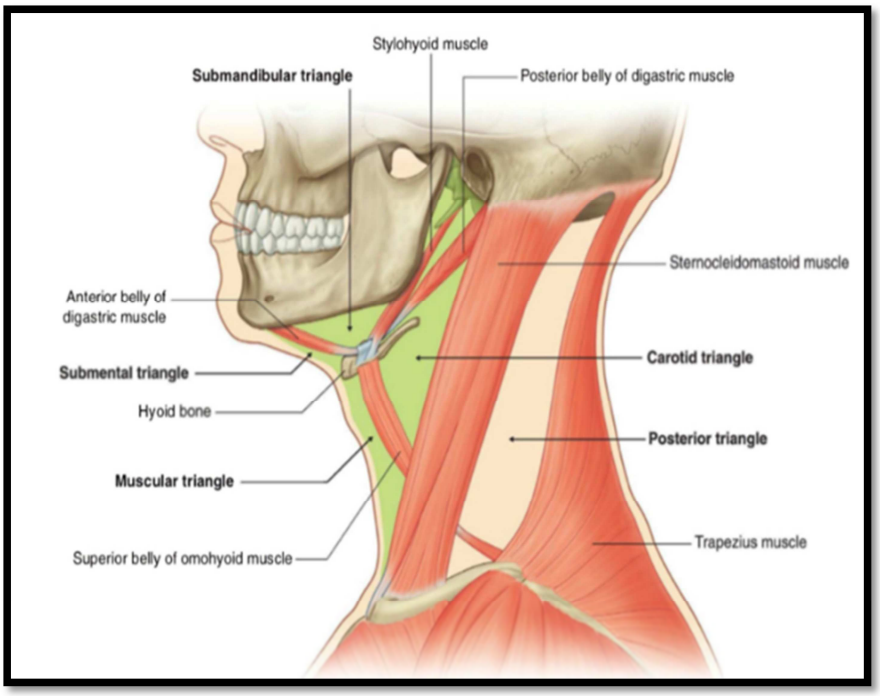


Figure 9[25]: Muscular triangle

The muscular triangle (As shown in Fig 9) is bounded superolaterally by superior belly omohyoid, inferolaterally by the posterior border sternocleidomastoid muscle and medially by midline of the neck. Its contents are Lower carotid sheath, Infrahyoid strap muscles, Upper aerodigestive tract, the thyroid and parathyroid glands.

POSTERIOR TRIANGLE

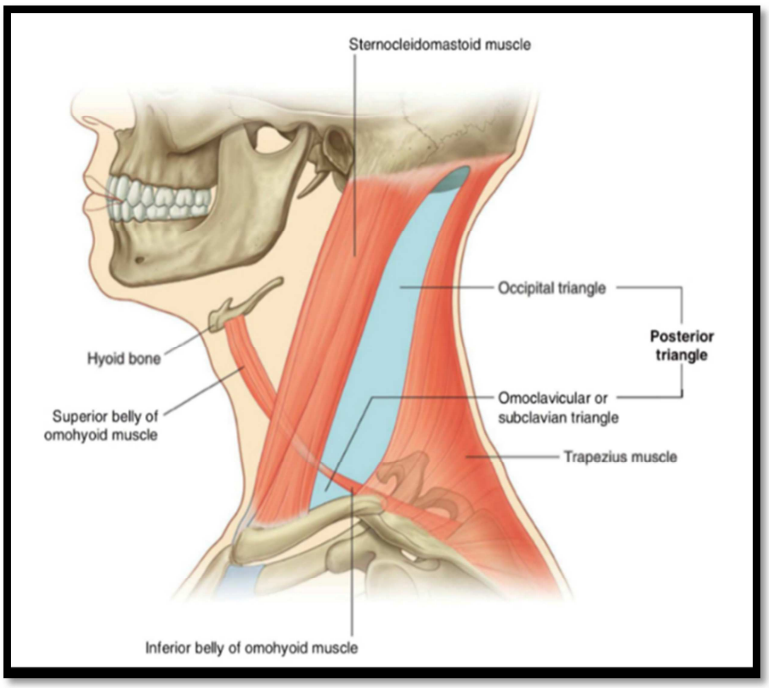


Figure 10[25]: Posterior triangle

The posterior triangle as shown in Fig 10 is bounded anteriorly by posterior border of the sternocleidomastoid muscle, posteriorly by anterior border of trapezius, and inferior border is formed by the middle third of the clavicle.

CAROTID SYSTEM

ARCH OF AORTA

Course

The aortic arch is the section of the aorta between the ascending and descending aorta. As it arises from the ascending aorta, the arch runs slightly backward and to the left of the trachea. The distal segment of the aortic arch then traverses downwards at the fourth thoracic vertebra. From this point on, it continues as the descending aorta. The aortic arch is a continuation of the ascending aorta and begins at the level of the second sternocostal joint. It arches superiorly, posteriorly and to the left before

moving inferiorly. The aortic arch ends at the level of the T4 vertebra. The arch is still connected to the pulmonary trunk by the ligamentum arteriosum (remnant of the foetal ductus arteriosus).

Branches

There are three major branches arising from the aortic arch. Proximal to distal:

- **Brachiocephalic trunk:** The first and largest branch that ascends laterally to split into the right common carotid and right subclavian arteries. These arteries supply the right side of the Head and Neck, and the right upper limb.
- **Left Common Carotid Artery:** Supplies the left side of the Head and Neck.
- **Left Subclavian artery:** Supplies the left upper limb. The brachiocephalic trunk is the first branch of the aortic arch and supplies blood to the right arm and right Head and Neck. The left Common Carotid Artery is the second branch of the aortic arch, which supplies blood to the left side of the head of the neck. The last branch of the aortic arch is the left subclavian artery that distributes blood to the left arm.

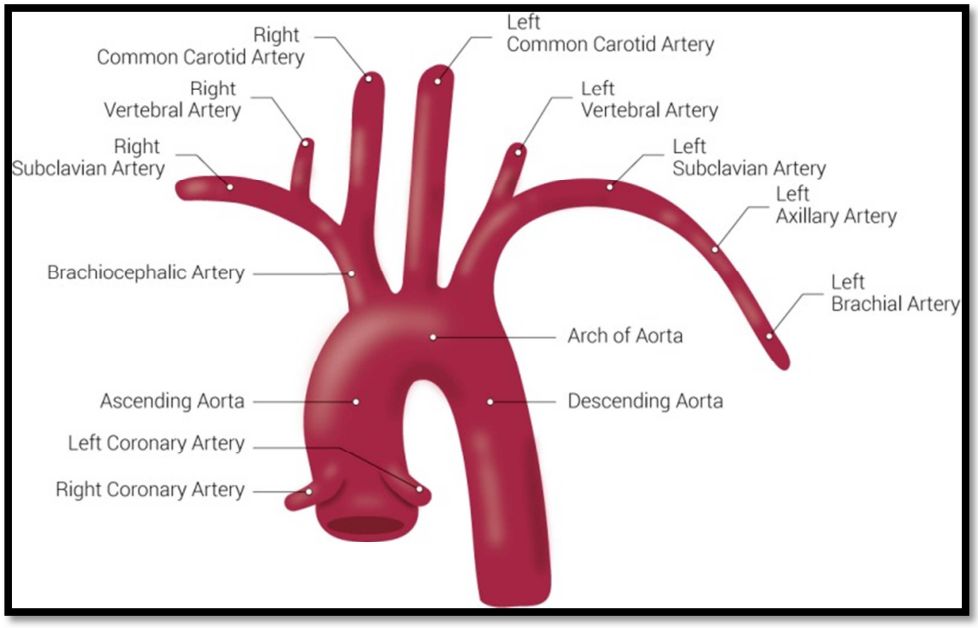


Figure 11[25]: Divisions of arch of aorta.

COMMON CAROTID ARTERY

Course

Common Carotid Artery begins in the thorax in front of the trachea opposite a point a little to the left of the centre of the manubrium. It ascends to the back of left sternoclavicular joint and enters the neck. In the neck both arteries have similar course. Each artery runs upwards within the carotid sheath, under cover of the anterior border of the sternocleidomastoid. It lies in front of the lower four cervical transverse processes. Usually at the level of the upper border of the thyroid cartilage, the artery ends by dividing into the external and internal carotid arteries. The Common Carotid Artery generally bifurcates into the Internal Carotid Artery and External Carotid Artery at the level of C3.

Structure: Mean diameters of ICA (4.66±0.78 mm) and CCA (6.10±0.80 mm) in women were significantly smaller than in men: 5.11±0.87 mm and 6.52±0.98 mm, respectively.

RELATIONS OF COMMON CAROTID ARTERY

	Thoracic part	**Lower neck**	**Higher neck**
Anterior	• Sternohyoid and sternothyroid muscles • Anterior part of lungs and pleura • Remains of the thymus Left brachiocephalic vein	• Sternoclavicular joint • Superficial fascia • Platysma Sternocleidomastoid, sternothyroid, and omohyoid muscles	• Skin • Branches of the cervical plexus • Platysma Sternocleidomastoid muscle
Posterior	• Trachea • Oesophagus • Left recurrent laryngeal nerve acic duct	• Sympathetic trunk Longus colli, longus capitis, and anterior scalene muscles	
Lateral	• Phrenic nerve • Left vagus Left pleura	• Vagus nerve • Internal Jugular Vein (within the same carotid sheath)	
Medial	• Brachiocephalic trunk/artery	Trachea	• Larynx • Pharynx • Thyroid gland

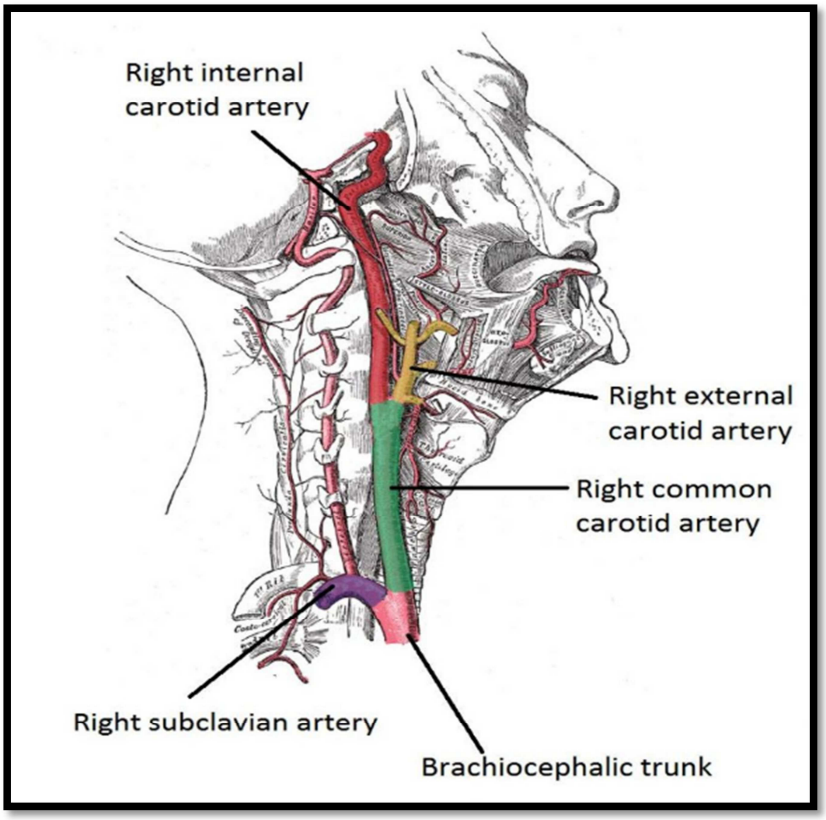


Figure 12[27]: Divisions of Common Carotid Artery.

EXTERNAL CAROTID ARTERY

Course

The External Carotid Artery begins opposite the upper border of the thyroid cartilage, and taking a slight curved course, passes upwards and forwards, and then inclines backward to the space behind the neck of the mandible where it divides into two branches – Superficial Temporal and Internal Maxillary arteries. It rapidly diminishes in size in its course up the neck, after giving off multiple branches from it. At its origin the artery is much superficial and near the midline than the internal carotid and contained within the carotid triangle.

Origin: Superficial, within the carotid triangle, and at the level of the thyroid cartilage (C4)

Branches:

ANTERIOR	POSTERIOR	ASCENDING	TERMINAL
Superior Thyroid	Occipital	Ascending Pharyngeal	Superficial Temporal
Lingual	Posterior Auricular	Pharyngeal	Internal Maxillary
External Maxillary			

The above table shows the branches of the external carotid artery. Anteriorly it gives three branches – Superior thyroid, Lingual and External maxillary branches. Posteriorly it gives two branches – Occipital and the Posterior Auricular Branch. Ascending part branches into Ascending pharyngeal and the Pharyngeal branches and it terminates giving Superficial Temporal and Internal Maxillary branches.

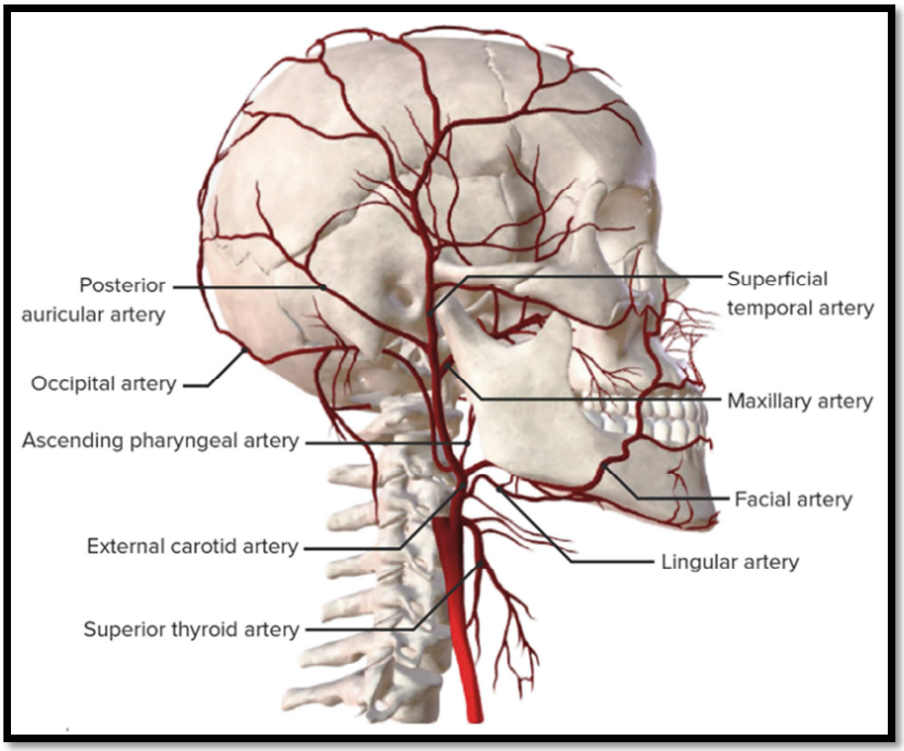


Figure 13[26]: Divisions of External Carotid Artery.

Branch	**Structures supplied**
Superior thyroid	• Thyroid gland • Infrahyoid muscles • Sternocleidomastoid muscle
Ascending pharyngeal	• Pharynx • Prevertebral muscles • Middle ear • Cranial meninges
Lingual	• Intrinsic muscles of the tongue • Floor of the mouth
Facial	• Tonsils • Palate • Submandibular glands

Occipital	• Posterior region of the scalp
Posterior auricular	• Parotid gland • Facial nerve • Ear • Scalp
Maxillary	• External acoustic meatus • Tympanic membrane • Dura mater • Calvaria • Mandible • Gingivae • Teeth • Temporalis muscles • Pterygoid muscles • Masseter muscles • Buccinator muscles
Superficial temporal	• Temporal region of the scalp

INTERNAL CAROTID ARTERY

The internal carotid artery supplies the following structures:

- Frontal lobe of brain
- Parietal lobe of brain
- Temporal lobe of brain
- Diencephalon
- Eyes
- Parts of the paranasal sinuses (ophthalmic artery)
- Contributes to the circle of Willis in the cerebrovascular system

Location

- Originates within the carotid triangle at the level of the thyroid cartilage (C4)
- Ascends and enters the skull through the carotid canal (temporal bone)
- Terminates as the middle and anterior cerebral arteries

Segments

The internal carotid artery is divided into segments:

- Modern division:
    - Cervical part: no branches
    - Petrous part
    - Cavernous part: relates to the cavernous sinus
    - Intracranial part
- Cincinnati classification:
    - Cervical
    - Petrous
    - Lacerum
    - Cavernous
    - Clinoid
    - Ophthalmic (supraclinoid)
    - Communicating (terminal) segments

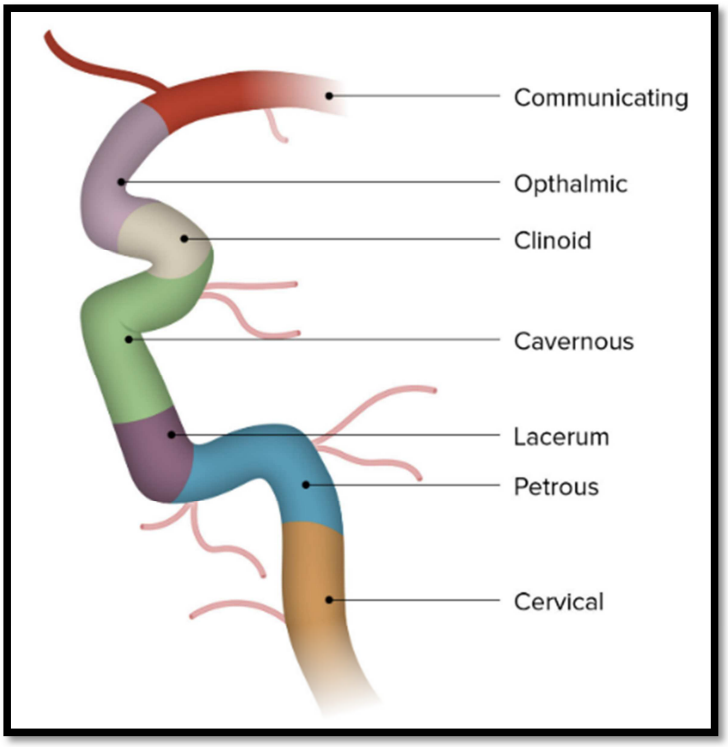


Figure 14[25]: Divisions of Internal Carotid Artery.

JUGULAR VENOUS SYSTEM

External Jugular Vein

Course

The external jugular vein and its tributaries supply the majority of the external face. It is formed by the union of two veins:

- **Posterior auricular vein** – drains the area of scalp superior and posterior to the outer ear.
- **Retromandibular vein (posterior branch)** – itself formed by the maxillary and superficial temporal veins, which drain the face.

These two veins combine immediately posterior to the angle of mandible, and inferior to the outer ear, forming the external jugular vein.

After formation, the external jugular vein descends down the neck within the superficial fascia. It runs anteriorly to the sternocleidomastoid muscle, crossing it in an oblique, posterior and inferior direction.

In the root of the neck, the vein passes underneath the clavicle, and terminates by draining into the subclavian vein. Along its route down the neck, the EJV receives tributary veins – posterior external jugular, transverse cervical and suprascapular veins.

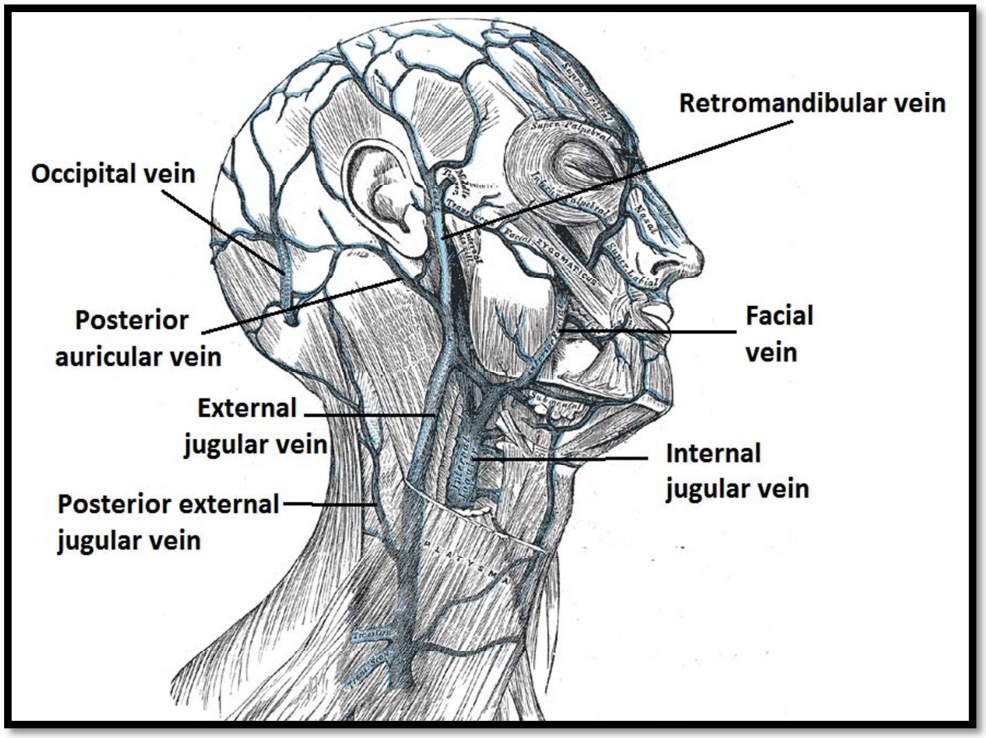


Figure 15[27]: Divisions of External Jugular Vein.

Anterior Jugular Veins

The anterior jugular veins vary from person to person. They are paired veins, which drain the anterior aspect of the neck. Often, they will communicate via a jugular venous arch. The anterior jugular veins descend down the midline of the neck, emptying into the subclavian vein.

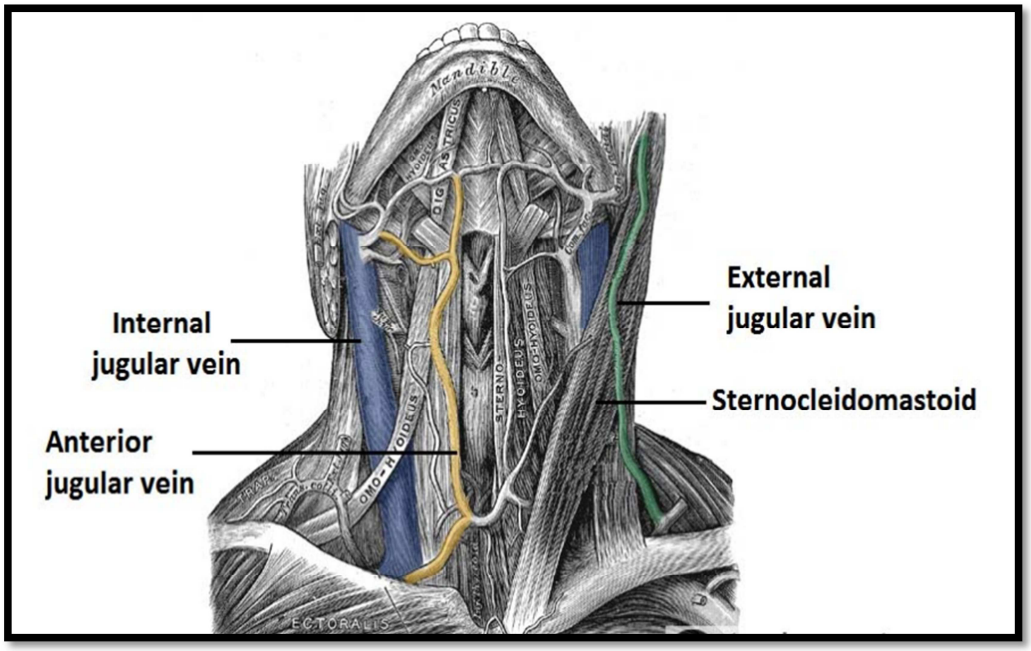


Figure 16[27]: Image showing course of anterior jugular vein.

Internal Jugular Vein

- Largest vein in the neck.
- Drains most of the tissues of the Head and Neck.

Course

1. Direct continuation of the sigmoid sinus. It begins at the jugular foramen and ends behind the sternal end of the clavicle by joining the subclavian vein to form the brachiocephalic vein.

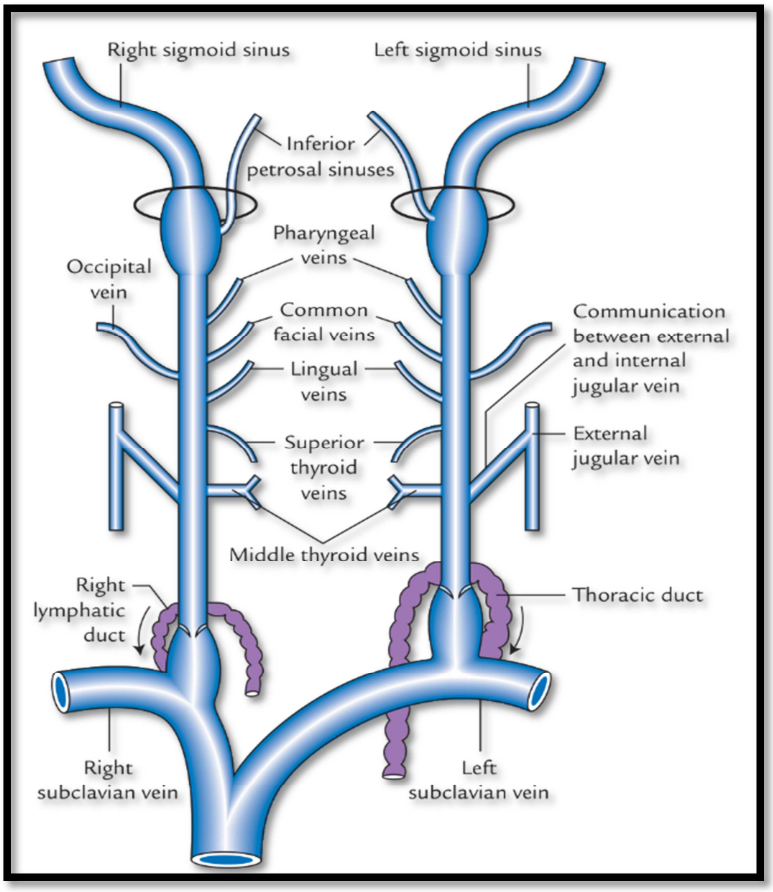


Figure 17[25]: Image showing course of IJV.

1. IJV goes down in carotid sheath in the neck, deep to SCM and lateral to the CCA. It joins the subclavian vein forming brachiocephalic vein.

2. The superior bulb which is a continuation of the sigmoid sinus, is located in the jugular fossa of the temporal bone, inferior to the floor of the middle ear cavity. The terminal point of the vein is the inferior bulb in the supraclavicular fossa

STRUCTURE AND FUNCTION

IJV documented as being two times the diameter of CCA and it has been documented to have normal venous diameter of 9.1-10.2 mm.

It drains skull, brain, face superficially, and major parts of the neck. The blood then is collected by brachiocephalic vein which then drains into right atrium.

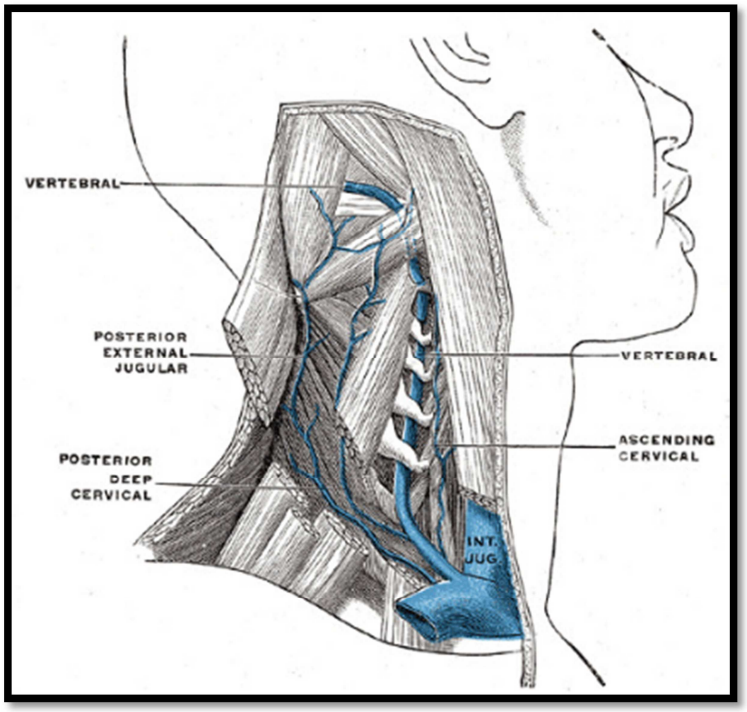


Figure 18[26]: Internal Jugular Vein.

Embryology

In the development of cranium, the early cranial vessels lead to the formation of a primordial channel in the hindbrain that collects blood and drains into precardinal vein. This vein later on develops in the cranial portion into IJV.

Lymphatics

Deep cervical lymph nodes which are present on superficial surface of IJV drain into left thoracic duct which further drains from diaphragm and also the left half of the upper body.

Nerves

The cervical plexus, phrenic nerve and the vagus nerve running medially in the carotid sheath along IJV. Loop of Ansa Cervicalis lying on the superficial lateral aspect of IJV

Muscles

The rectus capitis lateralis, levator scapulae, scalenus medius, and scalenus anterior lie behind IJV with the SCM superficial to it and posterior belly of the digastric and superior belly of the omohyoid muscles crossing over it. As it passes below clavicle SCM and infrahyoid muscles cover it.

Relations

Superficial

1. Sternocleidomastoid
2. Digastric posterior belly
3. Omohyoid superior belly
4. The parotid gland
5. The styloid process

The IXth nerve, Xth nerve, XIth, and XIIth, as well as the ICA.

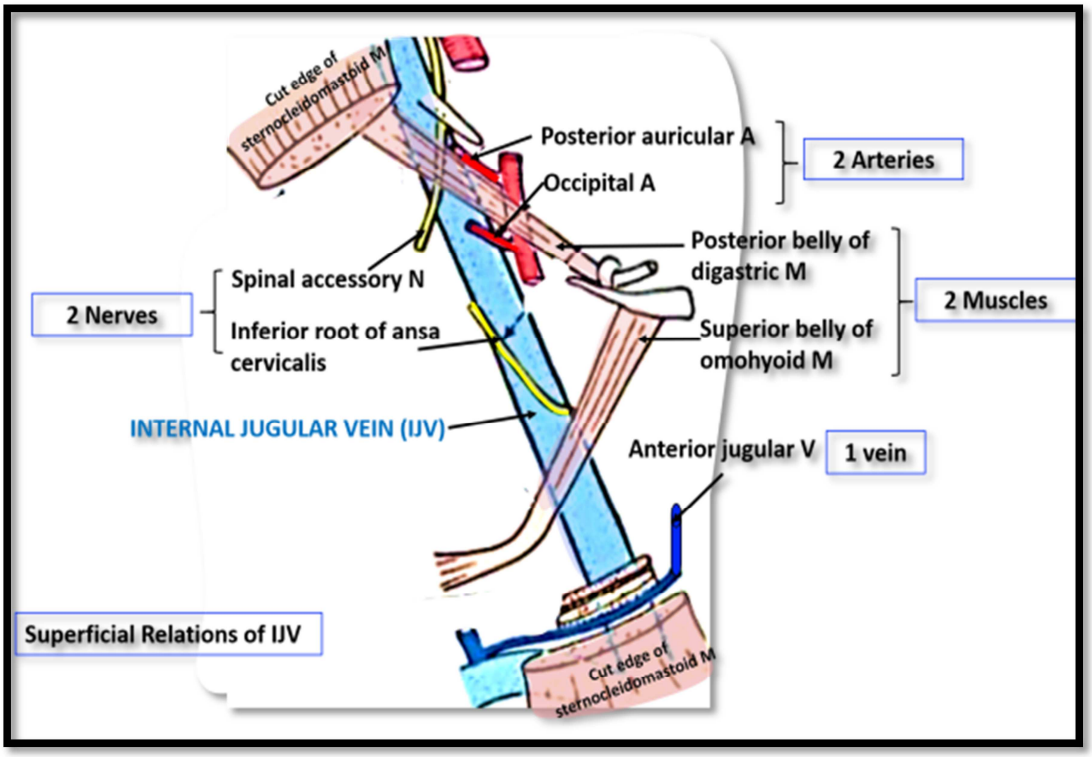


Figure 19[25]: Superficial relations of IJV.

Posterior

1. Transverse process of atlas
2. Cervical plexus
3. Scalenus anterior
4. First part of subclavian artery

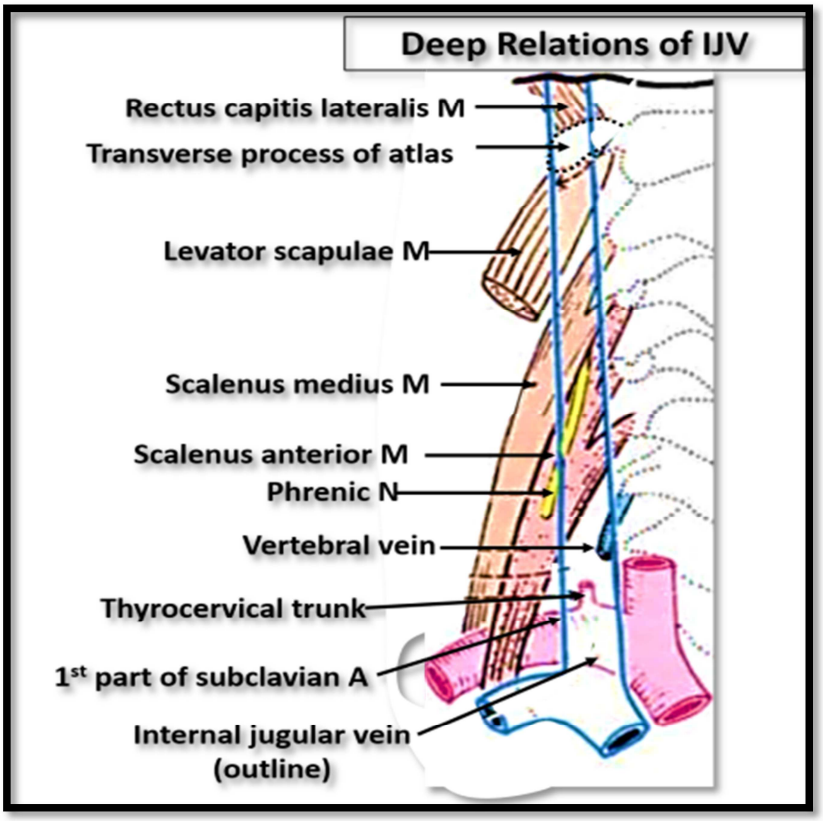


Figure 20[26]: Deep relations of IJV.

Medial

1. Internal carotid artery
2. Common Carotid Artery
3. Vagus nerve

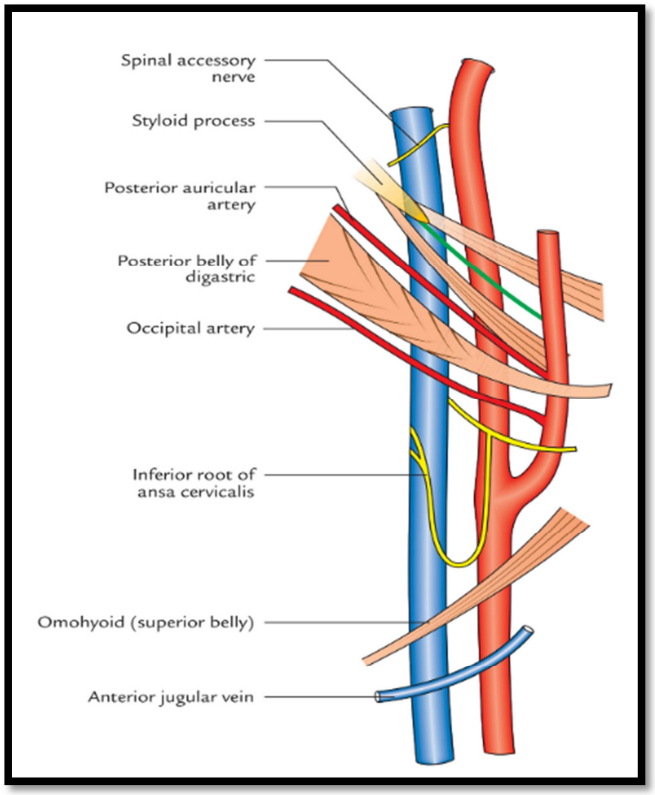


Figure 21[25]: Medial relations of IJV.

Tributaries

1. Inferior petrosal sinus
2. Common facial vein
3. Lingual vein
4. Pharyngeal vein
5. Superior thyroid vein
6. Middle thyroid vein

Special features

1. Presents with two dilations:
    - Firstly, at its commencement, which lies in the jugular fossa of the temporal bone, known as the **superior bulb** and is related to the floor of the middle ear.
    - Second, close to its termination, which lies in the lesser supraclavicular fossa between the sternal and clavicular heads of sternocleidomastoid. It is known as **inferior bulb** and is guarded by a pair of valves.
2. Vertically applied to the lateral side of the internal and common carotid arteries, enclosed with them and the vagus nerve in the facial sheath called **carotid sheath.**
3. The deep cervical lymph nodes lie along its entire course.
4. Constant in position and can be marked on the surface by a vertical line extending from midpoint between the tip of the mastoid process and the angle of the mandible, to the sternoclavicular joint.

BLOOD VESSELS AND VASCULAR VARIATIONS

- **Physiologic Variants**

Like many veins in the body, the internal jugular can have many anatomical variations. Some of the more clinically significant variations include a vein that is significantly smaller than expected or absent altogether.

Anatomical variations of the Internal Jugular Vein.

A) Normal.

B) Duplication.

C) Bifurcation.

D) Fenestration.

E) Posterior tributary.

F) Trifurcation.

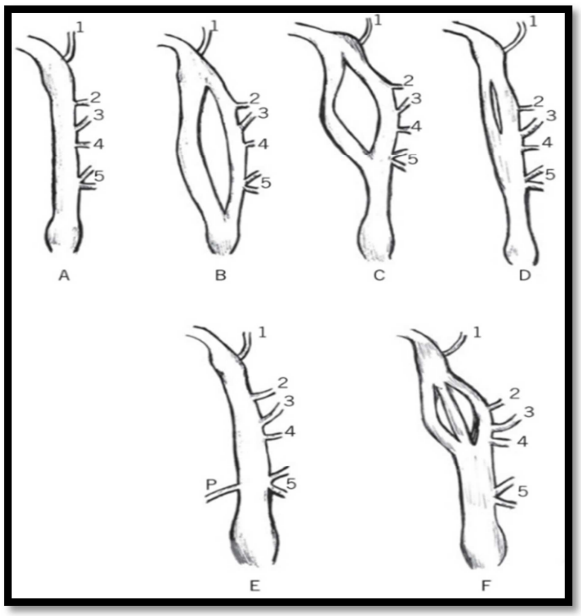


Figure 22[27]:Anatomical variants of Internal Jugular Vein (1. inferior petrosal sinus; 2. pharyngeal vein; 3. common facial vein; 4. lingual vein; 5. thyroid veins; 6. posterior tributary).

- **Internal Jugular Vein Asymmetry**

Asymmetrical almost always. 80% of the population has a larger right IJV. There is crowding of structures in the upper neck which prevents passive venous distension of IJV thus appearance of asymmetry in the Internal Jugular Veins is minimal. Asymmetry is most noticeable on the inferior side, as larger spaces in the neck allow for more passive distension of the veins. The difference can be so great that the vein is mistaken for a vascular mass.

- **Multiple Jugular Veins**

One of the Internal Jugular Veins may have multiple branches. In those cases, the veins further dorsal are typically smaller and may not enhance as well as the large ipsilateral vein on contrast-enhanced images. In such cases, a poorly enhanced vein may be mistaken for adenopathy.

- **Phlebectasia**

A rare venous system condition with a possible congenital cause. Clinically, it appears as a neck mass that expands when a patient performs a Valsalva manoeuvre, speaks, or lies down. Reduces in size when at rest or when sitting upright.

- **Thrombosis**

Infection, surgery, neoplasm, and intravenous drug abuse are all complications of central line placement. It appears enlarged on CT; older clots have lower attenuation than normal vessels. Lemierre's syndrome is defined by the presence of acute pharyngotonsillitis, septic thrombophlebitis of the ipsilateral Internal Jugular Vein, and septicemia with septic emboli, most commonly to the lungs and large joints.

- **Collateral and Pseudolateral veins**

Enhancement of prominent collateral veins bypassing thrombosed IJV via tubular/linear enhancement.

- **The Condylar Vein**

It is a vein connecting sigmoid sinus to suboccipital plexus of veins and is a possible mode of transportation for disease into the cranium.

- **Overlap of veins**

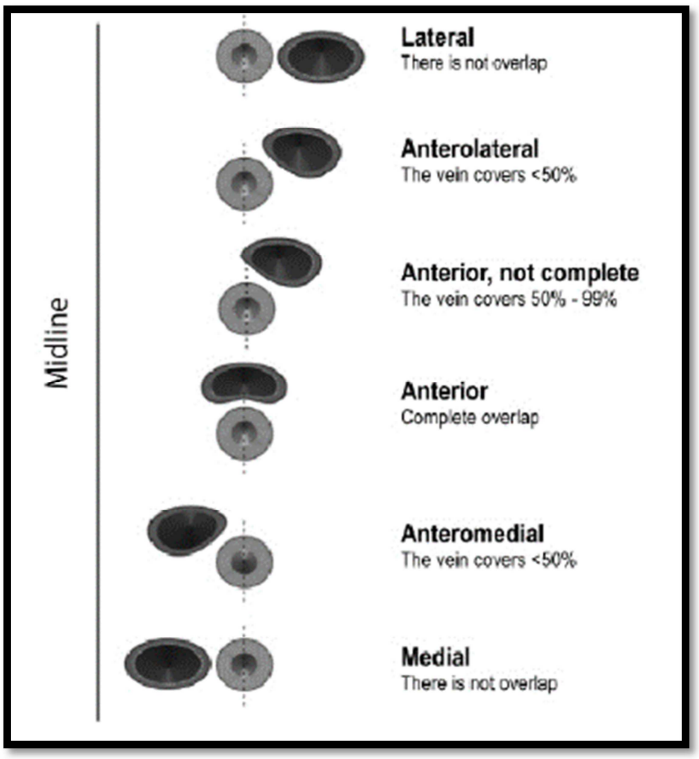


Figure 23[30]: Variations in overlap of IJV with CCA.

There are several types of variations in the overlapping of IJV and CCA as shown in Fig 24 above. The IJV can lie lateral, anterolateral, anterior, anteromedial, or medial to CCA.

IMAGING OF NECK

Imaging of the neck is routinely used at the time of presentation for diagnostic purposes in the patients. The imaging modality of choice depends on the clinical scenario. Knowledge of the normal anatomy as displayed by cross-sectional imaging techniques is helpful to understand the imaging of head and neck. To study the relationship of IJV and CCA the imaging modalities which has been traditionally used in the Ultrasonogram of the neck and recently Contrast enhanced computed tomography (CECT).

ULTRASOUND NECK

It is an imaging modality using high frequency sound. The probes contain piezoelectric crystals generating pulsed beams of sound in response to either mechanical or electrical stimuli. They also receive reflected beam which has been attenuated and refracted by tissue surfaces. Recent advances with high resolution USG have greater role to play in USG of the neck. It is ideal to evaluate the superficial structure of neck but due to attenuation of sound beam as it passes through tissues examination of large and deep neck structures are difficult. It does not penetrate bone, cartilage, and gas, making it an inappropriate technique for many primary head and neck cancers. It is useful in differentiating solid and cystic lesions and to detect calcification. Size, margin and consistency of the neck mass can be made out. Colour flow and doppler USG is used to evaluate the vessels within the neck, the relationship of masses to the major vascular structures and vascularity within masses and neck nodes can be evaluated. Although it has been seen that using ultrasonography to study the relationship of IJV to CCA shows IJV to assume a more anterior position as shown in Fig 25[28]. Ultrasonography is also used in the FNAC of small masses and nodes and to increase accuracy of core biopsy.

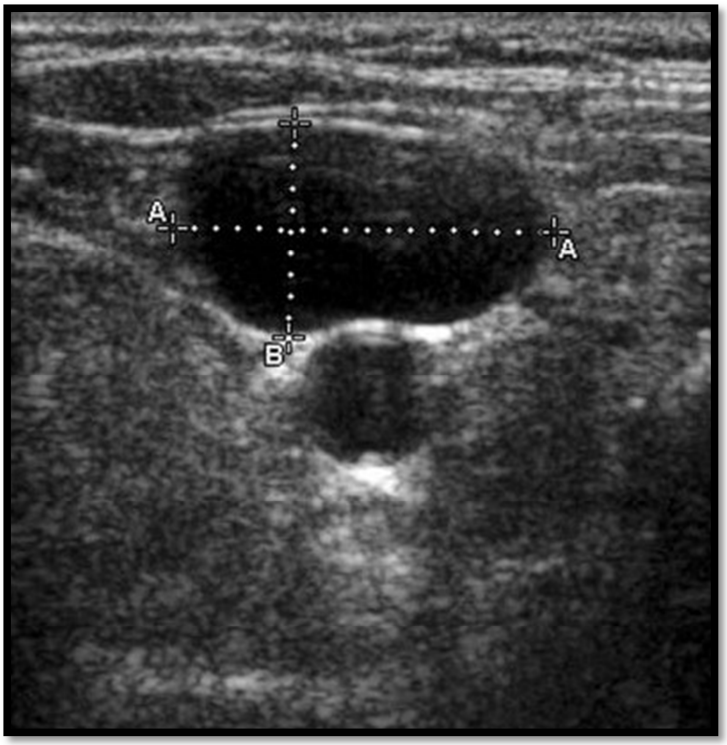


Figure 24[28]: Ultrasonographic image showing the relationship of IJV with CCA.

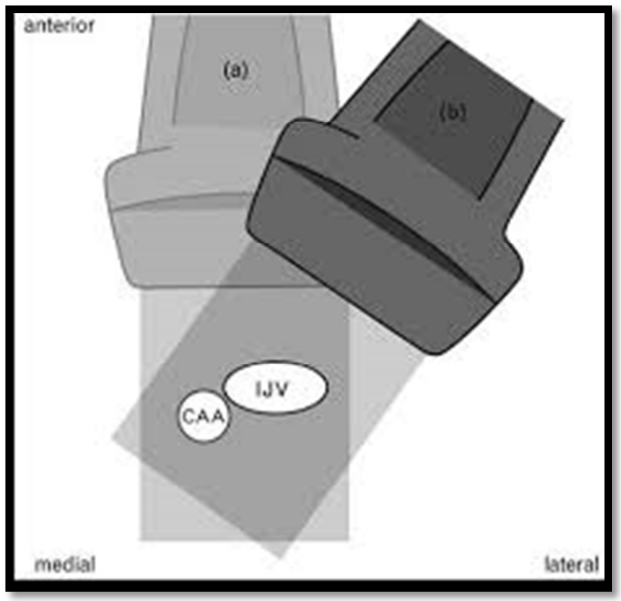


Figure 25[28]: The anatomical relationship of the right internal jugular vein (IJV) to the common carotid artery is depicted schematically (CCA).

CONTRAST ENHACED CT

CT uses ionizing radiation. Recent advances in CT uses multislice helical scanners that acquires 4, 16, 32 and 64 slices. Such scanners rapidly acquire images thus there is decreased movement and artefact. Iodinated contrast medium is administered to opacification of vessels, enhancement of the tumor and nodal rim enhancement.

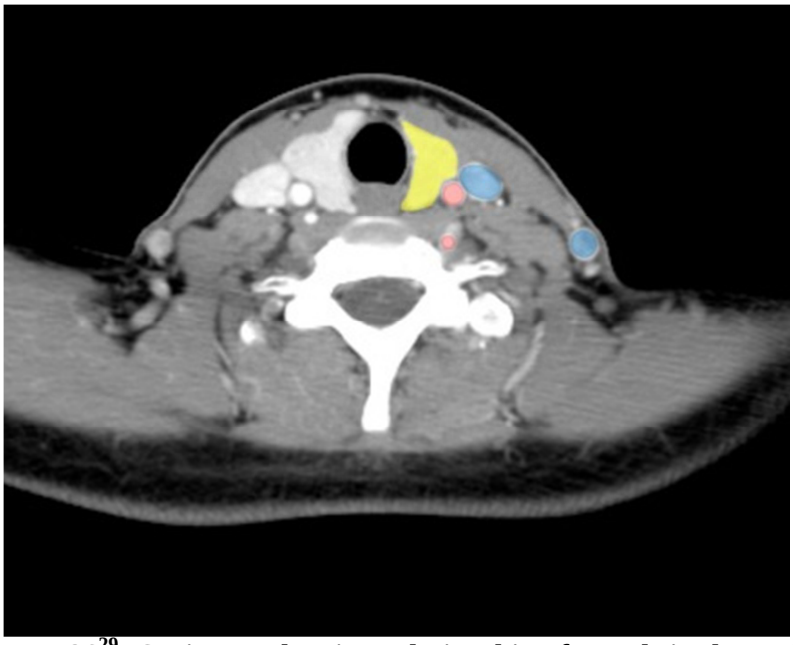


Figure 26[29]: CT image showing relationship of vessels in the neck.

We can evaluate bony structures and calcifications with superior multiplanar reconstructions. It is also easier to evaluate CT images than MR images.

ADVANTAGES

- Fast imaging
- Detailed cross-sectional images
- Good bony details
- Detect occult metastasis
- Multiplanar reconstructions
- Aids in Radiotherapy planning
- Less artifacts

DISADVANTAGES

- Radiation exposure
- Relatively expensive
- Poor soft tissue contrast
- Artifact due to dental fillings
- Underestimating ulcerative and proliferative lesions
- Overestimating tumor extent due to inflammation/edema & distortion of adjacent normal structures
- Contraindicated in allergy to contrast media, kidney failure

CLINICAL CORRELATION

1. The IJV is a guide for oncosurgeons while removing of deep cervical lymph nodes. It is a useful landmark when removing jugulodigastric and upper anterior group of deep cervical LNs.
2. Malignant and tuberculous LNs often get adhered to the IJV and the surgeon must resect a portion of the vessel while removing the nodes.
3. Central venous catheter insertion frequently involves the IJV. The variations of IJV along the major neck vessels may be to blame for unsuccessful cannulation attempts or iatrogenic arterial damage.
4. Trauma: IJV runs superficially in the neck and has no covering of bone or cartilage. It is easily vulnerable to blunt or penetrating trauma because it is located beneath the sternocleidomastoid muscle. A vein injury carries a danger of air embolism as well as substantial haemorrhage.
5. IJV is used as site for cannulation to provide total parenteral nutrition, temporary haemodialysis and also administration of chemotherapy.

Thus, a thorough anatomical knowledge can help a surgeon navigate through such clinical scenarios which render the IJV and CCA susceptible to damage. A CT study preoperatively can help predict the relationship of IJV with CCA and prevent inadvertent outcomes intraoperatively.

Our study attempts to not only find out the relationship of the IJV to CCA but also its relation at simulated neck rotation at 15, 30 and 45 degrees respectively.

MATERIALS AND METHODS

Type of Study & Source of Data: Observational study amongst the patients undergoing computed tomography of the neck at the Department of Radiology, KLES Dr. Prabhakar Kore Hospital & Medical Research Centre, Belagavi between 1st January 2021 to 31st December 2021 over a period of one year.

METHODS

Study design: A hospital based one-year observational Study.

Study Period: January 2021 to December 2021

Study population: Patients of both sexes between the age group of 18-60 years who are undergoing CT scan of the Neck in KLES Dr. Prabhakar Kore Hospital & Medical Research Centre.

INCLUSION CRITERIA: Patients of both sexes between the age group of 18-60 years who are undergoing CECT scan of Neck.

EXCLUSION CRITERIA: The following patients are excluded from the study:

- Patients with neck masses.
- Patients with previous neck dissections.
- Patients with prior history of radiotherapy.

SAMPLE SIZE

Sample size formula: The minimum sample size formula based on prevalence rate is

$$n = \frac{z^2 P(1-P)}{d^2}$$

where P is the percentage of prevalence and d is the percentage likely difference in the prevalence.

$z\alpha$ is linked with the level of significance. For 5% level of the significance $z\alpha = 1.96$.

With P = 54.3% [3] and d = 25% of P = 13.58%, the sample size is **52**.

METHODOLOGY

- After taking informed consent from the patient, their details and a thorough clinical history were obtained for compliance with inclusion and exclusion criteria.
- All patients were clinically examined including general physical examination and careful examination of the ear, nose and throat.
- The patient then underwent CT scan of the neck in the Department of Radiology at KLES Dr. Prabhakar Kore Hospital. Subjects were examined by CT imaging while in the supine position with a neutral head position and without a supportive head pillow.
- The RadiAnt DICOM viewer was used to view CT scans and evaluate CT images at the level of the cricoid cartilage, which corresponds to the central approach (the apex of the triangle formed by the medial and lateral portions of the sternocleidomastoid muscle and clavicle), or the anterior approach (at

the level of the cricoid cartilage along the medial edge of the sternocleidomastoid muscle) for venous puncture. The CCA was used as the reference for estimating the IJV location; this was recorded as lateral, anterior, medial, or posterior using a segmented grid.

- Measurements were taken by using computer-generated scales and the values were recorded. The centers of the IJV and CCA was defined as the intersection of the transverse and vertical diameters of each vessel. The center of the CCA was taken as a reference point for defining the location of the IJV, and an imaginary line was drawn from this point towards the center of the IJV. The location of each IJV was estimated using a clockwise or counter-clockwise rotation relative to the CCA at the center.

- Angles were measured and recorded as medial, anteromedial, anterior, anterolateral, lateral, posterolateral, posterior, or posteromedial by using a segmented grid.

- Thereafter, the degree of overlap (%) between the IJV and the CCA was calculated.

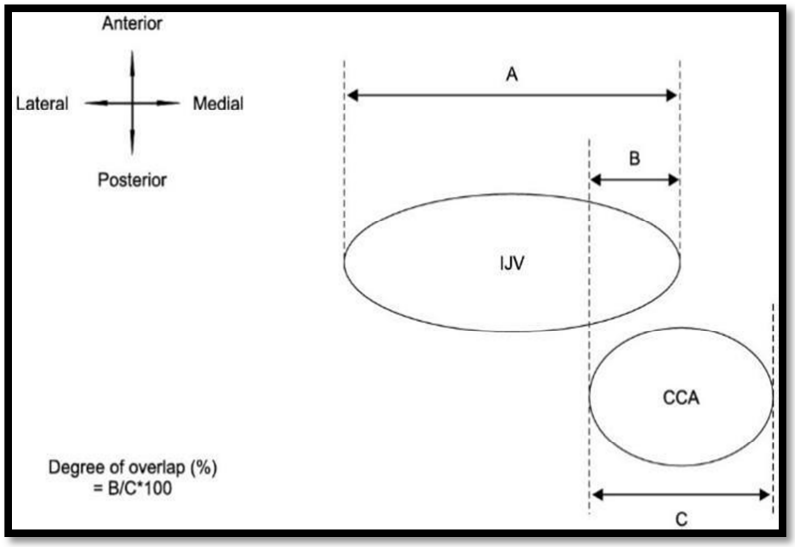


Figure 28 : Courtesy - Anatomical relationship of the internal jugular vein and the common carotid artery in Korean: A computed tomographic evaluation. Anesth Pain Med. 2015;10(2):118- 123)

(Simplified cross-sectional diagram of the right neck shown by CT image at the level of the cricoid cartilage. The percent overlap is an overlap diameter (B) of the internal jugular vein (IJV) divided by the transvers diameter (C) of the common carotid artery (CCA). A: transverse diameter of IJV, B: The overlap distance from the lateral wall of CCA to the medial wall of IJV, C: transverse diameter of the common carotid artery.

- Degree of overlap expressed as B/C × 100.
- In addition, the locational changes of the IJV and degree of overlap will be calculated according to the SR15, SR30 and SR45 in order to assess the influence of simulating body rotation on the position of the IJV.

STATISTICAL ANALYSIS

Statistical Analysis was done using SPSS software. Since the study is of observational study the plan of analysis will be as follows:

- For the continuous quantitative variables mean and standard deviation was calculated.
- For the purpose of comparison, the data was divided into two groups with respect to certain qualitative characteristic, the continuous variables were compared using suitable tools of statistics like student's unpaired t test. The values were evaluated using student's paired t test.
- Discrete variables were represented by median. The categorical data was expressed in terms of rates, ratios and percentages. The association between the outcome, clinical and demographic characteristics will be tested using Chi-square test, test of proportion or Fisher's exact test.
- For discrete variables non- parametric tests will be used. Apart from the above suitable tools like ANOVA, correlation, regression etc., will be used according to the need.
- Suitable graphs will be used to depict the comparison. For all the tests the value of p less than 5% (0.05) will be considered significant.

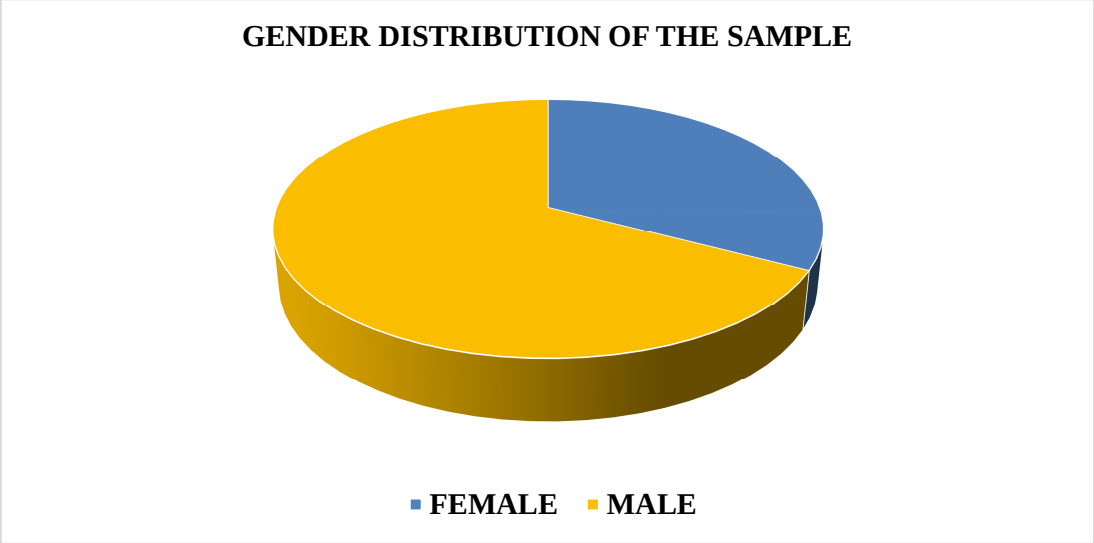
RESULTS

Table 1: Gender wise distribution of cases

GENDER	NUMBER	%
FEMALE	17	33.33
MALE	35	68.63
TOTAL	52	100.00

Among the study population of 52 cases, 17(33.33%) cases were females and 35(68.63%) of them were males.

Graph 1: Pie Chart for distribution of cases based on gender



Pie chart distribution showing gender distribution among the cases with 33.33% being females and 68.63% being males.

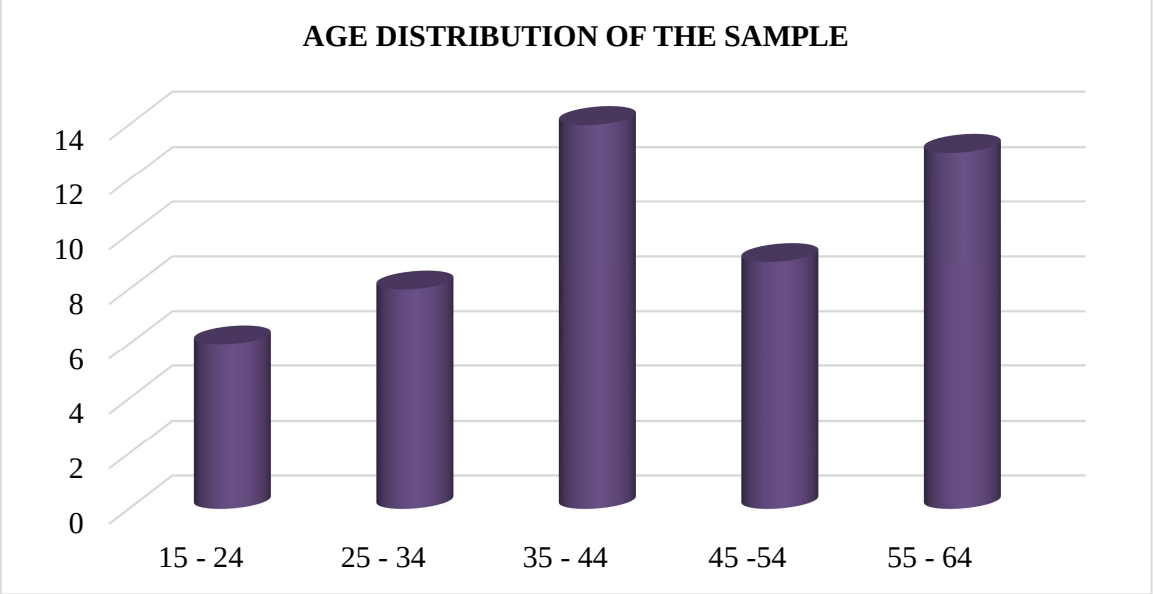
Table 2: Age wise distribution of cases

AGE	NUMBER	%
15 – 24	6	11.76
25 – 34	8	15.69
35 – 44	13	25.49
45 -54	9	17.65
55 – 64	11	21.57
65 – 74	4	7.84
TOTAL	51	100.00

In this study population, the mean age was 43.8

Among the study population, 6 cases were aged less than 25 years (11.76%), 8 cases between 25 to 35 years (15.69%), 13 cases were aged between 35 to 45 years (25.49%), 9 cases were aged between 45 to 55 years (17.65%), 11 cases were between 55 and 65 years (21.57%) and 4 were above 65 years (7.84%).

Graph 2: Bar graph showing age wise distribution of cases



On plotting the age distribution of samples there was a concentration of the samples between the ages of 35-44 followed by 55-64 years.

Table 3: Chart showing relationship of IJV with CCA

ANGLES	MEAN	S.D.	MIN	MAX
ANGLE AT 0 (Rt.)	83.21	25.38	49	142.6
ANGLE AT 0 (Lt.)	81.41	25.51	44.2	173.4
ANGLE 15 (Rt.)	83.21	24.29	37.7	140.3
ANGLE 15 (Lt.)	83.75	24.18	45.1	131
ANGLE 30 (Rt.)	82.06	25.96	0	137
ANGLE 30 (Lt.)	80.79	23.23	47.2	135.6
ANGLE 45 (Rt.)	82.68	23.42	49.1	136
ANGLE 45 (Lt.)	82.86	24.58	45	135.4

104 Internal Jugular Veins were evaluated and their relationship with respect to Common Carotid artery was evaluated and recorded as lateral, anterior, medial or posterior using a segmented grid. On the right-side angulation of IJV with CCA was 83.21 at 0, 83.21 at 15 degrees, 82.06 at 30 degree and 82.68 degree at 45-degree neck rotation respectively. On the left side angulation of IJV with CCA was 81.41 at 0, 83.75 at 15 degrees, 80.79 at 30 degree and 82.86 degree at 45-degree neck rotation respectively.

Graph 3: Angulation of IJV with CCA at supine, 15-, 30- and 45-degree rotation respectively.

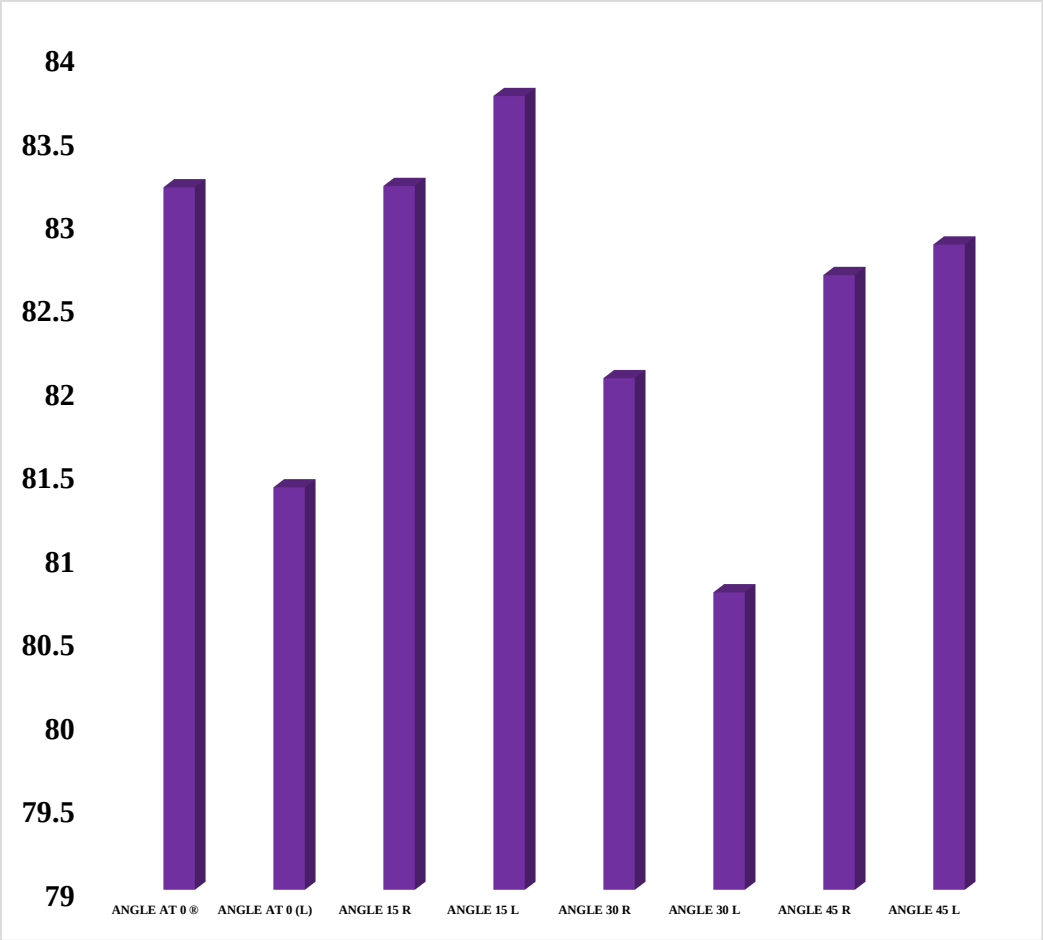


Table 4: Change in angulation of IJV with CCA on simulated neck rotation

Position	0	15	30	45
Anterior	0	0	1	0
Anterolateral	42	46	41	41
Lateral	39	32	40	41
Posterolateral	22	26	22	22
Posterior	1	0	0	0
TOTAL	104	104	104	104

Prior to simulating rotation, the IJV was Anterolateral (42%), Lateral (39%), Posterolateral (22%), Posterior (1%) and post 15-degree rotation they shifted to Anterior (4%), Anterolateral (32%), Lateral (60%), Posterolateral (6%), Posterior (2%); post 30-degree to Anterior (1%), Anterolateral (41%), Lateral (40%), Posterolateral (22%) and after 45-degree rotation to Anterolateral (41%), Lateral (41%) and Posterolateral (22%).

Table 5: Relationship of IJV with CCA at neutral position

Position	Right (0)	Left (0)	Total	p VALUE
Anterior	0	0	0	0.6805
Anterolateral	22	20	42	
Lateral	18	21	39	
Posterolateral	12	10	22	
Posterior	0	1	1	
TOTAL	52	52	52	

At supine position, there were 22 arteries were Anterolateral, 18 were Lateral, 12 were Posterolateral. On the left side, 20 were Anterolateral, 21 were Lateral, 10 were Posterolateral and only 1 was Posterior to the CCA. The p value was 0.6805 which was non-significant showing that there was not significant difference between the arteries on left side and right side of neck.

GRAPH 4: Relationship of IJV with CCA at neutral position

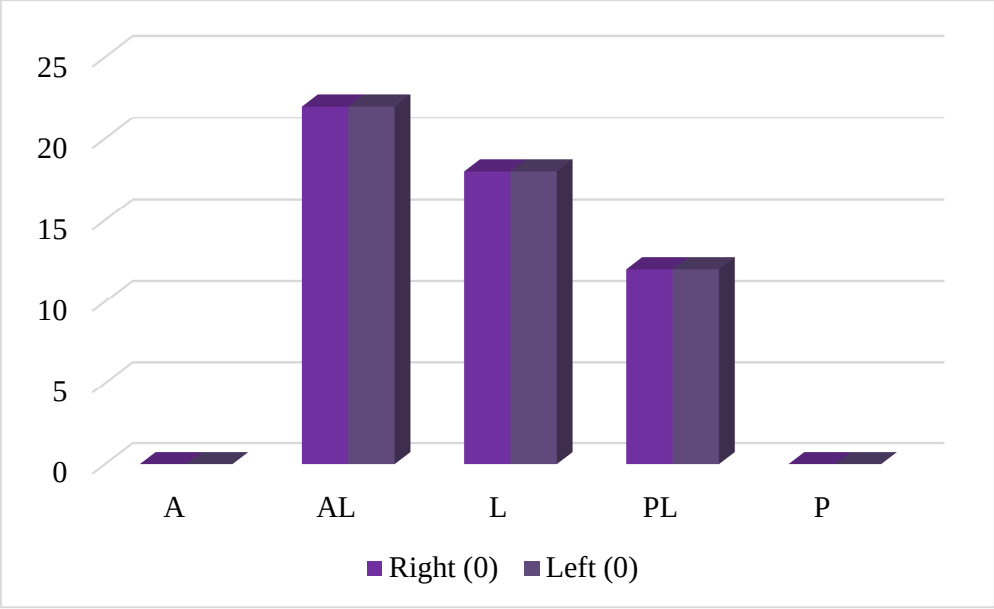


Table 6: Change in angulation of IJV with CCA on simulated neck rotation to 15-degrees

Position	ANGLE 15 R	ANGLE 15 L	Total	p VALUE
Anterior	0	0	0	0.8699
Anterolateral	23	23	46	
Lateral	17	15	32	
Posterolateral	12	14	26	
Posterior	0	0	0	
TOTAL	52	52	104	

After simulating 15-degree neck rotation, 23 IJVs were Anterolateral, 17 were Lateral, 12 were Posterolateral. Whereas on the left side, 23 were Anterolateral, 15 were Lateral and 14 were Posterolateral to CCA. The p value was 0.8699 which was non-significant showing that there was not significant difference between the arteries on left side and right side of neck.

GRAPH 5: Relationship of IJV with CCA after 15-degree rotation

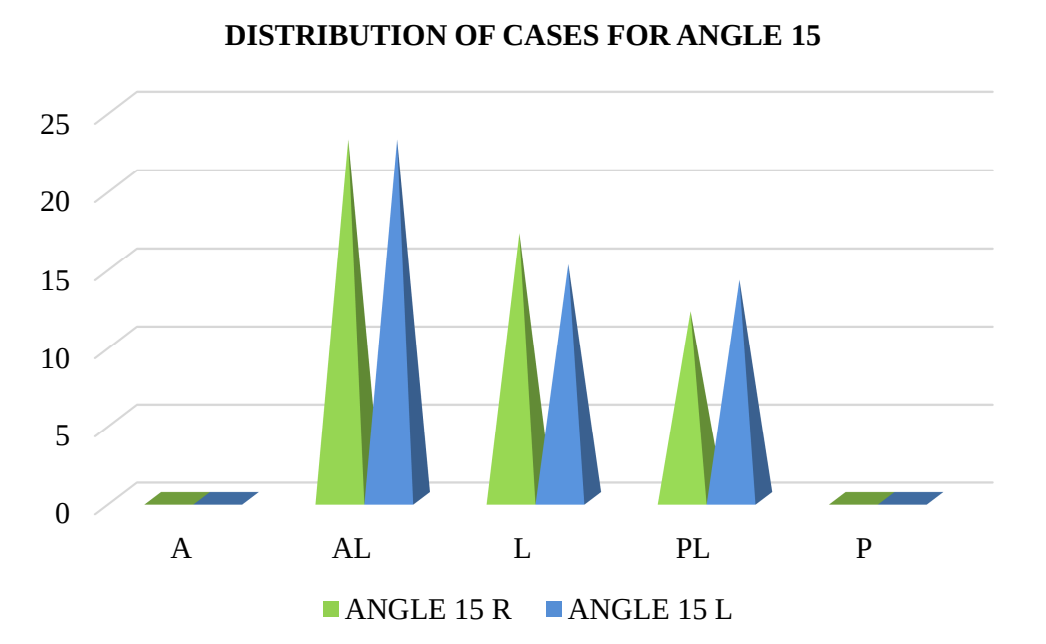


Table 7: Change in angulation of IJV with CCA on simulated neck rotation to 30-degrees

Position	ANGLE 30 R	ANGLE 30 L	Total	p VALUE
Anterior	1	0	1	0.6580
Anterolateral	21	20	41	
Lateral	18	22	40	
Posterolateral	12	10	22	
Posterior	0	0	0	
TOTAL	52	52	104	

After simulating 15-degree neck rotation, 23 IJVs were Anterolateral, 17 were Lateral, 12 were Posterolateral. Whereas on the left side, 23 were Anterolateral, 15 were Lateral and 14 were Posterolateral to CCA. The p value was 0.6580 which was non-significant showing that there was not significant difference between the arteries on left side and right side of neck.

Graph 6: Relationship of IJV with CCA after 30-degree rotation

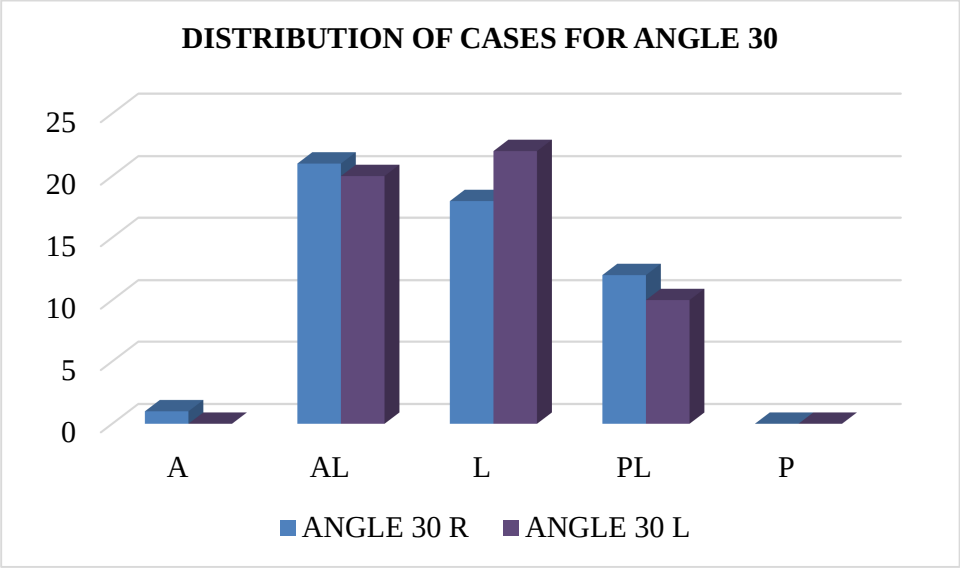


Table 8: Change in angulation of IJV with CCA on simulated neck rotation to 45-degrees

Position	ANGLE 45 R	ANGLE 45 L	Total	p VALUE
Anterior	0	0	0	0.8911
Anterolateral	21	20	41	
Lateral	21	20	41	
Posterolateral	10	12	22	
Posterior	0	0	0	
TOTAL	52	52	104	

After simulating 45-degree neck rotation, 21 IJVs were Anterolateral, 21 were Lateral, 10 were Posterolateral. Whereas on the left side, 20 were Anterolateral, 20 were Lateral and 12 were Posterolateral to CCA. The p value was 0.8911 which was non-significant showing that there was not significant difference between the arteries on left side and right side of neck.

Graph 7: Relationship of IJV with CCA after 15-degree rotation

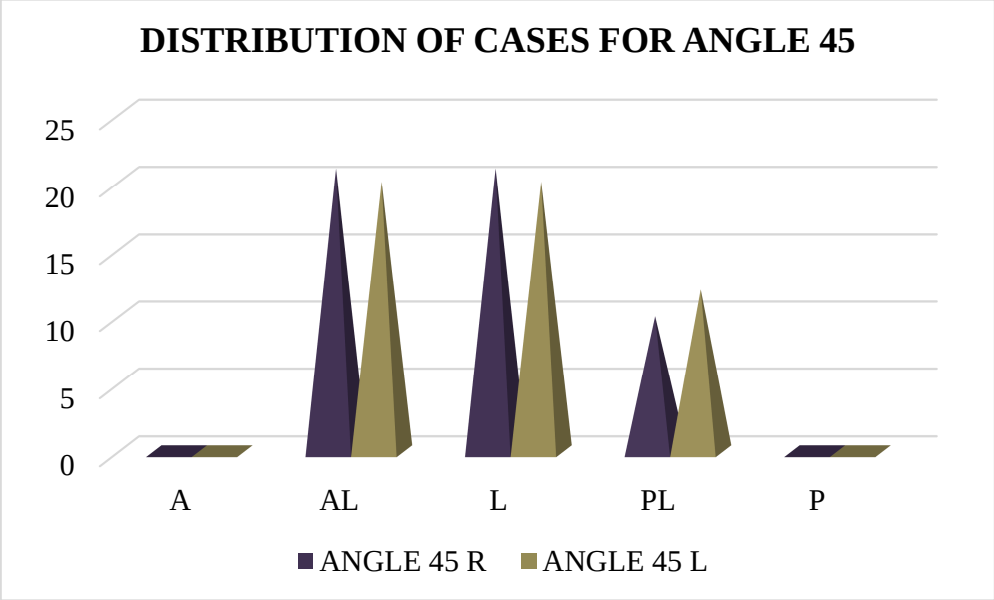


Table 9: Overlap of IJV with CCA at neutral position

Position	OVERLAP 0 DEGREE ®	OVERLAP 0 DEGREE(L)	Total	p VALUE
0	4	5	9	0.9763
0-25	16	17	33	
26-50	31	29	60	
51-75	1	1	2	
>75	0	0	0	
TOTAL	52	52	104	

At supine position 4 arteries showed no overlap, 16 arteries showed overlap between 0-25, 31 showed overlap between 25-50 and only 1 showed between 50-75%. On the left side, 5 IJVs showed no overlap with CCA, 17 showed overlap between 0-25, 29 showed overlap between 25-50, 1 between 50-75%. The p value was 0.9763 which was non-significant showing that there was not significant difference between the arteries on left side and right side of neck.

Graph 8: Overlap of IJV with CCA at neutral position.

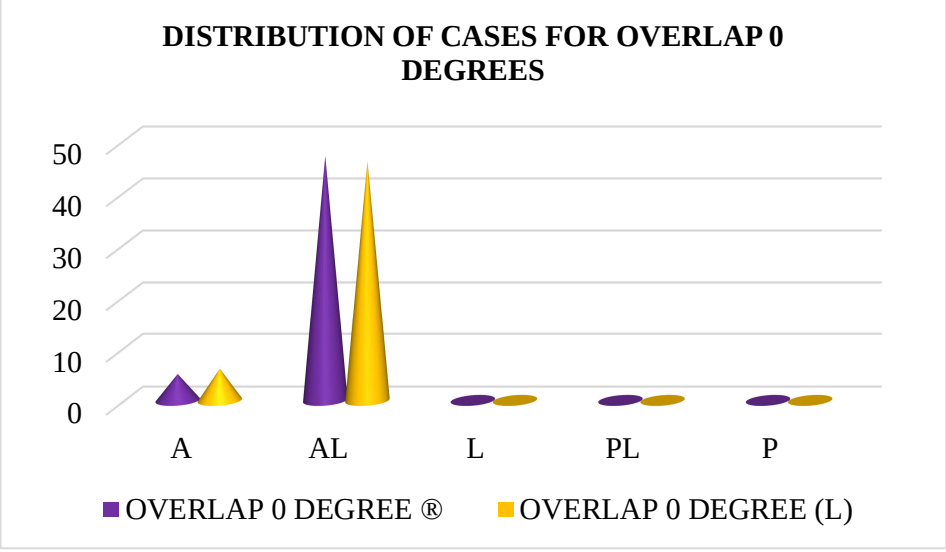


Table 10: Overlap of IJV with CCA after simulated rotation to 15-degrees

Position	OVERLAP 15 R	OVERLAP 15 L	Total	p VALUE
0	0	4	4	0.2814
0-25	15	17	32	
26-50	32	28	60	
51-75	4	2	6	
>75	1	1	2	
TOTAL	52	52	104	

After simulating 15-degree neck rotation 15 arteries showed overlap between 0-25, 32 showed overlap between 25-50, 4 showed between 50-75 and one artery showed overlap more than 75%. On the left side, 4 IJVs showed no overlap with CCA, 17 showed overlap between 0-25, 28 showed overlap between 25-50, 2 between 50-75 and 1 showed overlap more than 75%. The p value was 0.2814 which was non-significant showing that there was not significant difference between the arteries on left side and right side of neck.

Graph 9: Overlap of IJV with CCA after 15 degree rotation.

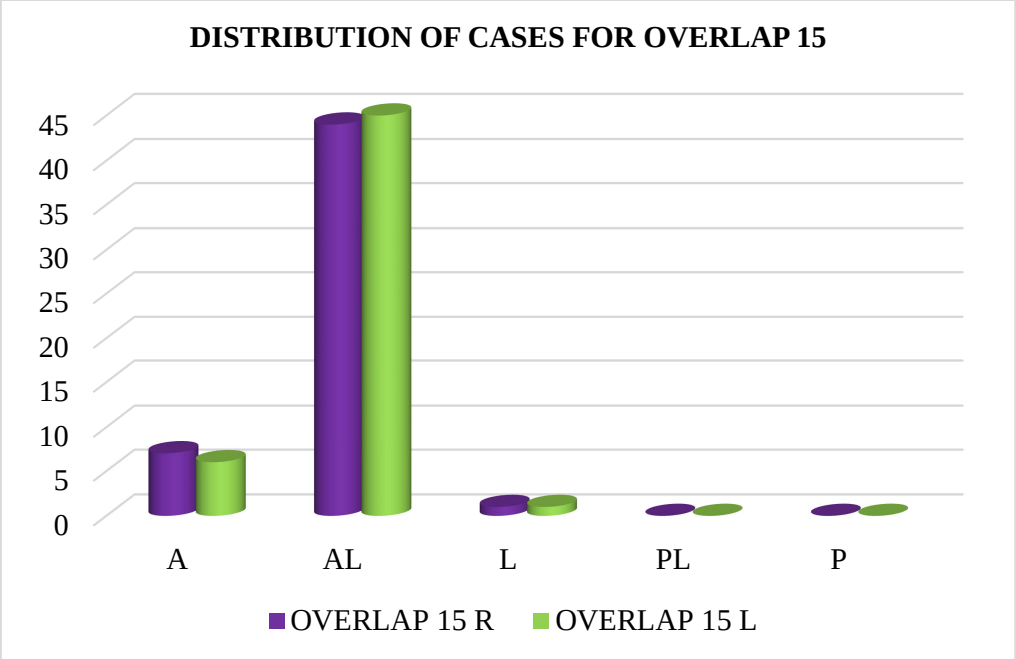


Table 11: Overlap of IJV with CCA after simulated rotation to 30-degrees

Position	OVERLAP 30 R	OVERLAP 30 L	Total	p VALUE
0	2	2	4	0.1655
0-25	6	16	22	
26-50	35	25	60	
51-75	6	7	13	
>75	3	2	5	
TOTAL	52	52	104	

After simulating 30-degree neck rotation 2 arteries showed no overlap, 6 arteries showed overlap between 0-25, 35 showed overlap between 25-50, 6 showed between 50-75 and three arteries showed overlap more than 75%. On the left side, 2 IJVs showed no overlap with CCA, 16 showed overlap between 0-25, 25 showed overlap between 25-50, 7 between 50-75 and 2 showed overlap more than 75%. The p value was 0.1655 which was non-significant showing that there wasn't significant difference between the arteries on left side and right side of neck.

Graph 9: Overlap of IJV with CCA after 30 degree rotation.

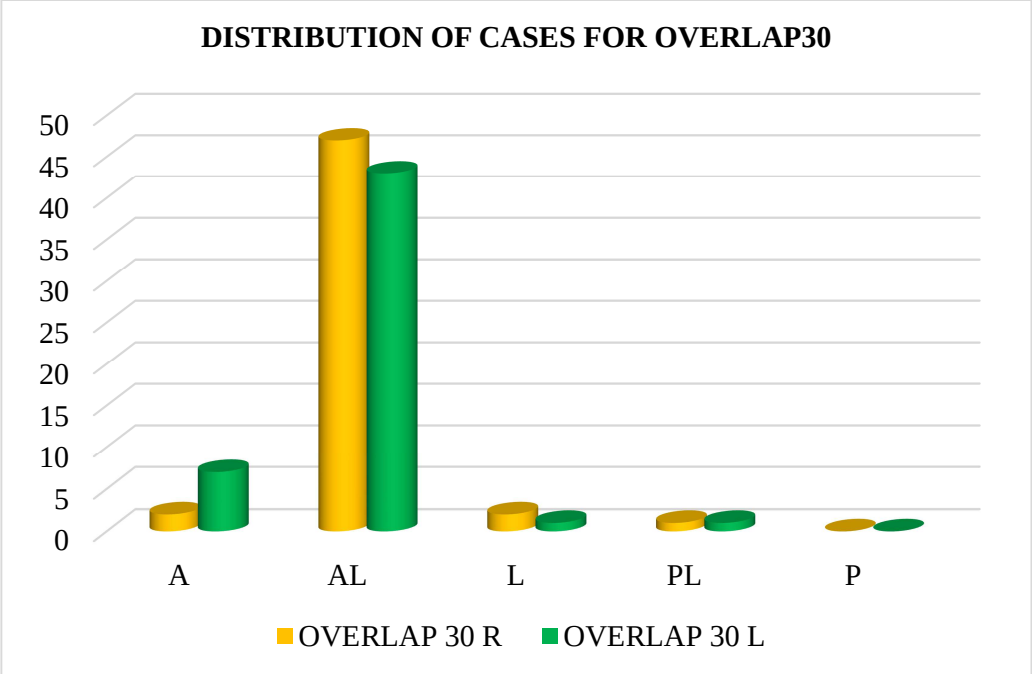


Table 12: Overlap of IJV with CCA after simulated rotation to 45-degrees

Position	OVERLAP 45 R	OVERLAP 45 L	Total	p VALUE
0	1	5	6	0.2514
0-25	12	18	30	
26-50	29	22	51	
51-75	6	4	10	
>75	4	3	7	
TOTAL	52	52	104	

After simulating 45-degree neck rotation 1 artery showed no overlap, 12 arteries showed overlap between 0-25, 29 showed overlap between 25-50, 6 showed between 50-75 and four arteries showed overlap more than 75%. On the left side, 5 IJVs showed no overlap with CCA, 18 showed overlap between 0-25, 22 showed overlap between 25-50, 4 IJVs between 50-75 and 3 IJVs showed overlap with CCA more than 75%. The p value was 0.2514 which was non-significant showing that there was not significant difference between the arteries on left side and right side of neck.

Graph 9: Overlap of IJV with CCA after 45 degree rotation.

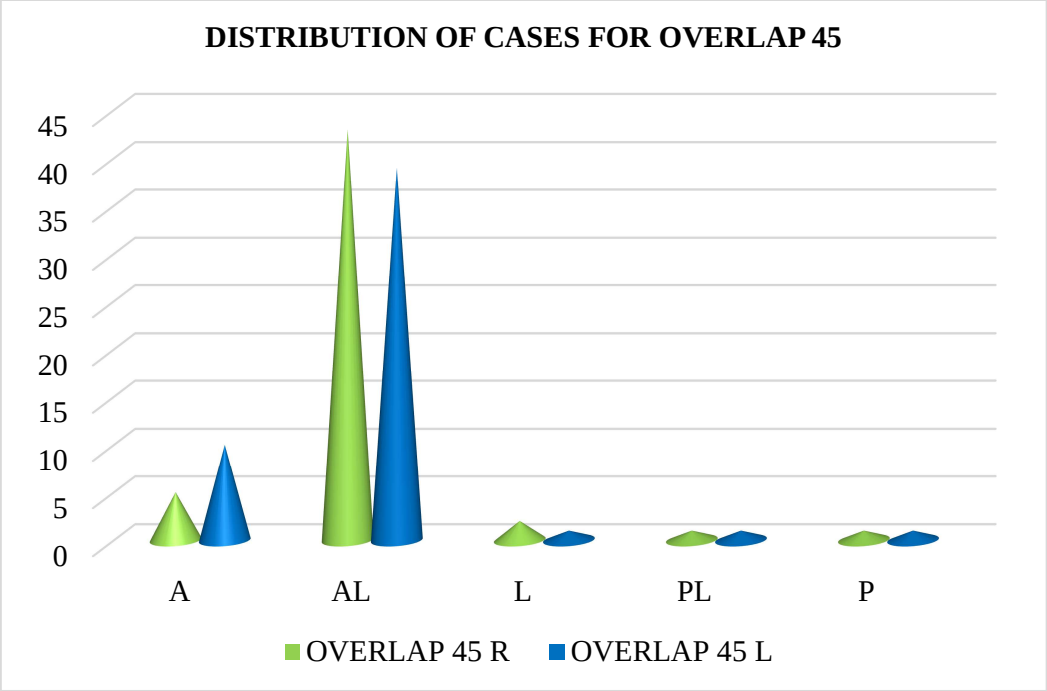
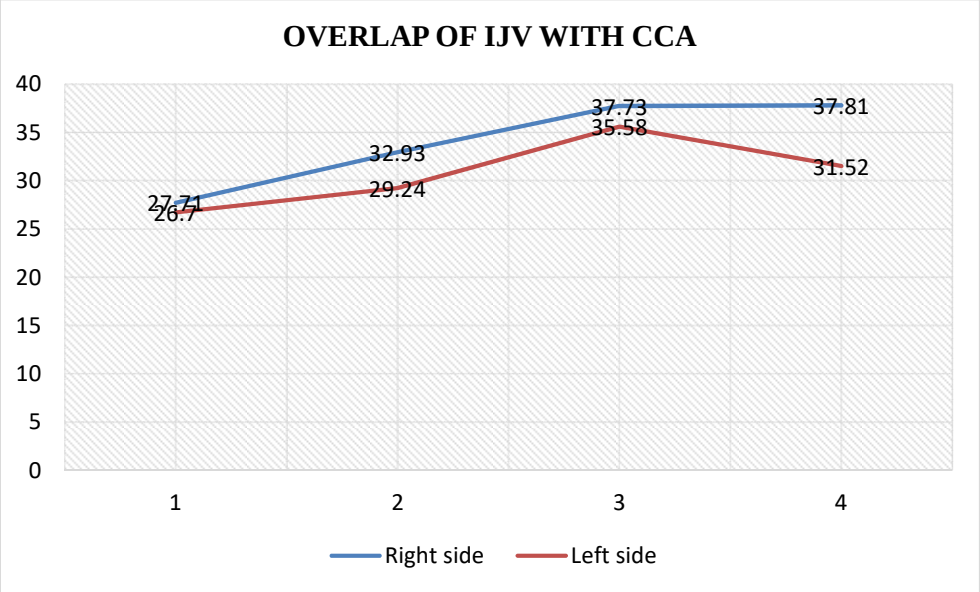


Table 13: Chart showing mean overlap of IJV and CCA with simulated neck rotation at 0, 15, 30 and 45 degrees

ANGLE	MEAN	S.D.	MIN	MAX
OVERLAP 0 DEGREE (R)	27.71	12.07	0	53.2
OVERLAP 0 DEGREE (L)	26.70	12.98	0	67
OVERLAP 15 R	32.93	17.01	10.2	114.2
OVERLAP 15 L	29.24	17.47	0	107.4
OVERLAP 30 R	37.73	19.94	0	111.3
OVERLAP 30 L	35.58	28.22	0	175.89
OVERLAP 45 R	37.81	24.40	0	142
OVERLAP 45 L	31.52	29.33	0	177.57

The mean overlap was calculated at 0, 15, 30 and 45 degrees of neck rotation and on the right side it was 27.7 at 0 degree, 32.93 at 15 degrees, 37.73 at 30 degree and 37.81 at 45-degree neck rotation. On the left side it was 26.7 at 0 degree, 29.24 at 15 degrees, 35.58 at 30 degree and 31.52 at 45-degree neck rotation.

Graph 10: Line graph showing increasing overlap of Internal Jugular Vein and Common Carotid Artery with simulated neck rotation at 0, 15, 30 and 45 degrees respectively.



With increasing simulated neck rotation to the right increased overlap of IJV and CCA was seen, with increase in overlap from 27.71 at 0 degree, 32.93 at 15 degrees, 37.73 at 30 degree and 37.81 at 45 degrees and on the left from 26.70 at 0 to 29.24 at 15 degree, 35.58 at 30 degree and 31.52 at 45 degrees rotation respectively. Therefore, there is a significant increase in overlap of the IJV and the CCA with simulated neck rotation which should be taken into consideration.

DISCUSSION

To reduce surgical errors and intraoperative difficulties, it is crucial for a surgeon to be aware of the anatomical relationships and variances between the IJV and CCA.

IJV anatomically sits lateral to the CA when the neck is in the midline, according to traditional descriptions. This anatomical relationship illustrates how these structures are related when the head is supine and not when rotation of the head has been done to the opposite side during cannulation. With increased rotation, the IJV has been described to assume a more anterior position thereby overlapping the CCA and leading to an increased risk of CCA puncture.[21]

The present study was done using simulated rotation in computed tomography which not only rendered the study easier but also did away with the discrepancy caused by ultrasound studies. Lim et al, found CT scanning not only delineates the anatomy of IJV but can also be used to study the relationship of IJV with CCA and find variations in the intervarying relationship.[22]

For our study we used the CCA as the reference point. Metz et al. noted that the relationship of IJV and CCA was constant as IJV was frequently observed to be lateral to the CA and suggested the usage of CCA as a reference point.

The present study found the IJV mostly in the lateral compartment (Mean: 83.21 degrees) relative to CCA with 18 in the lateral position, 22 in the anterolateral compartment and 12 in the posterolateral compartment. It was in line with other studies done as by Lim CL et al. who found that using the CCA as the reference, 85.2% was lateral, 12.5% anterior, 1.1% medial and 1.1% posterior to CCA. Even

Keum Y et al. in 2015 concluded that the IJV is lateral to CCA in 54.3% of the subjects. In 27.2% of cases, the location was posterolateral, in 17.9%, anterolateral, and in 0.6%, anterior. Though a study done in 2011 by Tim Maecken et al., found 3.0–3.3% of patients had the IJV located lateral to the CCA. On left side it was more frequently discovered in the anteromedial section. The IJV appeared more frequently in the anterolateral location on the right side.

In our study we tried to evaluate the effect of SR on the relationship of IJV with CCA not only at neutral position but 15, 30, and 45 degree rotations as well. Prior to simulating rotation, the IJV was Anterolateral (42%), Lateral (39%), Posterolateral (22%), Posterior (1%), and post 15-degree rotation they shifted to Anterior (4%), Anterolateral (32%), Lateral (60%), Posterolateral (6%), Posterior (2%); post 30-degree to Anterior (1%), Anterolateral (41%), Lateral (40%), Posterolateral (22%) and after 45-degree rotation to Anterolateral (41%), Lateral (41%) and Posterolateral (22%). Thus, the study showed an increase in simulated rotation caused the IJV to migrate anteriorly and overlap CCA. In the study by Lim et al, 300 patients had a substantial change in the IJV from an anteromedial to a more anterior position was seen when the head was rotated by 30 degrees. Although, not only did the author only take the effect of 30 degrees of head rotation into account but also the study was done using ultrasound guidance, which gave false results of the IJV being more anterior to the CCA as lateral scanning can only be done.

The present study tried to nullify this discrepancy by studying not only the relationship of IJV and CCA at a neutral head position but also the changes after inducing 15-, 3,0- and 45-degree neck rotation.

On measuring the overlap at different rotations our study showed an increase in overlap from 27.71 at 0 degree, 32.93 at 15 degrees, 37.73 at 30 degrees, and 37.81 at 45 degrees. Therefore, the overlap increased significantly with SR. In the year 2013 a study by Takeji Saitoh et al. also concluded that when the head was rotated from 30 degree to 60 degree, the overlap angle also increased. The author conducted the study entirely in Japanese subjects, and therefore the study results may not be generalizable to Indian population and in the obese.

Gaurav Purohit et al. concluded in 2018 in India that IJV was found commonly in anterolateral segments. With a 15° head rotation there is increased overlap in 44% of subjects on the right and 39% on the left. Greater overlap was seen when the SR was increased to 45 degrees. But is the study the effect of rotation was seen only with 15- and 45-degree SR. The study is also ultrasonographically guided, and in low volume centers USG is not available at all times for bedside cannulation thus it requires prior sound anatomical knowledge.

In 2014, Izumi Miki et al. discovered that the overlap CCA and IJV increased with 30- and 45-degree rotation as compared to the neutral position. The study was only conducted on healthy subjects, and the sample size was small, so the results could not be extrapolated to a larger population.

The round contour of the human neck makes ultrasound scanning from anterior to posterior impossible. Instead, lateral scanning has to be done to achieve best transducer-to-skin coupling, which places IJV falsely more anterior to CCA.

Izumi et al. examined ultrasonographic images from the midline to the left for head rotation at 0°, 15°, 30°, 45°, 60°, and 75°. When compared to the neutral

position, the overlap of CCA and IJV increased significantly with 45 and 30 degree rotation.

Kim et al. (2015) used CT to assess subjects and saw changes with SR to 30 degrees in Korean subjects in 2015. They observed that after SR30 the position of IJV changed from the one when in supine position significantly. IJV shifted more anteriorly with the right IJV shifting to anterior from an anterolateral position in 1 case and overlapping CCA completely. Our study incorporated this principle of simulated neck rotation in computed tomography and used it to study 104 IJVs and their relationship to CCA.

The study had its limitations in that it was conducted only in healthy subjects and needs to be replicated in the future in cancer patients with significant neck nodes or neck masses and take the same into account when studying the intervarying relationship of IJV and CCA.

CONCLUSION

The relationship of IJV with CCA has been a source of enigma for anaesthetists and surgeons alike – any aberration in the same can lead to an inadvertent outcome. Our study was an attempt to not only study the relationship of IJV and CCA at neutral position but also their varying relationship on simulation rotation to 15, 30 and 45 degrees which gave us a wider anatomical insight.

There was a male predilection in the cases with 35(68.66%) males and 17(33.33%) among 52 cases. The mean age of cases taken up for study was 43.8 years. There was a greater predilection towards older age groups. 104 IJVs were evaluated and their relationship to CCA was recorded. Right side showed angulation of IJV with CCA was 83.21 at 0 degree, 83.21 at 15 degrees, 82.06 at 30 degree and 82. 68 at 45-degree neck rotation, respectively. On the left side angulation was 81.41 at 0 degree, 83.75 at 15 degrees, 80.79 at 30 degrees and 82.86 at 45 degrees, respectively. It was observed that IJV occupied a lateral position to CCA at supine position and a minimal anterior shift was seen on increasing rotation of the neck. Not much difference observed between right and left side of neck.

Whereas, on evaluating the overlap of IJV with CCA at varying angles there was a significant increase overlap seen of IJV and CCA on increasing the simulation rotation from 27.71 at 0 degree, 32.93 at 15 degrees, 37.73 at 30 degrees and 37.81 at 45 degrees which should be considered in the surgical field or while performing central venous access.

The variations in position and the relationship between IJV and CCA could lead to complications during cannulation such a condition where the IJV is overlapping the CCA can account for unintentional carotid artery puncture.

Knowledge of these variations help us in preventing complications. It can help us simulate an intraoperative layout pre-operatively that helps us simulate a surgical field fraught with lesser bleeding complications and minimization of surgical errors. Thus, we can ensure safer surgeries with better outcomes. The study had its limitations in that it was conducted only in healthy subjects and needs to be replicated in the future in cancer patients with significant neck nodes or neck masses and take the same into account when studying the inter-varying relationship of IJV and CCA.

SUMMARY

The present study entitled "**EVALUATION OF ANATOMICAL RELATIONSHIP OF INTERNAL JUGULAR VEIN AND THE COMMON CAROTID ARTERY USING COMPUTED TOMOGRAPHY: A ONE YEAR OBSERVATIONAL STUDY AT KLES DR. PRABHAKAR KORE HOSPITAL & MEDICAL RESEARCH CENTRE"** was conducted in the Department of ORL & HNS of KLE University's Jawaharlal Nehru Medical College and KLES Dr.Prabhakar Kore Hospital and MRC, Belgaum from January 2020 to December 2021. The study included 52 patients who underwent computed tomography for various indications. The CT scans were collected and the intervarying relationships of IJV and CCA was studied in RadiAnt DICOM viewer.

There was a male predilection in the sample size with the age distribution predominantly in the older age groups. In our study we evaluated IJV's relationship with CCA when the neck was in the midline which showed the IJV to lie mostly in the lateral compartment. There was not much significant difference in the relationship on two sides of the neck. This was in line with studies done before which placed IJV to be lying mostly lateral to CCA. Yet the previous studies had been done with keeping in focus the head at neutral or 30 degree and our concern was mainly with the changing relationship of IJV to CCA with increased rotation due to increased predilection of CCA puncture in cases where the IJV came to lie directly over CCA with rotation at varying angles. Thus, in our study we tried to nullify this discrepancy by studying not only the relationship of IJV and CCA at a neutral head position but also the changes after inducing 15, 30 and 45 degree neck rotation. We studied the

overlap of IJV and CCA at varying angles and found that with increasing neck rotation there is an increase in the overlap of IJV with CCA.

Our study has future implications not only surgically but also to provide safe central venous access. Minimal intra-operative and immediate post-operative complications can be achieved with detailed anatomical knowledge about the anatomy of the vasculature and surrounding structures. It can help us simulate an intraoperative layout pre-operatively that helps us simulate a surgical field fraught with lesser bleeding complications and minimization of surgical errors.

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ANNEXURES – I

INFORMED CONSENT

"EVALUATION OF ANATOMICAL RELATIONSHIP OF INTERNAL JUGULAR VEIN AND THE COMMON CAROTID ARTERY USING COMPUTED TOMOGRAPHY: A ONE YEAR OBSERVATIONAL STUDY AT KLES DR. PRABHAKAR KORE HOSPITAL & MEDICAL RESEARCH CENTRE."

PRINCIPAL INVESTIGATOR: Dr.

Post Graduate student Department of ENT & HNS

CO-INVESTIGATOR :Dr.

Professor, Department of ENT & HNS

INTRODUCTION AND PURPOSE:

The purpose of the study is to evaluate the anatomical relationship and degree of overlap between internal jugular vein and common carotid artery using computed tomography (CT) in Belagavi population.

PROCEDURE:

If you agree to participate in this study, the relevant data will be collected as per the proforma and the final diagnosis will be confirmed. After getting inducted in the study, you will be evaluated on clinical examination. Following this the patient will then have to undergo CT scan examination and the scan will be studied.

BENEFITS:

Patient will not be eligible for any kind of monetary benefits or any free services.

RISKS:

Methods applied to do the study are safe.

COST OF PARTICIPATION:

The cost of the Investigation will be borne by the Study Subject. The other indirect expenses will be borne by the Investigator.

PRIVACY AND CONFIDENTIALITY:

The results of the study may be published in journals for scientific purposes. However, your identity will not be revealed. All information collected will be coded so that no one other than the investigator will know your identity.

WITHDRAWAL FROM THE STUDY:

You can withdraw from the study at any time if you wish to do so.

AUTHORIZATION TO PUBLISH THE RESULTS:

The researcher may use the information gathered from this study for presentation in scientific meetings. However, your identity will not be revealed.

QUERIES AND CONTACT:

If you have any queries regarding the study, you can contact Dr. Harsha Hegde, Chairperson, JNMC, IEC & Scientist D. ICMR, National Institute of Traditional Medicine, Belagavi, Mobile No: 9480422500.

CONSENT SUMMARY:

I have been explained all the contents of this consent form in my local language and having understood and clarified all my queries about the study to the best of my knowledge, I hereby give my voluntary consent for participation in the study. I do sign the informed consent form in front of an eyewitness whom I recognize.

Name and Signature/ left thumb impression of the participant:

Name and Signature of the interviewer:

Name and Signature/ left thumb impression of the eyewitness (Relative):

Signature of the guide: **Date:**

ANNEXURES – II

PROFORMA

"EVALUATION OF ANATOMICAL RELATIONSHIP OF INTERNAL JUGULAR VEIN AND THE COMMON CAROTID ARTERY USING COMPUTED TOMOGRAPHY: A ONE YEAR OBSERVATIONAL STUDY AT KLES DR. PRABHAKAR KORE HOSPITAL & MEDICAL RESEARCH CENTRE."

Date:

O.P. No / I.P. No:

Name: Age:

Sex: Occupation:

Address: Phone No:

CLINICAL PROFILE

Chief Complaint:

History of Present Illness: Past History:

Personal History:

Family History:

General Physical Examination -

Blood Pressure: Pulse: Respiratory Rate:

Pallor Icterus Clubbing Cyanosis

Lymphadenopathy Oedema

ENT Examination

1. EAR EXAMINATION:

Pinna

Pre auricular area Post auricular area

External auditory canal Tympanic membrane

TUNING FORK TESTS:

	Right	Left
Rinne's test	256 Hz	512 Hz

1024 Hz

Weber's test:

Absolute Bone Conduction test:

FACIAL NERVE EXAMINATION:

2. NOSE EXAMINATION

External appearance:

- Root
- Bridge
- Dorsum
- Alae
- Tip
- Columella

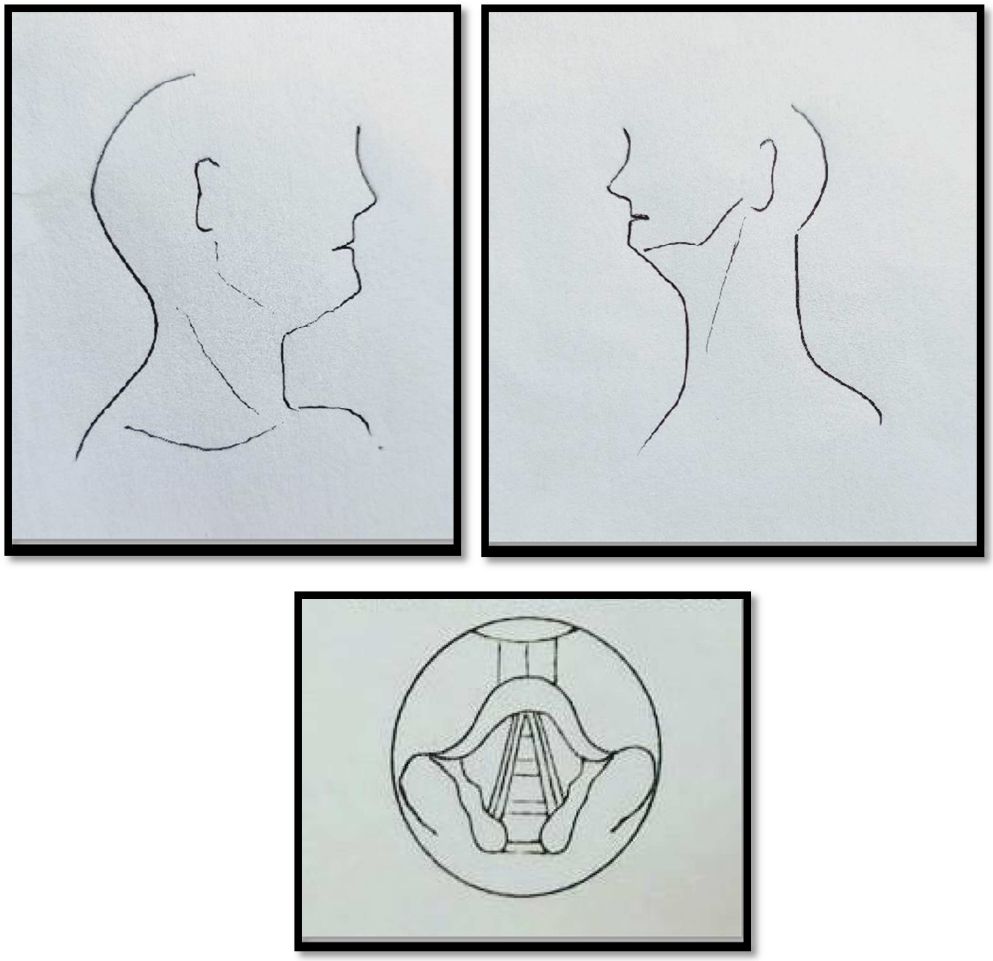
Cold spatula test

Anterior Rhinoscopy

Posterior Rhinoscopy

Paranasal Sinus Examination

3. THROAT EXAMINATION :

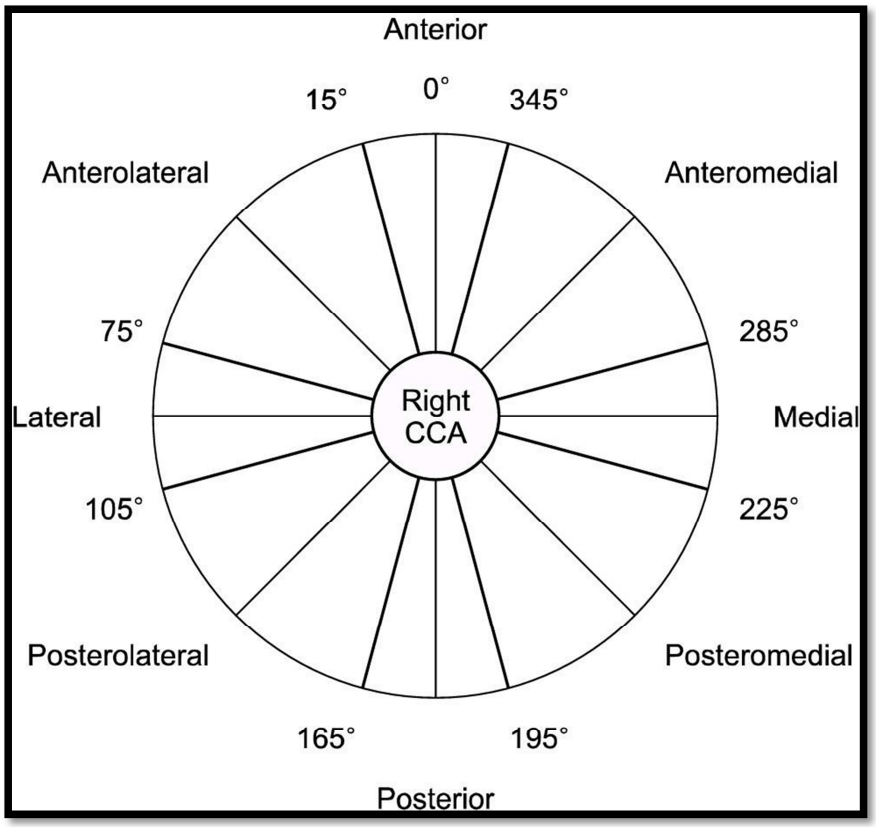


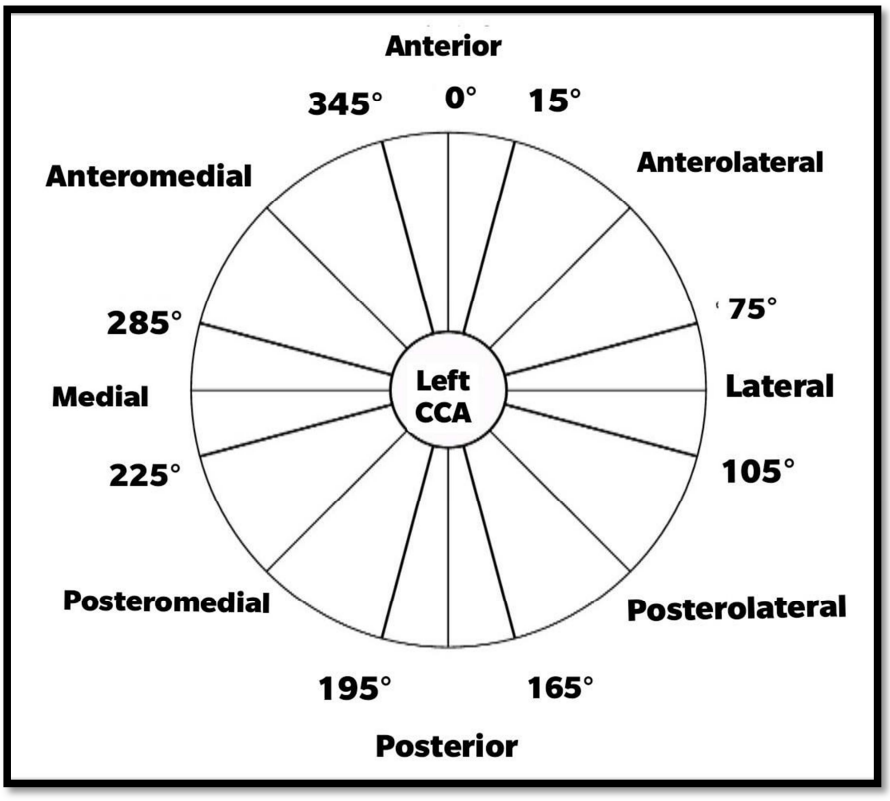
4. NECK EXAMINATION :

Findings on CT:

SEGMENTED GRID FOR PLOTTING ANATOMICAL POSITION OF RIGHT INTERNAL JUGULAR VEIN (IJV) RELATIVE TO RIGHT COMMON CAROTID ARTERY (CCA) GIVEN IN COUNTER CLOCK DISPOSITION USING THE CCA AS THE CENTRE OF THE DIAL

(Courtesy : Anatomical relationship of the internal jugular vein and the common carotid artery in Korean: A computed tomographic evaluation. Anesth Pain Med. 2015;10(2):118-123**)**


Anterior
0°
15°
345°
Anterolateral
Anteromedial
75°
285°
Lateral
Right
CCA
Medial
105°
225°
Posterolateral
Posteromedial
165°
195°
Posterior


Anterior
345°
0°
15°
Anteromedial
Anterolateral
285°
75°
Medial
Left
CCA
Lateral
225°
105°
Posteromedial
Posterolateral
195°
165°
Posterior

Definition of anatomical positions of the right internal jugular vein (IJV) relative to the right common carotid artery (CCA), given in a counter-clock disposition using the CCA as the centre of the dial. A mirror image applies for the left IJV. Anterior: < 15-degree and ≥ 345-degree, 15-degree Anterolateral < 75- degree, 75-degree ≤ Lateral < 105-degree, 105-degree ≤ Posterolateral <165-degree, 165-degree ≤ Posterior < 195-degree, 195-degree ≤ Posteromedial < 225-degree, 225-degree ≤ Medial <285-degree, 285-degree ≤ Anteromedial <345-degree.

FINDINGS ON CT

			SUPINE		**AFTER 15**		**AFTER 30**		**AFTER 45**		
Sl. No	**Patient Name**	**Age /Sex**	**Right Side**	**Left Side**	**Overlap (O=B/C x100)**	**Rt. Side**	**Lt. Side**	**Right Side**	**Left Side**	**Right Side**	**Left Side**

Table 1 : Anatomic Relation of Each Internal Jugular Vein Relative to Their Common Carotid Artery before and after Simulating 15-degree Body Rotation (SR15) to the Contralateral Side on Each Side.

BEFORE SR15 AFTER SR15

Position	Right	Left	Total	R ight	Left	Total
Anteromedial						
Anterior						
Anterolateral						
Lateral						
Posterolateral						
Total						

Data will be expressed as number of cases and percentage. AM: anteromedial to the carotid artery, A: Anterior to the carotid artery, AL: anterolateral to the carotid artery, L: Lateral to the carotid artery. PL: posterolateral to the carotid artery. G machine 128 slides

Table 2: Anatomic Relation of Each Internal Jugular Vein Relative to Their Common Carotid Artery before and after Simulating 30-degree Body Rotation (SR30) to the Contralateral Side on Each Side.

Before SR30 After SR30

Position	Right	Left	Total	Right	Left	Total
Am						
A						
Al						
L						
Pl						
Total [n (in%)]						

Data will be expressed as number of cases and percentage. AM: anteromedial to the carotid artery, A: Anterior to the carotid artery, AL: anterolateral to the carotid artery, L: Lateral to the carotid artery. PL: posterolateral to the carotid artery

Table 3 : Anatomic Relation of Each Internal Jugular Vein Relative to Their Common Carotid Artery before and after Simulating 45-degree Body Rotation (SR45) to the Contralateral Side on Each Side.

Before SR45 After SR45

Overlap (%)	Right	Left	Total	Right	Left	Total
0						
<25						
≥ 25 and <50						
≥ 50 and ＜75						
≥ 75						
Total						

Data will be expressed as number of cases and percentage.

Table 4. The Incidence of Overlap and the Mean Overlap Percentage before and after Simulating 15- degree Body Rotation (SR15) on Each Side.

BEFORE SR15 AFTER SR15

Overlap (%)	Right	Left	Total	Right	Left	Total
0						
<25						
≥ 25 and <50						
≥ 50 and ⩽75						
≥ 75						
Total						

Data will be expressed as number of cases and percentage.

Table 5. The Incidence of Overlap and the Mean Overlap Percentage before and after Simulating 30- degree Body Rotation (SR30) on Each Side.

	BEFORE SR30			AFTER SR30		
Overlap (%)	**Right**	**Left**	**Total**	**Right**	**Left**	**Total**
0						
<25						
≥ 25 and <50						
≥ 50 and ＜75						
≥ 75						
Total						

Data will be expressed as number of cases and percentage.

Table 6. The Incidence of Overlap and the Mean Overlap Percentage before and after Simulating 45- degree Body Rotation (SR45) on Each Side.

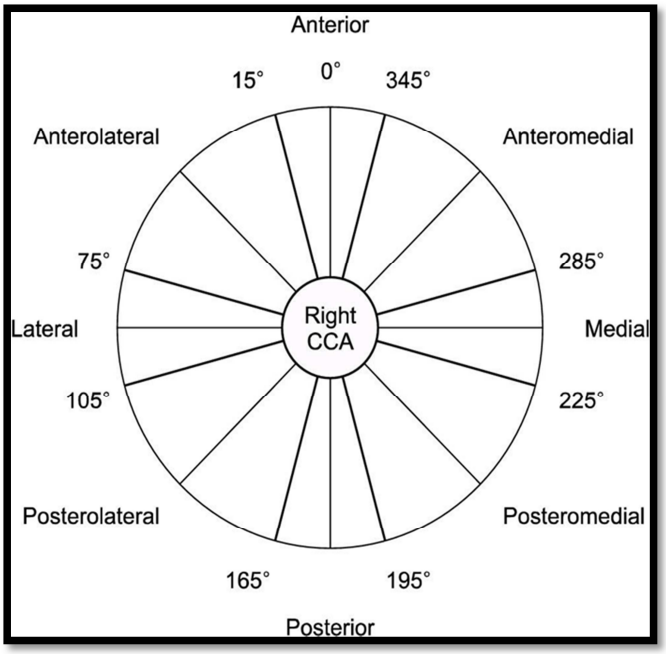
	BEFORE SR45			AFTER SR45		
Overlap (%)	**Right**	**Left**	**Total**	**Right**	**Left**	**Total**
0						
<25						
≥ 25 and <50						
≥ 50 and ＜75						
≥ 75						
Total						

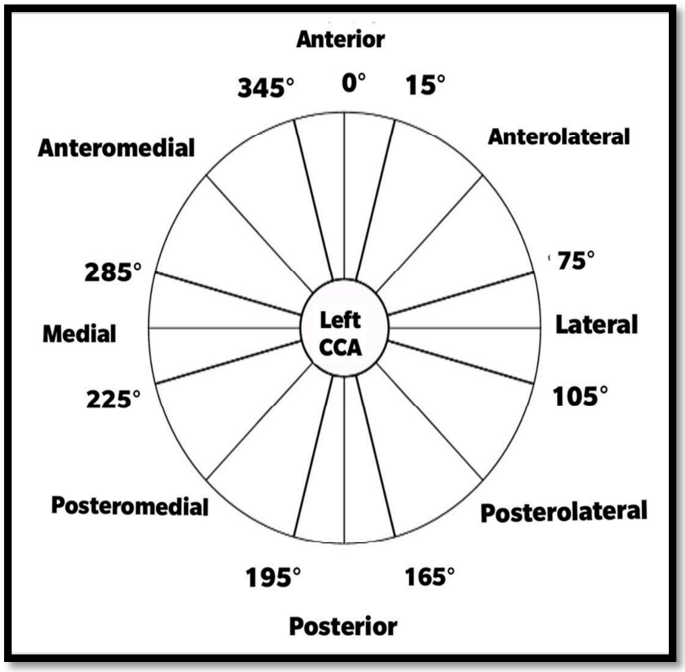
Data will be expressed as number of cases and percentage.

ANNEXURES – III

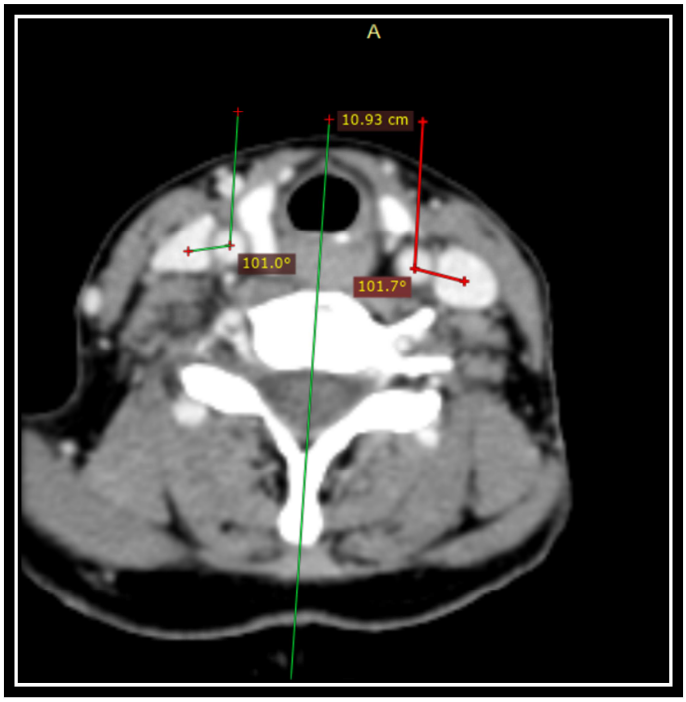
PHOTOS

Photograph 1: CT console room in the hospital.

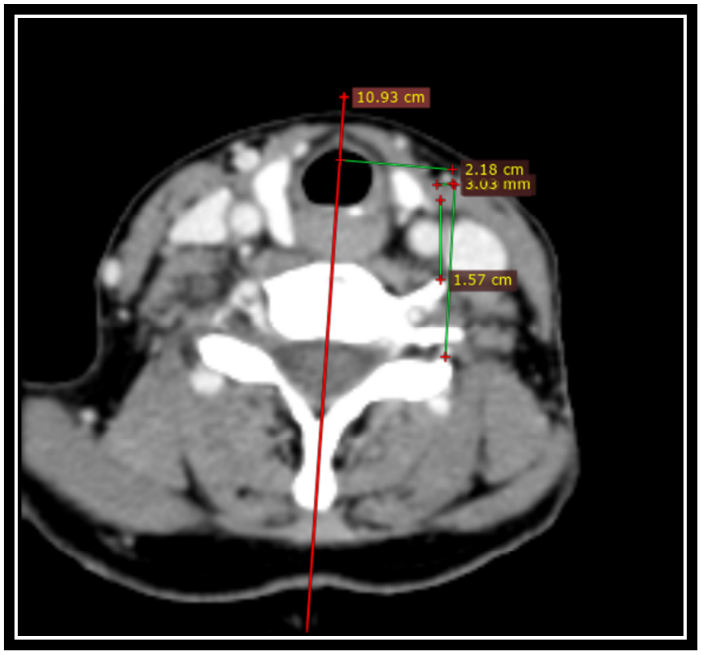




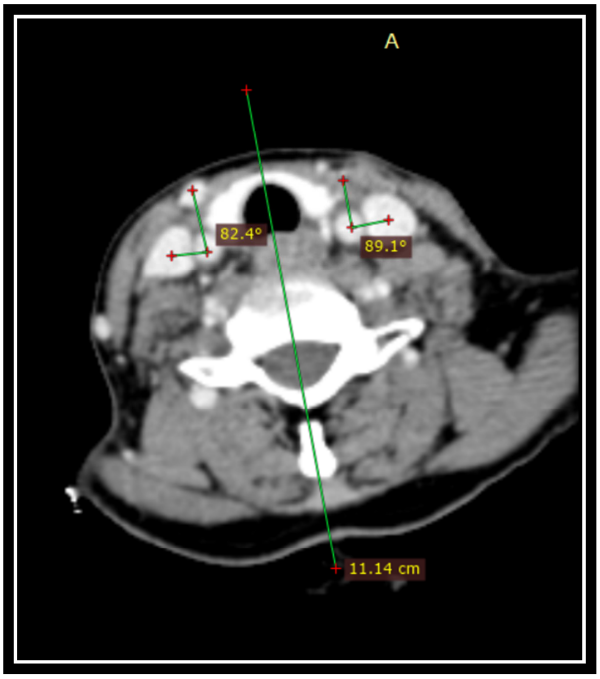
Photograph 2: Segmented 360-degree grid used to plot the relationship of IJV to CCA using CCA as the reference point.



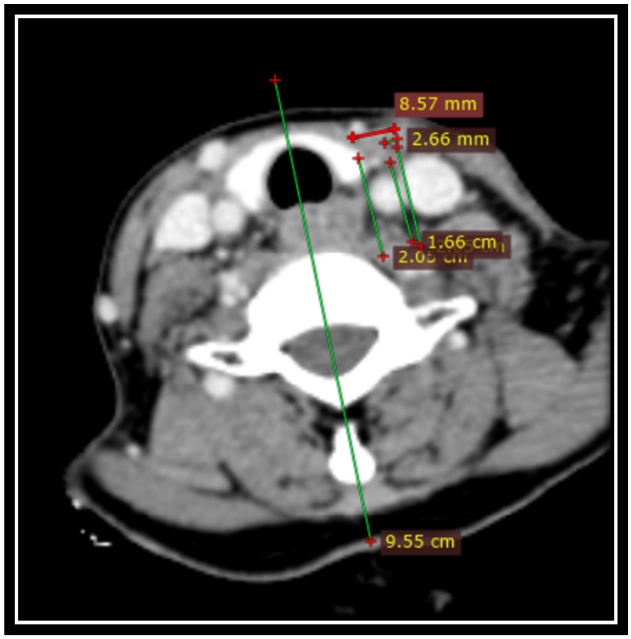
Photograph 3: Angulation of IJV with CCA at supine position (0-degree) as evaluated using RadiAnt Software.



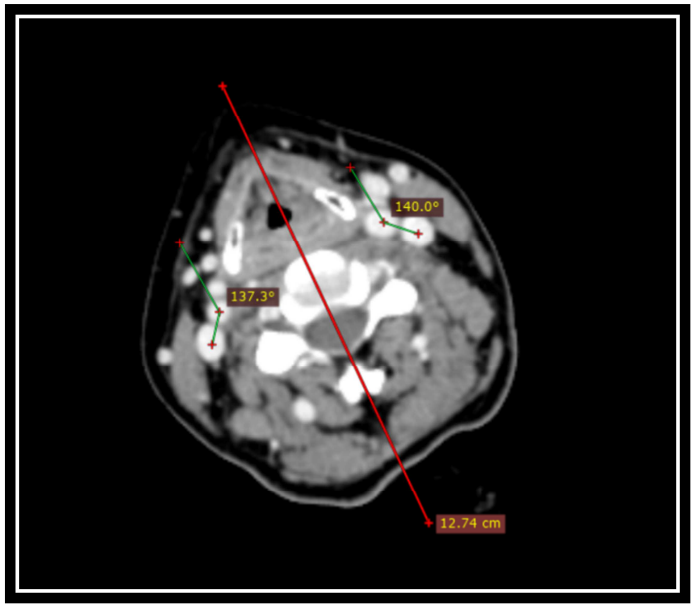
Photograph 4: Overlap of IJV and CCA at supine position (0-degree) as evaluated using RadiAnt Software.



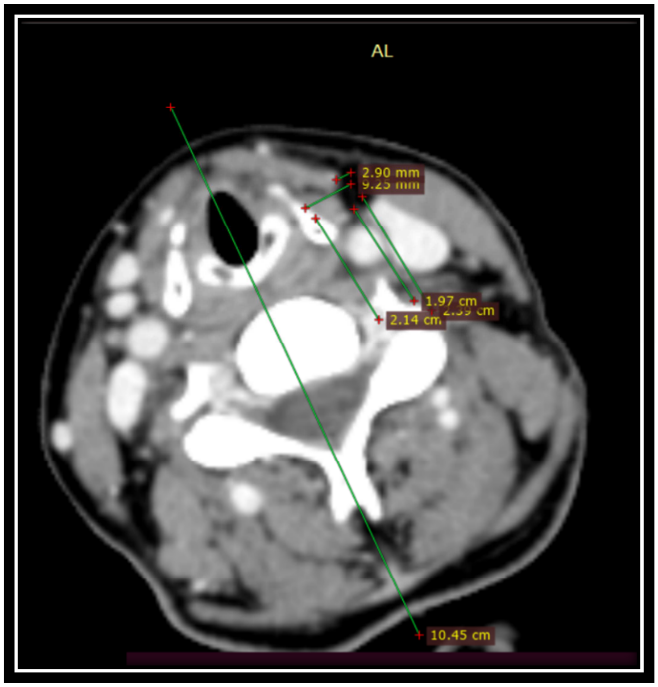
Photograph 5: Angulation of IJV with CCA at 15-degree simulated neck rotation as evaluated using RadiAnt Software.



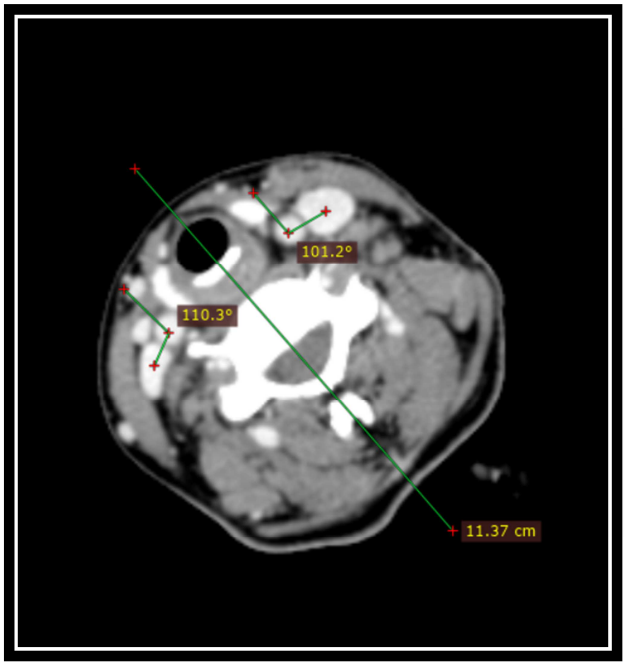
Photograph 6: Overlap of IJV and CCA at 15-degree simulated neck rotation as evaluated using RadiAnt Software.



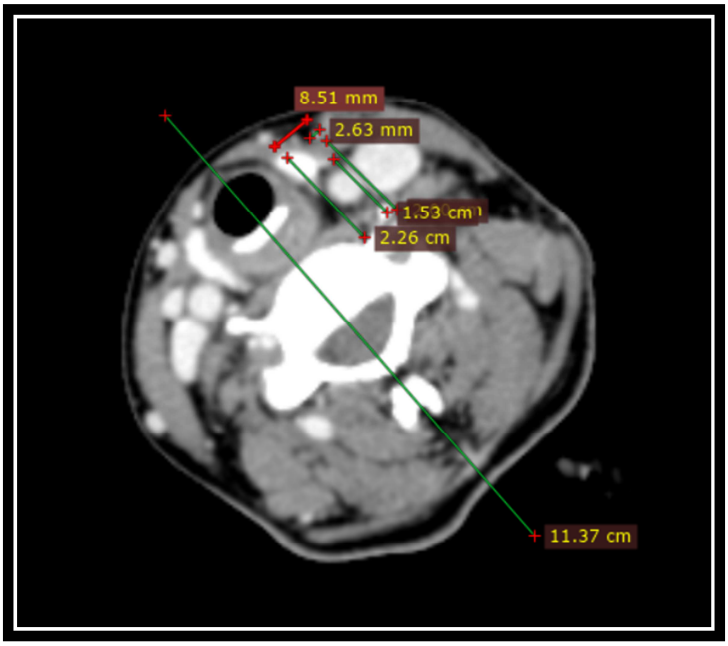
Photograph 7: Angulation of IJV with CCA at 30-degree simulated neck rotation as evaluated using RadiAnt Software.



Photograph 8: Overlap of IJV and CCA at 30-degree simulated neck rotation as evaluated using RadiAnt Software.



Photograph 9: Angulation of IJV with CCA at 45-degree simulated neck rotation as evaluated using RadiAnt Software.



Photograph 10: Overlap of IJV and CCA at 45-degree simulated neck rotation as evaluated using RadiAnt Software.

ANNEXURE - IV

KEY TO MASTER CHART

Age	In years
Sex	Male or Female
CT no	Patient scan number
Angle at 0 ®	Angle between right IJV and CCA at supine position
Angle at 0 (L)	Angle between left IJV and CCA at supine position
Angle at 15 ®	Angle between right IJV and CCA with 15-degree simulated rotation
Angle at 15 (L)	Angle between left IJV and CCA with 15 degree simulated rotation
Angle at 30 ®	Angle between right IJV and CCA with 30 degree simulated rotation.

ANNEXURE - V - MASTER CHART																			
NAME	CT NO.	AGE	SEX	ANGLE AT 0 ®	ANGLE AT 0 (L)	OVERLAP 0 DEGREE ®	OVERLAP 0 DEGREE (L)	ANGLE 15 R	ANGLE 15 L	OVERLAP 15 R	OVERLAP 15 L	ANGLE 30 R	ANGLE 30 L	OVERLAP 30 R	OVERLAP 30 L	ANGLE 45 R	ANGLE 45 L	OVERLAP 45 R	OVERLAP 45 L
Nirmala Siddanavar	29651	48	F	94	82.9	29.72	23.4	90	72.1	29.92	25.4	88.4	83.9	23.68	28.03	91.5	81.2	35.3	25.06
Moulasaab	29639	58	M	84.5	101.9	29.95	26.6	115	122	16.26	37.3	88.8	100	40.98	59.76	91.3	106.2	49.66	35.05
Ballavva	29540	40	F	90.8	107.1	20.04	21.5	104.8	115	12.89	16.03	126	112.8	16.03	12.5	88.5	93.3	20.17	17.16
Kallava	29661	60	F	129.8	173.4	0	5.6	115	94	15.1	10.3	111	90	39.08	69.13	117.8	97.4	12.57	83.4
Reyaz	26988	60	M	77	77	19.17	25.2	72	71	43	30.25	70	64	25	6.47	68	62	24.3	16.9
Shankar nagappa	49797	58	M	59.9	81.2	19.76	19.75	54.4	78	46.7	33.2	52.1	76	48.3	18.88	50	75	51.6	26.2
Ratnavva rajannava	29157	60	F	77	77.7	19.17	23.1	94.2	102	43.04	30.25	77.5	93.1	25	6.47	103	116	24.5	0
Baravaraj morkar	29157	46	M	52.8	52.6	16.72	28.4	95.1	106	19.8	30.24	98.4	109.7	26.5	17.8	100.3	116	13.2	7.71
Shingerawwa	29167	60	F	71	71	12.56	22.4	122	121	12	22.01	123	126	28.6	18	127	131	32.35	16.9
Mohammed gaus	29584	44	M	59.9	81.9	37.8	33.1	45.7	88.2	46.7	32.2	66	72	48.3	18.86	52.7	82.1	51.6	26.2
Laxman godale	36725	38	M	57.1	54.2	26.7	24.5	55.2	53.1	14.32	41.2	55	51.2	34.12	50.31	52	53	20.6	41
Gangappa	518	50	M	74.4	75.7	20	18.2	72	73.2	28.3	34.9	70.4	76	28.28	32.46	73.2	74.5	7.41	7.44
Yallakka	17354	40	F	74.6	73.8	21	20.1	72.3	71.6	33	22	70.4	67.8	34	40	61.3	64.5	40	20
Channava	29176	65	F	86	61.8	33	32.3	84.5	60.9	35	32	82.3	60.4	36	35	83.4	81.1	38	41
Amit	17295	21	M	126	126	36.9	34.3	123.3	124	38.44	20	121	120.4	25	20	122	119.8	27	34
Anjana	26875	21	M	84	79	46	43.4	81	76	36.6	42	80.6	75.8	36.6	175.89	79.8	56.7	142	177.57
Bhavana	462	54	F	130	110	37.6	33.2	109	131	36.7	26.3	0	108.5	0	7.57	106.9	135.4	20.4	26.1
Banabai	32144	70	M	55	75.8	47.3	31.8	53	71	56.9	65.98	56	76.2	50.4	36.4	55.4	75	55.2	50
Nagappa	17301	65	M	74.5	82.5	35	33.9	73	80	39.6	22.4	71.5	78.6	37.6	23	72	81.2	38.5	29
Shyamala	17238	37	M	75.5	53.5	28.7	39.8	82.4	55.6	10.2	30.8	81	53.4	74.7	66.7	80.6	52.3	78.7	63
kanchan	16444	47	F	76.8	48.5	30.8	0	66.1	58.2	27.2	0	80.7	47.8	80.7	47.8	87.9	58.6	27.2	0
ganavva pant	25868	32	M	52.2	44.2	42.5	46	46.4	45.1	50	37	55.4	49.9	59.9	34	51.9	45	49.7	38
shante patil	5320	40	F	49	50.5	53.2	39.5	37.7	50.5	50	42.7	47.3	47.2	61.3	37.6	49.1	53	42.9	39.5
Shannapa chethi	3830	63	M	75	62	37	67	96.8	96.5	36.7	37	127.9	59	45.4	31	91.6	60	55.9	17.4
Kalantri	981	35	M	59.9	81.9	37	37	58.6	80.9	43.4	33.2	56.4	81.7	48.3	18.06	55.8	82.3	51.6	26.2

NAME	CT NO.	AGE	SEX	ANGLE AT 0 ®	ANGLE AT 0 (L)	OVERLAP 0 DEGREE ®	OVERLAP 0 DEGREE (L)	ANGLE 15 R	ANGLE 15 L	OVERLAP 15 R	OVERLAP 15 L	ANGLE 30 R	ANGLE 30 L	OVERLAP 30 R	OVERLAP 30 L	ANGLE 45 R	ANGLE 45 L	OVERLAP 45 R	OVERLAP 45 L
Veeresh Angad	3442	42	M	107.4	109.4	0	0	105.4	106.7	114.2	107.4	105.3	107.8	111.3	112.8	103.5	108.9	115.9	111.7
Mahadevi	4213	36	F	97.5	91.8	29.5	22.6	96.4	90.7	15.8	23.5	93.4	87.9	19.96	25.9	97.8	96.6	25.9	24
Umadas	5436	37	F	89.5	100.1	19.2	19.8	89.9	100.2	41.5	31.7	88.7	100	35.9	32	88.6	98.99	32.3	29.4
Bhavana	39563	54	F	130	110	37.6	36.7	109	131	25.9	0	108.5	135.6	17.7	20.6	106.9	135.4	26.3	0
Ramachandra	32144	41	M	81.4	94.9	0	0	80.7	93.4	22.74	0	79.9	91.4	26	0	80.6	92.3	29.24	24
Vitarag	43987	18	M	142.6	83	37.04	21.91	140.3	82	39.97	22.58	137	89.1	41.87	29.47	136	87.8	42.25	14.61
Iman Sanadi	23115	57	M	51.7	51.1	33.39	38.29	51.4	50.3	47.24	43.32	52.4	50.2	30.88	54.77	53	52.2	35.18	20.09
Sankallepa	35612	65	M	64.6	66.1	17.89	28.3	61.3	65	18.28	31.89	63.4	65.7	24.97	31.56	64.3	65.6	27.57	31.58
Shamshuddin	9823	28	M	50.2	91.6	31.6	15.07	56.6	82.4	33.15	16.1	58.7	81.3	31.9	11.88	56.7	76.7	38.4	12
Sanjay Sulebhavi	23654	34	M	66	66	28.5	26	65.4	63.4	29	26.7	69	68.7	28.7	26.5	60	61	35	27.1
Rudrrapa	6532	35	m	73.4	78.3	23	21.2	74.3	71.6	31	24	71.5	66.7	33	45.6	62	66.4	32.4	43
Laxmi	48734	29	f	86	61.8	33	32.3	84.5	60.9	35	32	82.3	60.4	36	35	83.4	81.2	34.2	41
Puttaraj	2134	45	m	126	126	36.9	34.3	123.3	124	38.44	20	121	120.4	25	20	122	120	24	21
Ashok Kamble	5432	56	m	55	75.8	47.3	31.8	53	71	56.9	65.98	56	76.2	50.4	36.4	55.4	75	55.2	50
Honurappa	8432	59	m	74.5	82.5	35	33.9	73	80	39.6	22.4	71.5	78.6	37.6	23	72	81.2	38.5	29
Parikshitmath	29220	34	m	75.5	53.5	28.7	39.8	82.4	55.6	10.2	30.8	81	53.4	74.7	66.7	80.6	52.3	78.7	63
Ningappa Hegdal	9123	60	M	76.8	48.5	30.8	0	66.1	58.2	27.2	0	80.7	47.8	80.7	47.8	87.9	58.6	27.2	0
Pandurang	50350	31	m	107.4	109.4	0	0	105.4	106.7	11.1	12.1	105.3	107.8	0	0	103.5	108.9	0	0
Laxmi Bhandurang	50494	53	m	86	61.8	21	33	86	60.2	32	34	84.3	63.2	34	38.6	82.3	61.4	36.5	32.3
Noorahamad	50350	48	m	128	83.4	24	29.8	101	115	34	16.2	101.8	91.2	35.6	33.4	106.1	98	34	33.4
Shantaram	50472	24	M	74.5	73.2	21	33	96.4	105.4	22	34	100.3	103.6	25.4	39.9	95	104.3	25.4	22.3
Kasturi	50019	19	F	126	121	36.9	38.45	103.1	81.9	20	23	100.4	78.6	28	27	98.7	75.6	34	24
Dundappa	50461	32	f	57.1	54.2	26.7	24.5	55.2	53.1	14.32	41.2	55	51.2	34.12	50.31	52	53	20.6	41
Vasu Bhajantri	48377	28	m	74.4	75.7	20	18.2	72	73.2	28.3	34.9	70.4	76	28.28	32.46	73.2	74.5	7.41	7.44
Channama	49897	35	m	75	73.8	21	20.1	72.3	71.6	33	22	70.4	67.8	34	40	61.3	64.5	40	20
Amar	50114	21	f	125	123	35.8	32.4	121.3	121	36.77	21	120	118.1	24.6	21	121	123	22	20.8