"COMPARISON OF MODIFIED COMBINED LONG AND SHORT AXIS VERSUS OBLIQUE AXIS IN PLANE METHOD FOR ULTRASOUND GUIDED RIGHT INTERNAL JUGULAR VEIN CANNULATION IN ADULT PATIENTS -A ONE YEAR RANDOMISED CONTROLLED TRIAL"

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Sub: Institutional Ethical Clearance for the study.

With reference to the above, we wish to inform you that your proposed research project titled **"COMPARISION OF MODIFIED COMBINED LONG AND SHORT AXIS VERSUS OBLIQUE AXIS IN PLANE METHOD FOR ULTRASOUND GUIDED RIGHT INTERNAL JUGULAR VEIN CANNULATION IN ADULT PATIENTS- A ONE YEAR RANDOMISED CONTROLLED TRIAL",** is ethical and justifiable. The proposed research project has been cleared by the JNMC Institutional Ethics Committee.

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ABBREVIATIONS

aPTT	Activated partial thromboplastin time
ASA	American society of Anesthesiologists
BP	Blood Pressure
CCA	Common carotid artery
cm	Centimeter
CPR	Cardio-pulmonary resuscitation
CVC	Central venous catheter
CVP	Central venous pressure
DVT	Deep vein thrombosis
ECG	Electrocardiography
EJV	External jugular vein
Fr	French scale
Hb%	Hemoglobin percent
HR	Heart Rate

ICA	Internal carotid artery
IJV	Internal jugular vein
INR	Internationalized normalized ratio
IV	Intravenous
kg	Kilogram
LA	Local anesthetic
PCWP	Pulmonary capillary wedge pressure
pH	Measure of the hydrogen ion concentration of a solution
PICC	Peripherally inserted central venous catheter
PT	Prothrombin Time
RR	Respiratory Rate
SCM	Sternocleidomastoid muscle
SpO2	Peripheral capillary oxygen saturation
SVC	Superior vena cava
USG	Ultrasonography

ABSTRACT

"COMPARISON OF MODIFIED COMBINED LONG AND SHORT AXIS VERSUS OBLIQUE AXIS IN PLANE METHOD FOR ULTRASOUND GUIDED RIGHT INTERNAL JUGULAR VEIN CANNULATION IN ADULT PATIENTS-A ONE YEAR RANDOMISED CONTROLLED TRIAL"

Background:

Among the different large veins that can be cannulated the right internal jugular vein (IJV) is most preferred for its straight course to the right side of the heart, lack of valves and ease of cannulation. Cannulation of the right IJV is most commonly done using the landmark guided central approach. It is associated with a higher risk of carotid puncture. In this context the oblique in plane approach has been found to be better and was associated with less complications.

Objective:

This study is being undertaken to find out which method is better Modified combined short and long axis method (MCSL) or Oblique axis in plane (OA-IP) method in terms of first attempt success rate for right Internal jugular vein (IJV) catheter placement.

Methods:

A total of 60 adult patients were divided into two groups of 30 each to be cannulated by either the oblique plane or the Modified combined short and long axis method.

Oblique Axis In-Plane method: In this group, the ultrasound probe is placed on the jugular vein at mid-neck level to capture a transverse cross-sectional image of the Common carotid Artery (CCA) and Internal jugular vein (IJV) together. Once the short axis view is obtained, the probe is rotated 45 degrees clockwise with the orientation marker medially and the needle will be inserted from lateral to medial by using in plane technology.

Modified Combined Short and Long Axis Method: In this group, the ultrasound probe is

placed in the supraclavicular fossa to determine the plane of needle puncture. The needle is inserted at an angle of 30 degrees to the skin with the short axis out of plane technique and visualize the needle tip as a white spot between the two shadows on the ultrasound screen. Rotate the ultrasound probe 90 degrees clockwise and puncture the anterior wall of the IJV with long axis in-plane technique. And the following observations will be made.

Time taken to identify/locate the vein/Puncture the vein: _____seconds.
Success rate and time taken to locate IJV, time taken for cannulation, number of carotid punctures and other complications were assessed.

Results:

This study compared two ultrasound-guided techniques for right internal jugular vein (RIJV) cannulation: Oblique Axis In-Plane (OA-IP) method and Modified Combined Short and Long Axis (MCSL) method in adult patients through a randomized controlled trial over one year. Age and gender distribution between both groups were comparable, with no statistically significant differences. Arterial puncture was significantly higher in the MCSL group (20%) compared to none in the OA-IP group (p=0.02). Hematoma occurrence was slightly higher in the MCSL group (10%) versus the OA-IP group (3.3%), but this was not statistically significant (p=0.612). Pneumothorax was absent in both groups. Catheter displacement occurred only in the OA-IP group (13.3%), though the difference was not statistically significant (p=0.112).First-attempt success rate was significantly higher in the OA-IP group (93.3%) than in the MCSL group (3.3%) (p=0.000).Needle insertion attempts**:** OA-IP group had a higher single-attempt success rate (93.3%) compared to only 3.3% in the MCSL group, which required multiple attempts (p=0.000).Time to locate the vein: OA-IP method was significantly faster (9.7 ± 0.7 sec) compared to MCSL (15 ± 0.78 sec) (p=0.000).Duration of cannulation: OA-IP method was significantly quicker (199.2 ± 13.33 sec) than MCSL (393.2 ± 70.7 sec) (p=0.000).

Conclusion:

The oblique in plane method has a higher first attempt success rate, shorter duration of cannulation and lower incidence of complications. It is a viable and efficient alternative to the modified combined short and long axis method but involves a small learning curve.

Key words:

Central venous catheter, Internal jugular vein, modified combined short and long axis method, oblique in plane method.

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INTRODUCTION

Intravenous access has become an indispensable practice in the daily routine of anesthesiologists, serving as a critical tool for fluid and the administration of medications in addition to monitoring[1]. Central venous catheters, widely used in procedures such as dialysis, have evolved significantly since their inception in the 1800s.A pivotal moment occurred in 1929 when Dr. Werner Forssmann famously self-experimented by inserting a catheter into his own cubital vein and threading it into his right atrium. This groundbreaking, though controversial, act laid the foundation for future developments. The introduction of the “Seldinger technique", named after Dr. Sven-Ivar Seldinger, was a major advancement. This technique, which involves using a guidewire to facilitate catheter insertion, significantly improved the safety and ease of central line placement. Over time, catheter materials and designs have evolved to minimize complications such as infection and thrombosis. In the last 60 years, developments in methodology and equipment have made central venous catheterization a safer procedure for both patients and clinicians[3].Central venous catheter placement using the Seldinger technique with ultrasound guidance has become the norm, increasing success rates and lowering complications.[4] Among the various sites, the IJV is frequently chosen for central venous catheterization, especially in critical cases. This is due to its predictable anatomy, which includes a direct course to the heart and the absence of valves that could obstruct catheter insertion[5]. However, complications such as hematoma, pneumothorax, and injury to adjacent structures can still occur[6].

Historically, IJV cannulation was performed using surface landmark techniques, which were associated with higher rates of complications and lower success rates[7]. To enhance the precision and safety of anesthesia procedures, ultrasound has been integrated into clinical practice. Ultrasound technology has revolutionized the field by enabling real-time visualization of nerves, muscles, and other anatomical structures[8]. With its portability, ease of use, and high-quality imaging, ultrasound has quickly become the gold standard in many regional anesthesia procedures[9]. Recently, it has also been adopted for advanced anesthesiology techniques, such as monitoring depth and assessing characteristics in real-time[10].

By enabling visibility of the vein, surrounding structures, and the needle's course, USG guided central venous cannulation has greatly increased needle placement accuracy and decreased the risk of complications[11].Several approaches for central venous access exist, and identifying the safest and most efficient method is paramount. Two primary ultrasound-guided techniques for IJV cannulation are the modified combined long- and short-axis method and the oblique in-plane technique. The modified combined method uses both short-axis (transverse) and long-axis (longitudinal) views, providing a more comprehensive image of the vein and needle, which can enhance both safety and accuracy[12].

The oblique in-plane method, in contrast, relies on a single, angled view to visualize the needle in the same plane, making it simpler but potentially more difficult to ensure correct needle placement[13].

In a randomized controlled trial conducted over the course of a year, we evaluated the effectiveness of these two ultrasound-guided techniques—the modified combined long- and short-axis method versus the oblique in-plane method—for RIJV cannulation in adult patients. The study assessed the success rates, complication rates, and overall efficacy of each approach[14]. The results of this trial could provide valuable insights into which technique offers the best outcomes for safe and effective central venous access in clinical practice.

AIMS & OBJECTIVES

This study aims to assess and compare two USG-guided methods for internal jugular central venous catheterization: the oblique axis in-plane approach and the modified combination short- and long-axis method. The following criteria will be the main focus of the comparison.

Primary Objective:

- To assess the success rate of cannulation on the first attempt[2].

Secondary Objectives:

- To determine the total number of needle insertion attempts required for[6] successful cannulation[7].
- To evaluate the total time taken to complete the procedure.
- To monitor and report any mechanical complications, including:
    - Arterial puncture[5]
    - Hematoma formation[8]
    - Pneumothorax occurrence[9]
    - Displacement of the catheter[10]

BASIC SCIENCES

Veins are blood vessels responsible for returning deoxygenated blood to the heart. These vessels form an extensive network across the body, facilitating the collection and transportation of blood. In addition to their primary role in circulation, veins are also crucial for providing access for intravenous injection of fluids and medications, which are vital for various medical interventions and procedures[1].

Among the largest veins in the body is the Internal Jugular Vein (IJV), a paired venous structure that plays a critical role in draining blood from essential regions such as the brain, face, and neck[5]. The IJV channels deoxygenated blood toward the heart's right atrium, acting as a primary pathway for venous return[2]. Positioned laterally in the neck, the IJV is a commonly used site for central venous access, particularly for procedures like catheter insertion or hemodialysis. [4]

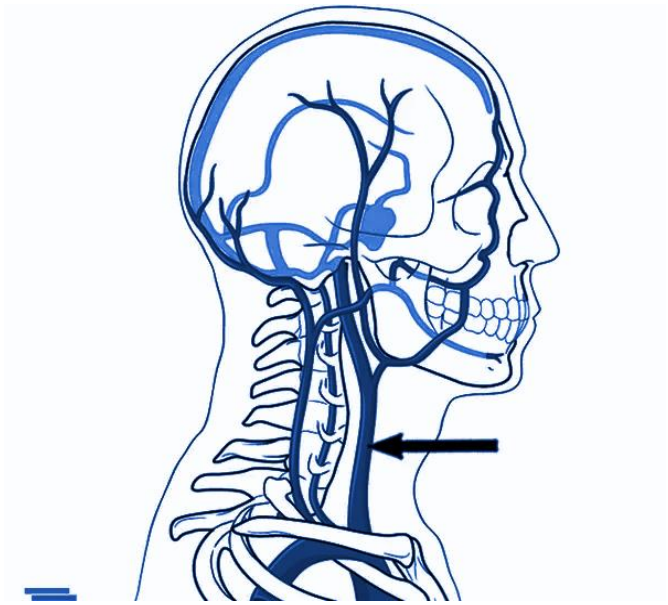


Figure 1-Anatomy of Internal Jugular Vein.

Embryology and Development of the Internal Jugular Vein

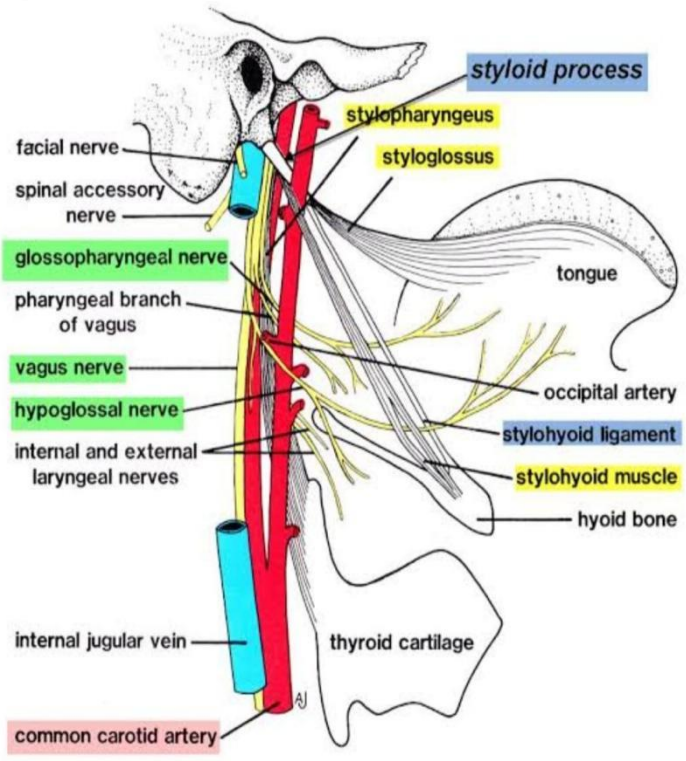


FIGURE 2: JUGULAR FORAMINA ANATOMY

The development of the internal jugular veins can be traced back to early embryological stages, originating from the right and left anterior cardinal veins. These veins are integral to the initial venous system and contribute to the formation of the superior vena cava (SVC), which is responsible for returning deoxygenated blood from the upper body to the heart[18].

Throughout embryogenesis, the anterior cardinal veins undergo several transformations, eventually merging with the common cardinal veins. This fusion contributes to the creation of essential components of the venous system, including the superior vena cava, ensuring the efficient return of blood from the head, neck, and upper extremities to the heart[8].

The internal jugular vein (IJV) develops as an extension of the sigmoid sinus, a key part of the dural venous sinus system within the brain. The sigmoid sinus, located within the cranial cavity,

collects venous blood from the brain and is joined by smaller venous channels, including the superior and inferior petrosal sinuses, which also drain blood from the brain[16].

As the sigmoid sinus transforms into the internal jugular vein, it exits the skull through the jugular foramen, a significant opening at the base of the skull. This foramen allows not only the internal jugular vein but also several cranial nerves (IX, X, and XI) to pass into the neck[15]. Upon leaving the cranium, the IJV travels down the neck, where it plays a vital role in draining blood from the brain, face, and certain regions of the neck[5].

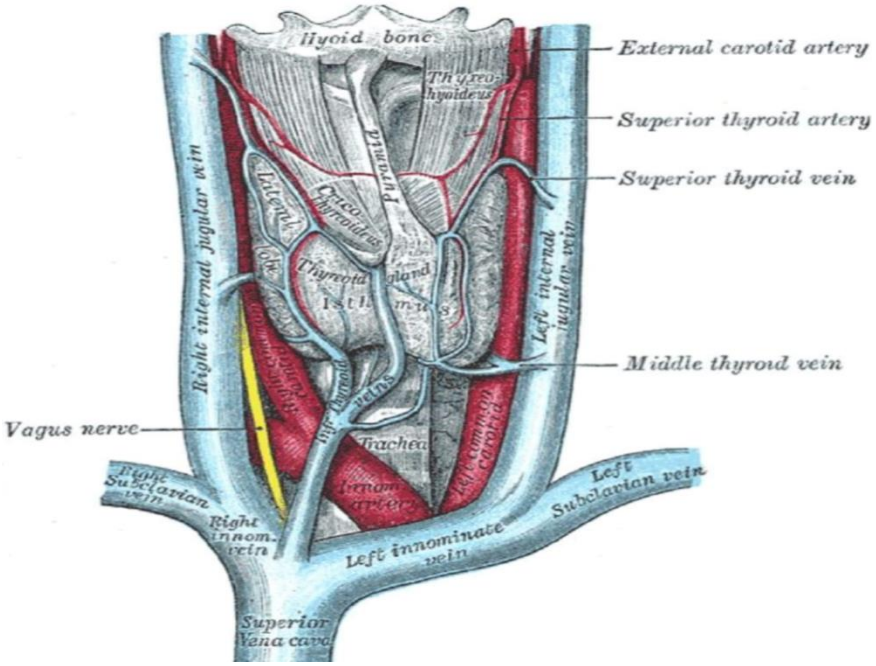


FIGURE 3: COURSE OF IJV

The internal jugular vein is an essential part of the venous system, playing a significant role in both its function and anatomy[8]. During embryonic development, it originates from the anterior cardinal veins and becomes a key component of the venous circulation that facilitates the return of blood to the heart[16]. Its connection to structures like the sigmoid sinus and the jugular foramen underscores its critical role in draining blood from the brain and upper body[17].

On the right side, the internal jugular vein (IJV) travels downward and eventually merges with the right subclavian vein to form the right brachiocephalic vein near the sternoclavicular joint[8]. The right brachiocephalic vein subsequently empties into the superior vena cava (SVC)[15].

Throughout its path, the right IJV is positioned laterally to the internal carotid artery (ICA), common carotid artery (CCA), and the vagus nerve (cranial nerve X), all of which are surrounded by a fibrous structure called the carotid sheath[15].

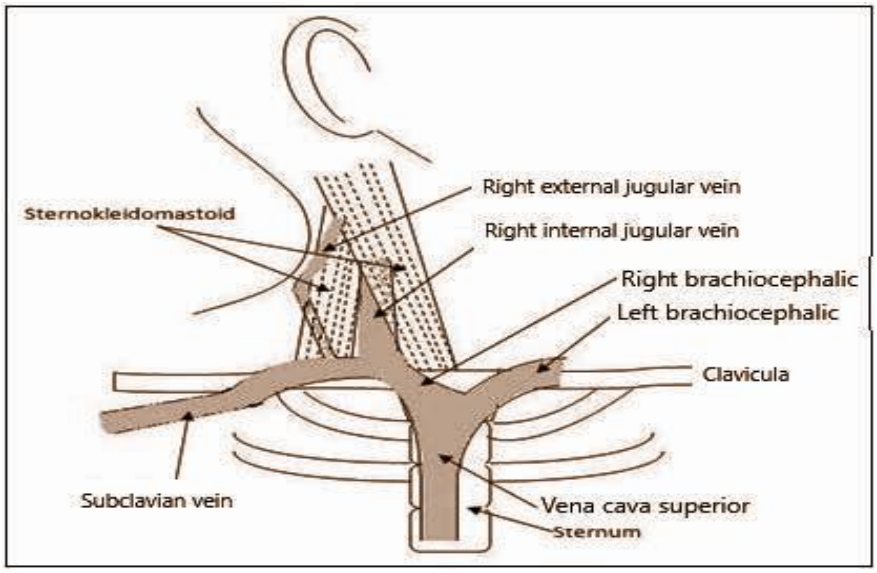


FIGURE 4: IJV COURSE ON LEFT AND RIGHT

At the distal end of the right internal jugular vein (IJV), near the lower clavicular region, there is an inferior bulb, which contains one-way valves that help prevent the backward flow of blood[8].

The left internal jugular vein also descends vertically and joins the left subclavian vein to form the left brachiocephalic vein at the level of the left sternoclavicular joint[17]. This vein then crosses to the right side of the body and merges with the superior vena cava (SVC) at an angle[15]. The left IJV follows a more tortuous path due to two bends along its course, making it more winding compared to the right IJV[8]. Furthermore, the left IJV is positioned more medially than its right counterpart[17].

Similar to the right IJV, the left IJV contains both a superior and an inferior bulb, each equipped with valves that facilitate the correct direction of blood flow[8].

THE CAROTID SHEATH

The carotid sheath is a fibrous connective tissue structure that encases and provides protection to vital vascular and nervous components in the neck. It is created by the condensation of fibroareolar tissue[17].

Anatomically, the carotid sheath is formed anteriorly by the pretracheal fascia and posteriorly by the prevertebral fascia[8] (Fig. 5).

Contained within the carotid sheath are the following structures:

- Internal jugular vein (IJV)[17]
- Internal carotid artery (ICA)[17]
- Vagus nerve (cranial nerve X)[17]

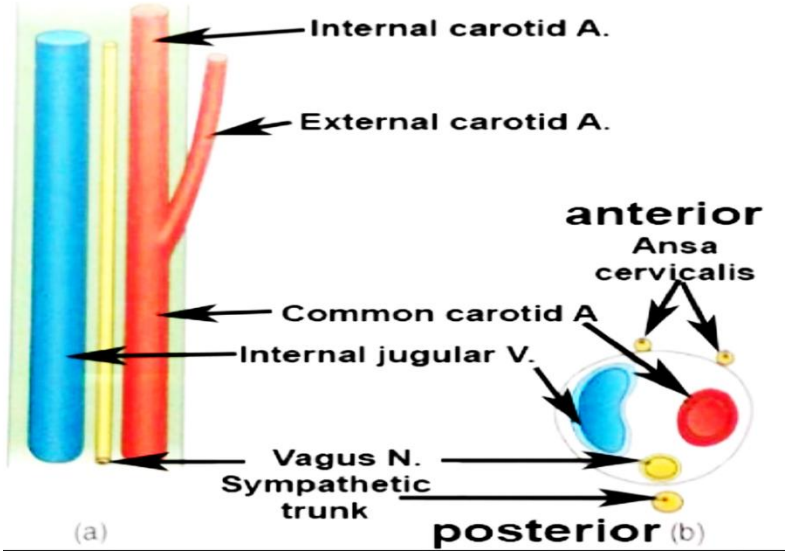


FIGURE 5: CAROTID SHEATH ANATOMY

Relations of the Internal Jugular Vein (IJV)

The anatomical relationships of the internal jugular vein (IJV) are essential for minimizing complications during procedures such as catheter insertion[8]. The IJV's position is relatively consistent and can be located by drawing an imaginary line from the midpoint between the mastoid process and the angle of the mandible, extending down to the sternoclavicular joint[17].

Right IJV:

At the base of the skull, the common carotid artery (CCA) is situated anterior to the right IJV[17]. As the vein travels downward, the artery moves medially, positioning itself closer to the vein[8].

Left IJV:

On the left side, the relations are similar, with the left IJV also shifting medially during its descent[8]. In some instances, it may be positioned very near to or even overlap with the common carotid artery (CCA)[17].

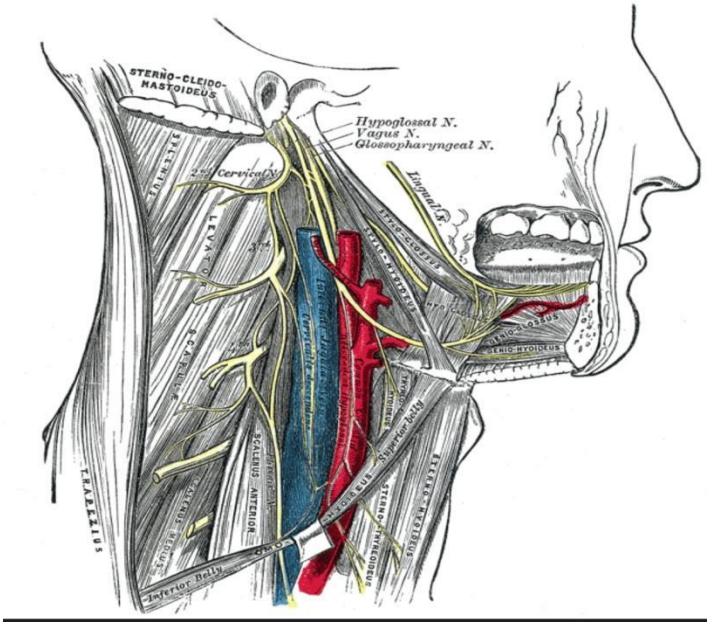


FIGURE 6: RELATIONS OF IJV

Superficial Relations of the Internal Jugular Vein (IJV)

From top to bottom, several structures lie superficial to the IJV, including:

Muscles:

- The posterior belly of the digastric muscle (upper part) [17]
- The superior belly of the omohyoid muscle (lower part) [8]
- The sternocleidomastoid muscle[17]

Arteries:

- The occipital artery[8]
- The posterior auricular artery[17]

Veins:

- The anterior jugular vein[8]

Nerves:

- The spinal accessory nerve[17]
- The Ansa cervicalis[8]

Bony Structure:

- The styloid process

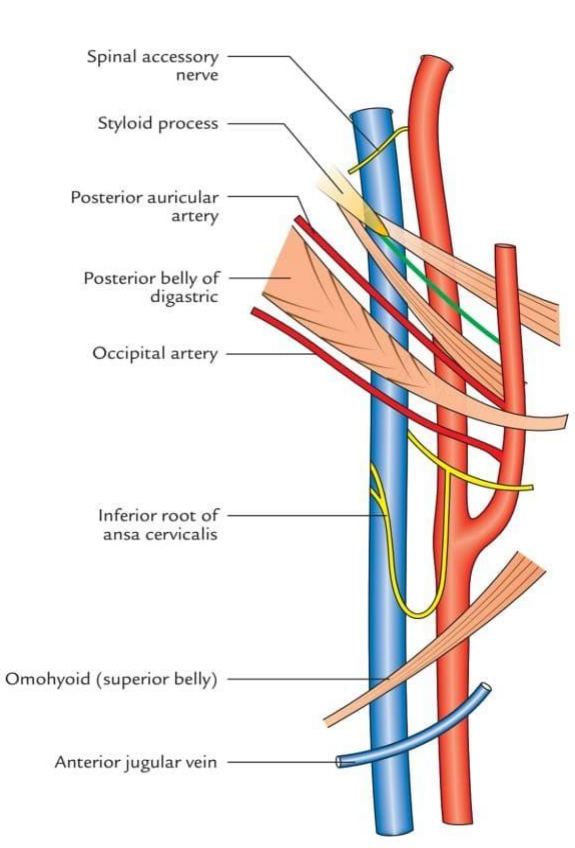


FIGURE 7: SUPERFICIAL RELATIONS OF IJV

The Internal Jugular Vein (IJV) is closely associated with several **deep structures.** These include:

- **Rectus capitis lateralis**: A muscle located next to the cervical spine, contributing to head movement.
- **Transverse process of the atlas**: The bony protrusions on the first cervical vertebra (C1).
- **Levator scapulae**: A muscle that aids in elevating the scapula.
- **Scalenus medius and cervical plexus**: The scalenus medius is a muscle involved in neck movement, while the cervical plexus is a network of nerves supplying the neck and diaphragm.
- **Scalenus anterior and the phrenic nerve:** The scalenus anterior is a muscle involved in breathing, and the phrenic nerve controls the diaphragm.
- **Thyrocervical trunk and vertebral artery's initial segment**: The thyrocervical trunk is a branch of the subclavian artery supplying the neck, and the vertebral artery supplies blood to the brain.
- **First segment of the subclavian artery**: This major artery supplies blood to the upper limbs and neck.
- **Thoracic duct (on the left side):** The thoracic duct is the main vessel responsible for draining lymph from the body's lower limbs and abdomen into the venous system.

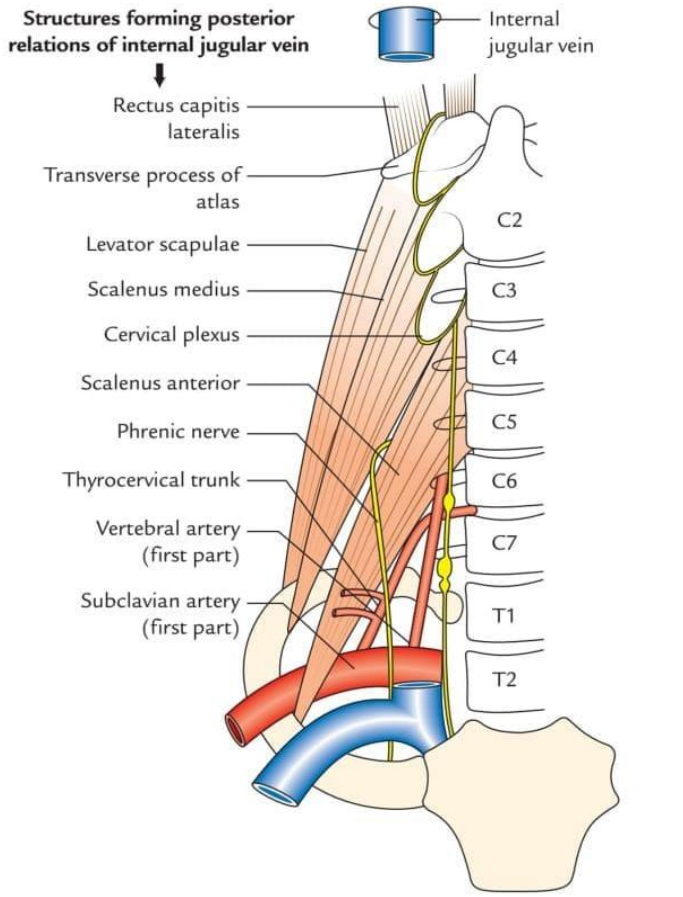
The **medial relations** of the Internal Jugular Vein (IJV) can be divided into its upper and lower courses:

- **Upper Course:**
    - **Internal Carotid Artery (ICA):** The ICA runs medially to the IJV, supplying blood to the brain.
    - **Cranial Nerves IX, X, XI, and XII:** These include:
        - **Glossopharyngeal nerve (IX)**
        - **Vagus nerve (X)**
        - **Accessory nerve (XI)**

- **Hypoglossal nerve (XII)**

  These nerves pass close to the IJV and are involved in various functions such as speech, swallowing, and movement of the head and neck.

FIGURE 8: DEEP RELATIONS OF IJV



- **Lower Course:**
    - **Common Carotid Artery (CCA):** The CCA is located medially to the IJV and supplies blood to the neck, face, and head.
    - **Vagus Nerve (X):** The vagus nerve continues its path in the lower course and is positioned medially to the IJV, playing a key role in parasympathetic innervation throughout the body.

The **sternocleidomastoid (SCM)** muscle has the following anatomical features:

- **Origin**:
    - It originates from two locations:
        - The **manubrium of the sternum**.
        - The **clavicle**.
- **Insertion**:
    - The SCM inserts at the **mastoid process** of the temporal bone[17].

The muscle's two points of origin create a triangular region, with the **clavicle** forming the base. This triangular space is known as **Sedillot's triangle**[8]. The **Internal Jugular Vein (IJV)** descends through the neck and passes beneath the apex of this triangle on both sides[17].

This anatomical relationship makes **Sedillot's triangle** an important landmark, especially when inserting a **central venous catheter**, as it helps guide the placement of medical instruments in this region[8]

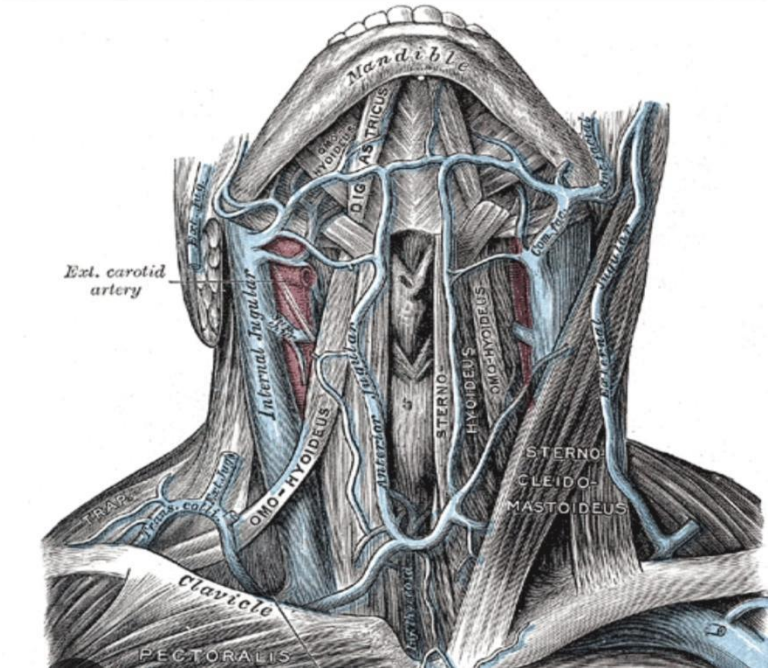


FIGURE 9 STERNOCLEIDOMASTOID AND SELLIDOTS TRIANGLE

The **external jugular vein (EJV)** is formed by the union of the **posterior branch of the retromandibular vein** and the **posterior auricular vein**. It is responsible for draining blood from regions outside the cranium, including the **face** and **neck**[17].

- The EJV originates in the **parotid gland**, near the angle of the mandible, and proceeds downward, typically at a right angle to the neck[8].
- It runs superficially, passing over the **sternocleidomastoid (SCM)** muscle, and eventually pierces the deep fascia[17].
- The vein drains into the **subclavian vein**[8].

Throughout its course, the EJV contains two pairs of **valves**, which help regulate blood flow[17].

An important anatomical landmark for procedures like **internal jugular vein (IJV) catheterization** using the posterior approach is where the EJV crosses the **clavicular head of the SCM**, usually at the upper border of the **thyroid cartilage**. This location aids in guiding medical professionals during the catheterization process[8].

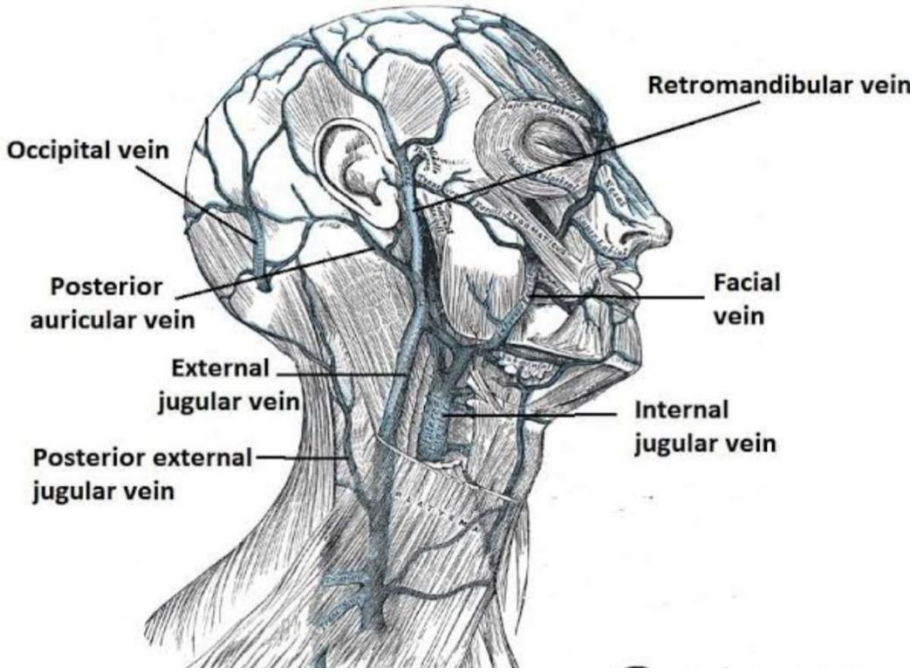


FIGURE 10: EXTERNAL JUGULAR VEIN ANATOMY

Central venous cannulation involves the insertion of a catheter into a large vein, ideally positioned at the atrio-caval junction within the proximal superior vena cava, right atrium, or proximal inferior vena cava[1]. This optimal placement reduces the risk of thrombosis due to the high blood flow in these areas[4]. When properly managed and free from infection, a central line can remain in place for extended periods, ranging from weeks to months[6].

Applications:

- **Drug Administration:**
    - Long-term medications, such as antibiotics and total parenteral nutrition (TPN)
    - Chemotherapy drugs
    - Irritant drugs (e.g., potassium chloride and calcium chloride) that can damage peripheral veins
    - Vasopressors and inotropes
    - Large-volume blood transfusions

- **Therapeutic Procedures:**
    - Hemodialysis
    - Plasmapheresis
    - Extracorporeal membrane oxygenation (ECMO)
    - Cardiac catheterization
- **Intravenous Access:**
    - Long-term or frequent IV access
    - Frequent blood draws
    - Difficulty establishing peripheral IV access

- **Monitoring:**
    - Central venous pressure (CVP)
    - Pulmonary capillary wedge pressure (PCWP)

Relative Contraindications:

- Thrombosed or narrowed veins
- Severe coagulopathy or low platelet count
- Infection at the insertion site
- Trauma at the insertion site (e.g., clavicle fractures for subclavian line)
- Burns at the insertion site
- Uncooperative patients or patient refusal

This procedure is essential for various medical treatments, offering a reliable and effective means of accessing the venous system for both long-term care and monitoring.

Types of Central Venous Catheters (CVCs):

1. **non-tunneled catheters**:
    - These catheters exit the skin directly at the venipuncture site and are secured with sutures[1].
    - Made of **polyurethane**, they typically measure **20-30 cm** in length and have a caliber up to **8.5fr**[1].
    - Placed via **direct vein puncture**, with the catheter tip positioned at the **atrio-caval junction**[4].
    - Designed for **short-term**, continuous use in **hospitalized patients**[1].
2. **Tunneled catheters**:
    - These catheters are inserted subcutaneously for a distance before entering the vein[4].
    - The subcutaneous tunneling enhances **durability** and **infection resistance**, making them suitable for **long-term use** (from months to years)[6].
    - Commonly used for **intermittent, long-term therapies**, such as **chemotherapy**[4].
3. **Peripherally inserted central catheters (piccs)**:
    - Inserted through a **peripheral vein** in the arm (e.g., **cephalic** or **basilic veins**) and advanced until the tip is positioned at the **atrio-caval junction**[1].
    - Made of **polyurethane**, piccs are typically **50-60 cm** long with smaller calibers (up to **5fr**).
    - Not ideal for **large-volume resuscitation** due to their smaller size.
    - Suitable for **intermittent use** for drug or antibiotic administration and can remain in place for weeks or months[4].
    - The long subcutaneous course and exit point in the arm allow for **home use**[6].
    - **Picc lines** are easy to insert, have a **low complication rate**, and are commonly used in **children** due to their simplicity and comfort[4].

These catheters provide critical access for various medical treatments, with each type having specific advantages for short- or long-term care depending on patient needs[4].

Complications of Central Venous Cannulation can be divided into **immediate** and **delayed** categories:

Immediate Complications:

1. **Failure to Cannulate the Vein**: Difficulty in accessing the vein may occur, requiring repositioning or alternative techniques[4].
2. **Arterial Puncture**: Accidental puncture of an artery instead of a vein, which can lead to bleeding.
3. **Local Hematoma**: A collection of blood at the insertion site due to vessel injury.
4. **Pneumothorax**: Accidental puncture of the pleura, leading to air in the pleural space and lung collapse.
5. **Hemothorax**: Blood entering the pleural cavity, often due to vascular injury.
6. **Guidewire-Induced Arrhythmia**: The introduction of the guidewire may trigger irregular heart rhythms[4].
7. **Thoracic Duct Injury (Left Side)**: Damage to the thoracic duct can occur, particularly on the left side, leading to chyle leakage.
8. **Air Embolism**: Introduction of air into the bloodstream, which can be life-threatening if it reaches the heart or lungs[4].

Delayed Complications:

1. **Catheter Site Infection**: Infections at the insertion site or along the catheter[6].
2. **Vascular Erosion**: The catheter can erode into surrounding structures, potentially leading to serious complications[6].
3. **Vessel Stenosis**: Narrowing of the vein due to prolonged catheter placement or injury during insertion[6].
4. **Thrombosis of the Vein**: Formation of blood clots inside the vein, which may lead to occlusion or embolism[6].

These complications can vary in severity and require prompt identification and management to prevent further complications. Proper technique, sterile precautions, and careful monitoring can minimize risks[4].

Seldinger Technique: Developed by Dr. Sven Ivar Seldinger in 1953, the **Seldinger technique** is a widely used procedure for safely accessing blood vessels and hollow organs[4]. The steps involved are:

1. **Needle Insertion**: The target vessel is punctured with a needle.
2. **Guidewire Insertion**: A guidewire is inserted through the needle.
3. **Needle Removal**: The needle is removed, leaving the guidewire in place.
4. **Tract Dilation**: The tract is dilated to facilitate catheter insertion.
5. **Catheter Placement**: A catheter is threaded over the guidewire into the target vessel or organ.

This technique is essential in many interventional radiology procedures and is used for:

- Central venous catheter placement
- Chest drain insertion
- Pacemaker/ICD lead insertion
- Percutaneous enteral gastrostomy tube insertion
- Digital subtraction angiography
- Landmark Technique
- Relies on anatomical landmarks: This technique involves identifying anatomical landmarks on the body surface to locate the target vessel. The needle is then inserted based on these landmarks[7].
- Blind puncture: Landmark technique is often referred to as a "blind puncture" because it relies on external landmarks rather than real-time visualization of the vessel[7].

- **Higher risk of complications:** Compared to the Seldinger technique, the landmark technique has a higher risk of complications such as arterial puncture, hematoma formation, and infection[6].

FEATURE	SELDINGER TECHNIQUE	LANDMARK TECHNIQUE
GUIDANCE	Guide wire	Anatomical landmarks
TRAUMA	Reduced Trauma	More Traumatic
VERSATILITY	Versatile	Limited
RISK OF COMPLICATIONS	Lower	Higher

Internal Jugular Vein (IJV) Cannulation Approaches:

Several approaches can be used to cannulate the **Internal Jugular Vein (IJV)**, such as **anterior**, **central**, and **posterior** methods[4]. Important anatomical landmarks for IJV cannulation include:

- The two heads of the **sternocleidomastoid (SCM)** muscle
- The **external jugular vein**
- The **clavicle**

- The **sternal notch**

Typically, the patient is positioned **supine**, with the head turned **45 degrees to the left** and placed in the **Trendelenburg position** to help distend the IJV[1]. The needle is inserted at an

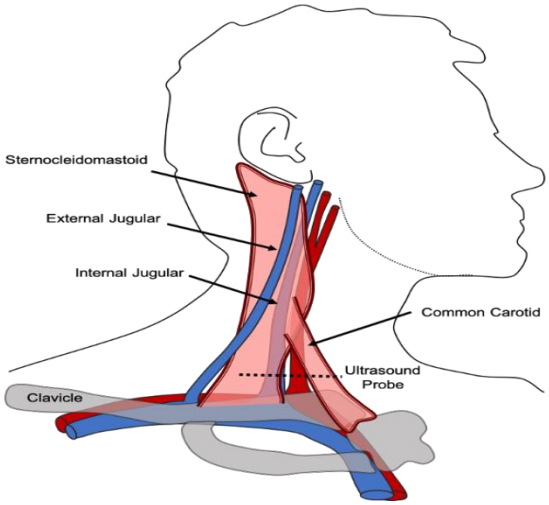


FIGURE 11 IJV APPROACHES

angle of **20-30 degrees** towards the **sagittal plane** once the vein is identified[4]. Upon

aspirating **dark blood**, venous access is confirmed[4]. Next, the **guidewire** is inserted, the needle removed, and a **dilator** and **catheter** are advanced over the guidewire[4].

This technique is critical in ensuring safe and effective **venous access**[4].

Ultrasound-guided internal jugular vein (IJV) catheterization has several approaches[8]. While the short-axis out-of-plane method offers clear visualization of the IJV and common carotid artery (CCA), it carries a risk of posterior vessel wall puncture and arterial puncture because the entire needle isn't visible[11]. The long-axis in-plane method allows visualization of the entire needle, including the tip, but is challenging in patients with short necks and requires precise needle placement within the narrow ultrasound beam, increasing the risk of arterial puncture if the needle deviates from the probe[10].

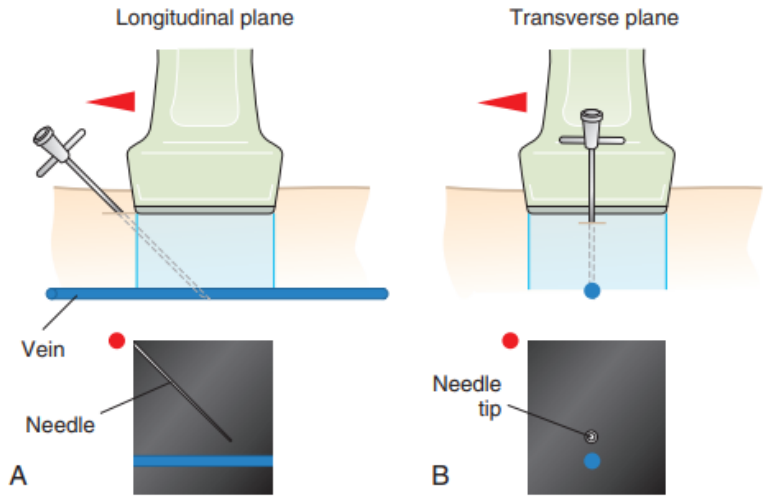


FIGURE 12: DIFFERENT PLANES ON USG

The oblique-axis in-plane (OA-IP) method, introduced by Phelan et al. in 2009, aims to combine the benefits of both short-axis and long-axis methods. It provides an elongated view of the IJV and CCA. Current research compares modified short-axis and long-axis methods with the OA-IP method to determine the safest and most effective IJV puncture technique[18].

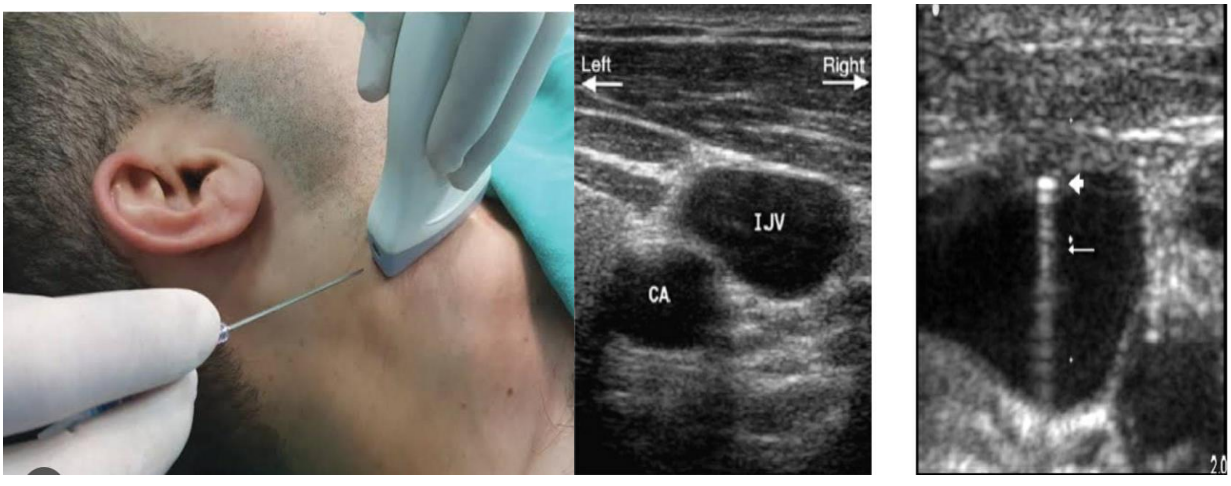


FIGURE 13: OBLIQUE AXIS IN PLANE METHOD.

The modified combined short and long axis (MCSL) method integrates the advantages of the modified short-axis out-of-plane (MSA-OOP) and the combined short-axis long-axis (CSLA) approaches. This allows for accurate needle placement and visualization of the entire needle

during IJV catheterization[12].This study aims to compare the MCSL and OA-IP methods to determine which has a higher first-attempt success rate for right IJV catheter placement[14].

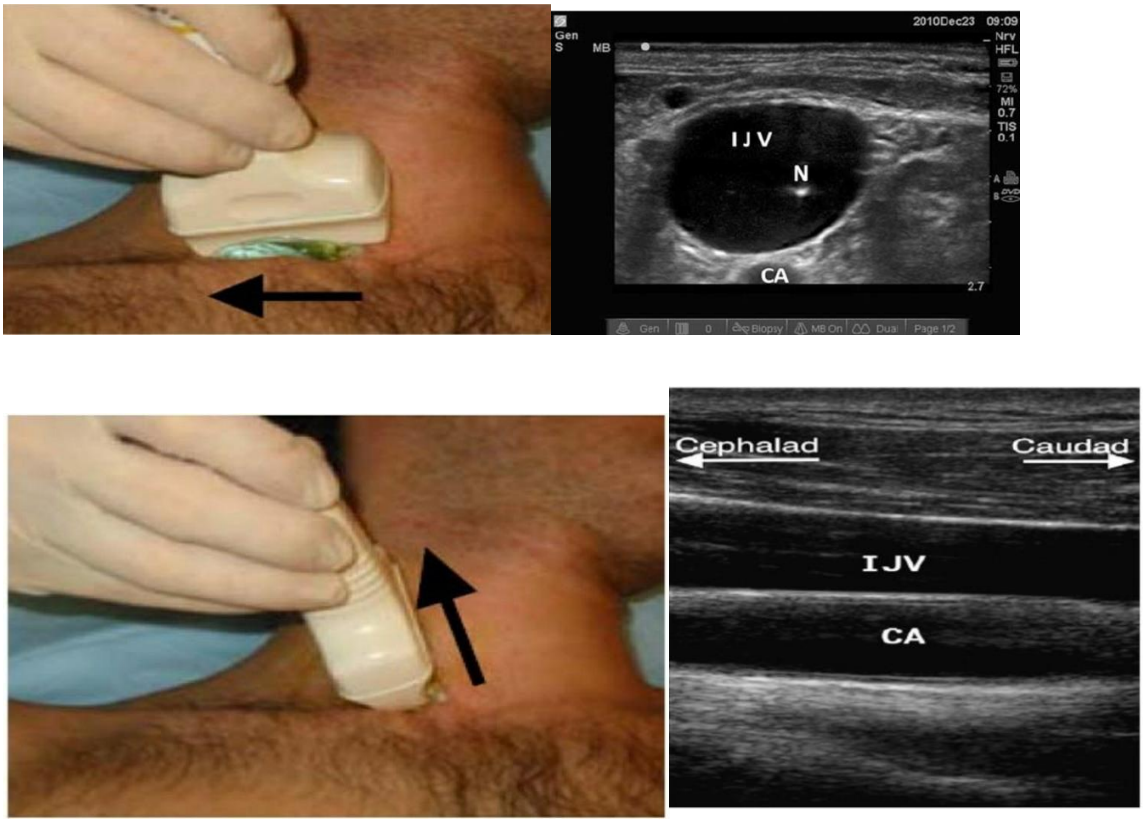


FIGURE 14 MODIFIED COMBINED LONG AND SHORT AXIS.

Central Venous Catheter Development:

Central venous catheters have evolved significantly since their initial use in 1929[2]. Werner Forrsmann's pioneering work involved self-catheterization, which, while initially rejected in his home country, spurred development in the USA[2]. The ability to perform cardiac catheterization in the 1950s and 1960s further fueled catheter development[4]. Material improvements to reduce inflammation, multi-lumen designs for simultaneous administration of incompatible medications, and larger catheters for hemodialysis have all contributed to the modern CVC[3]. Ultrasound guidance has become the standard of care for CVC insertion, improving success rates and reducing complications compared to landmark-based techniques[4]. Many companies, such as ARROW, manufacture CVC kits[1].

Central Venous Catheter Characteristics:

- **Length and Caliber:** CVCs range from 2 to 12 inches in length and 4Fr to 12Fr (240 to 16G) in caliber, accommodating both pediatric and adult patients.
- **Material:** Typically made of polyurethane, newer catheters may have antibacterial coatings like chlorhexidine or silver sulfadiazine. The material is flexible and kink-resistant.
- **Lumen/Ports:** Modern CVCs have up to four lumens, allowing simultaneous administration of multiple medications.
- **Kit:** A typical CVC kit includes a puncture needle, J-tip guidewire, dilators, a blade, the catheter itself, and sometimes suture material and drapes.
- **Parts:** A multi-lumen catheter has a hub with suture holes, color-coded lumens, clamps, luer connectors, injection caps, and the individual lumens themselves.

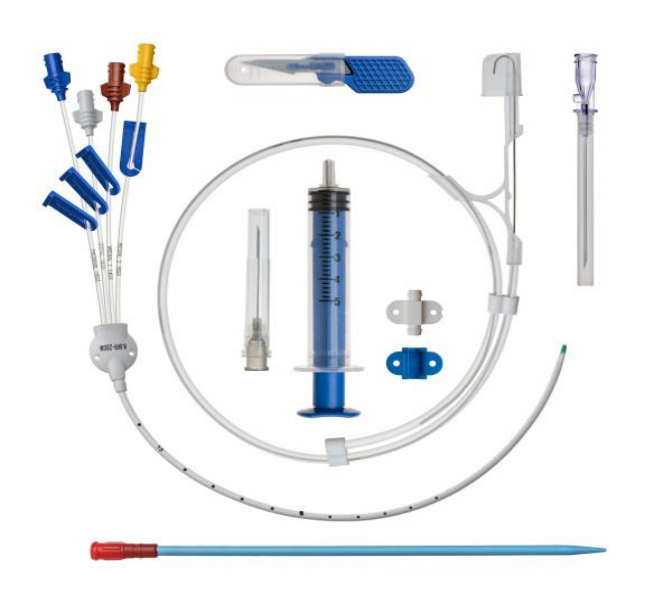


FIGURE 15: CENTRAL VENOUS CANNULATION KIT.

Ultrasound

Pythagoras, in the 6th century BC, described sound wave characteristics through his work on stringed instrument harmonics[2]. Later, in the late 18th century, Lazzaro Spallanzani's echolocation studies in bats significantly advanced our understanding of sound waves[3].

A pivotal moment came in 1880 when Pierre and Jacques Curie discovered the piezoelectric effect in certain materials, a cornerstone of ultrasonography[4]. Subsequent developments, including sonar (Fessenden and Langevin) and radar (Watson-Watt), furthered our knowledge of ultrasound physics. Medical ultrasound emerged in the late 1940s thanks to the work of George Ludwig and John Wild in the US, and Karl Theodore Dussik in Europe[1].

Basics of Ultrasound

Ultrasound uses sound waves with frequencies above the human hearing range[4] (>20 kHz). Medical ultrasonography typically employs frequencies between 1 and 15 MHz[1].

Ultrasound transducers contain piezoelectric material, typically a synthetic ceramic like lead zirconate titanate (PZT)[4]. Applying a rapidly alternating electrical voltage to this material causes it to expand and contract, generating sound waves. This conversion of electrical energy to mechanical vibrations is the *reverse piezoelectric effect*[4]. The mechanical properties of the PZT determine the range of frequencies the transducer can produce[4].

These sound waves propagate through a medium by creating compressions and rarefactions (areas of high and low density) of particles. When the waves encounter different tissues, some are reflected back to the transducer as echoes. The transducer then converts these mechanical vibrations (echoes) back into electrical signals—the *direct piezoelectric effect*[4]. A computer processes these electrical signals, and based on their amplitude, creates a grayscale image displayed on the ultrasound screen[1].

Key ultrasound wave parameters include frequency, wavelength, velocity, power, and intensity[19]. Frequency (f), measured in hertz (Hz), is the number of sound wave cycles per second. It's related to wavelength (λ) and propagation speed (c) by the formula: $f = c/\lambda$. Frequency depends on the piezoelectric crystal properties, while propagation speed is determined by the tissue's density and stiffness[4]. The average propagation speed in soft tissues is 1540 m/s[1].

Two key factors in ultrasonography are penetration depth and image resolution (sharpness), which is related to wavelength[19]. Shorter wavelengths (higher frequency) provide better resolution but less penetration, while longer wavelengths (lower frequency) offer deeper penetration but lower resolution[1]. Choosing the right transducer frequency involves balancing axial resolution and penetration.

Higher frequencies are used in linear-array transducers for superficial structures like blood vessels, soft tissues, and joints. Lower frequencies are used in curvilinear and phased-array transducers to visualize deeper structures in the chest, abdomen, and pelvis.

In ultrasound, average power measures the total energy delivered to a tissue over a specific time (watts). Intensity describes the power concentrated within a given area (watts per square centimeter). Tissue heating from ultrasound is primarily determined by intensity[19].

Resolution

While diagnostic ultrasound imaging typically produces negligible heat when used with recommended settings, heat generation becomes a critical factor in therapeutic ultrasound Image resolution in ultrasound has four components: axial, lateral, elevational, and temporal[1].

- **Axial Resolution:** This is the ability to distinguish two objects along the ultrasound beam's path (vertical resolution on the screen)[1]. It's directly related to transducer frequency: higher frequencies lead to better axial resolution but shallower penetration.

- **Lateral Resolution:** This refers to the ability to distinguish two objects perpendicular to the ultrasound beam (horizontal resolution)[1]. It depends on the beam's width at a specific depth. Optimal lateral resolution is achieved by placing the target structure within the ultrasound beam's focal zone—the narrowest, highest-intensity part of the beam. Lateral resolution worsens with increasing depth due to beam divergence and scattering[1].

- **Elevational Resolution:** This is an inherent property of the transducer, representing the ability to resolve objects within the beam's height/thickness[4]. It's influenced by the number and sensitivity of the PZT crystals[4].

- **Temporal Resolution:** This describes the clarity of moving structures in the image.

The Ultrasound Transducer: Source of Waves and Image

The ultrasound transducer generates and receives ultrasound waves[4]. It contains a piezoelectric crystal that converts electrical current into mechanical (ultrasound) energy. This energy is transmitted to tissues as pulsatile, longitudinal, mechanical waves[4]. The transducer also receives reflected waves from the tissues. The transducer is a critical component, as it dictates the characteristics of the emitted, received, and processed energy[1].

Selecting an Ultrasound Transducer

Transducer selection depends on frequency, array configuration, and footprint[1].

Frequency

- **High-Frequency (above 10 MHz):** Best for superficial structures (<3 cm). Excellent resolution but limited penetration due to attenuation. Used for superficial structures like peripheral nerves and vessels[1].
- **Mid-Range (5-10 MHz):** Used for structures 3-6 cm deep. Offers a balance between resolution and penetration. Suitable for structures like the infraclavicular brachial plexus and deeper vessels[1].
- **Low-Frequency (below 5 MHz):** Used for deeper structures. Provides better penetration but lower resolution. Commonly used in obstetrics, spinal imaging, and for patients with high BMI[1].

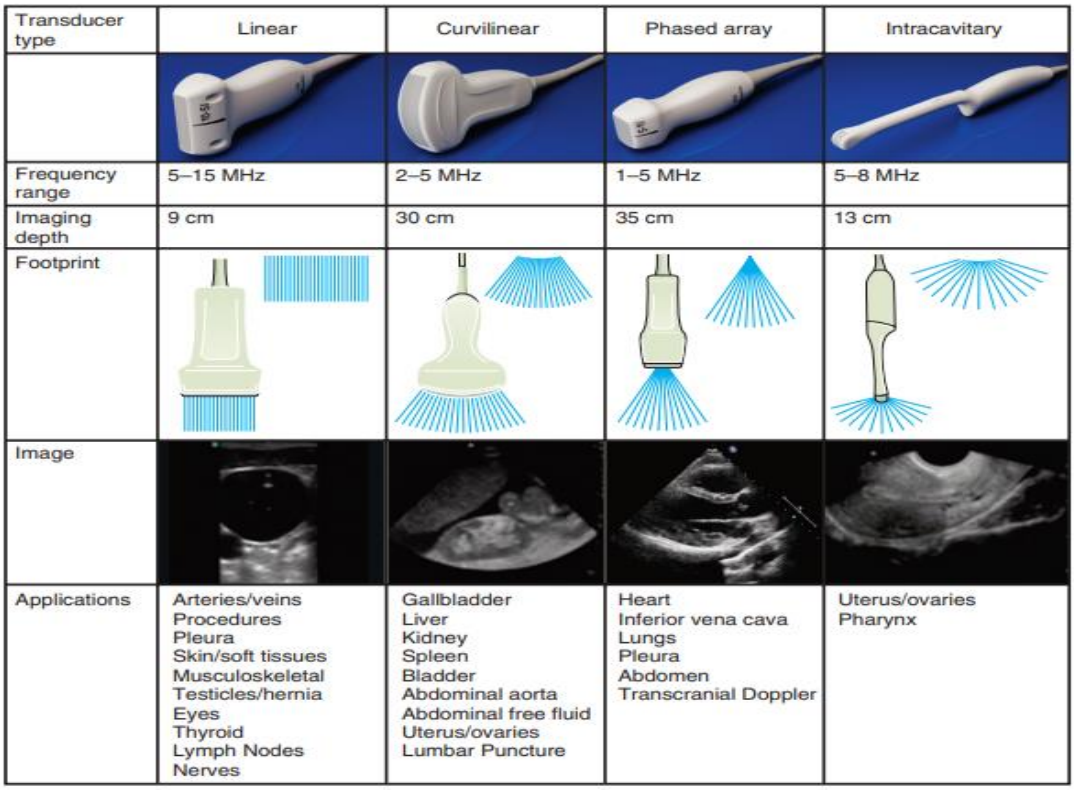


FIGURE 16: DIFFERENT TYPES OF USG PROBES.

Array Configuration:

- **Linear Array:** Elements arranged in a line, providing a uniform rectangular image[1].
- **Curved Array:** Elements arranged along a convex surface, creating a fan-shaped beam that widens with depth. Useful for visualizing structures behind obstructing anatomy (e.g., clavicle)[1]. However, lateral resolution may be slightly reduced compared to linear arrays at the same frequency and diameter[19]

Footprint

The transducer's physical size is chosen based on the anatomical area being scanned[1]. The ideal combination of footprint, array configuration, and frequency is determined by patient-specific factors[19].

Ultrasound Artifacts

Ultrasound artifacts are visual misrepresentations in ultrasound images that don't correspond to actual anatomical structures[1]. Understanding these artifacts is crucial for accurate image interpretation and diagnosis[19]. They arise from violations of fundamental assumptions about ultrasound wave behavior[4].

Fundamental Assumptions of Ultrasound:

- Constant sound speed (1540 m/s) in all tissues.
- Single, uniform ultrasound beam.
- Straight-line wave travel and echo return.
- Uniform attenuation.
- Echo amplitude related to reflector properties and distance.
- Negligible image processing time[4].

When these assumptions are violated, artifacts occur. They can be categorized by their underlying mechanisms: wave propagation, beam characteristics, velocity errors, or attenuation.

Artifacts of Wave Propagation:

Reverberation: Occurs at interfaces with large acoustic impedance differences (e.g., air, metal, calcium) [1]. Multiple reflections between highly reflective structures create a series of bright, parallel lines at uniform intervals, decreasing in brightness with depth[19].

A-lines: A classic example in the lung, caused by reflections between the pleural surface and the transducer.

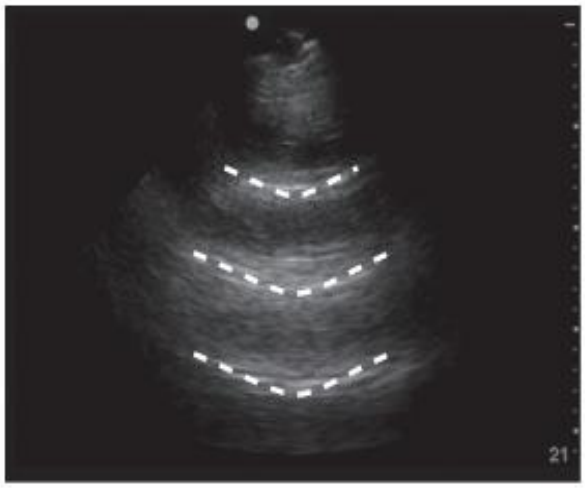


FIGURE 17. A LINES ON USG

Comet-tail: Bright tapering vertical lines from closely spaced reverberations (e.g., in lung).

Ring-down: Vertical white band from resonant vibrations in air bubbles within fluid (e.g., abscesses).

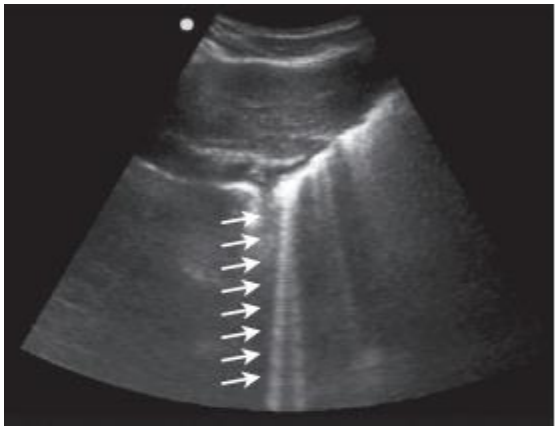


FIGURE 18 RING DOWN ARTIFACTS.

Minimizing Reverberation: Tilting the transducer, decreasing transducer-object distance, tissue harmonic imaging (THI - enhances comet-tail), spatial compounding (reduces comet-tail and ring-down[1]).

- **Mirror-Image:** A false image appears deeper than the real structure due to reflections between the transducer, a strong reflector (e.g., diaphragm), and the target. Changing the angle of insonation and decreasing gain can reduce this.
- **Refraction:** Bending of sound waves at oblique angles between tissues with different sound speeds. Most pronounced at fat-soft tissue interfaces[4].

  Edge Shadowing (Lateral Cystic Shadowing): A refractive shadow at the edges of curved specular reflectors (e.g., gallbladder). Changing the angle of insonation can help differentiate it from true shadowing[1].
- **Side and Grating Lobes:** Secondary lobes projecting from the main beam. Strong reflectors within these lobes create artifacts[4].

  Minimizing Side/Grating Lobes: Decreasing gain, THI, repositioning, changing angle, apodization (reduces side lobes).
- **Beam-width and Slice-thickness:** Related to limitations in lateral and elevational resolution. Structures may appear stretched or fused.

  Minimizing Beam-width/Slice-thickness: Adjusting focal zone depth, standoff pads[1].

Artifacts of Attenuation:

- **Acoustic Shadowing:** A hypoechoic region distal to highly attenuating structures (e.g., bone, stones). Useful for diagnosing stones but can obscure deeper structures. Higher frequencies and THI enhance shadowing[4].

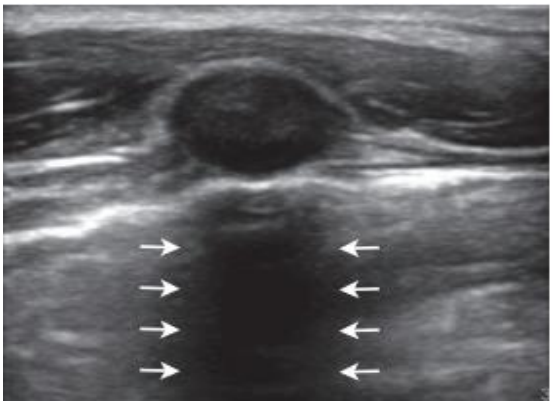


FIGURE 19. ACOUSTIC SHADOWING.

Acoustic Enhancement: A hyperechoic region distal to low-attenuating structures (e.g., fluid-filled bladder). Sound travels unimpeded through the fluid, resulting in stronger echoes from deeper tissues. Decreasing far-field gain can reduce enhancement. THI increases it.

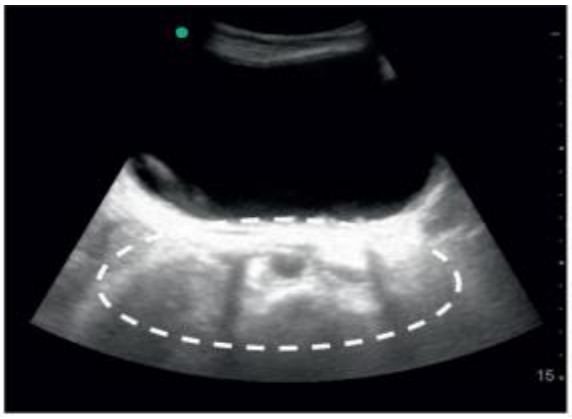


FIGURE 20: ACOUSTIC ENHANCEMENT

Doppler Imaging and Doppler Shift

Doppler imaging uses the Doppler effect to visualize and measure blood flow. The Doppler effect is the change in frequency of a wave due to the relative motion between the source and the observer. In [1] ultrasound, the moving blood cells act as the "observer[4]."

When ultrasound waves encounter moving blood cells, the frequency of the reflected waves changes. This change in frequency is called the *Doppler shift*.

- **Positive Doppler Shift:** When blood flows *towards* the transducer, the reflected wave has a *higher* frequency.
- **Negative Doppler Shift:** When blood flows *away* from the transducer, the reflected wave has a *lower* frequency.

Color Doppler uses these frequency shifts to represent blood flow direction and velocity. Typically:

- **Red:** Indicates flow *towards* the transducer.
- **Blue:** Indicates flow *away* from the transducer.

The brightness of the color represents the velocity of flow. Doppler ultrasound is essential for assessing blood flow in vessels, detecting stenosis (narrowing), and identifying other vascular abnormalities[4].

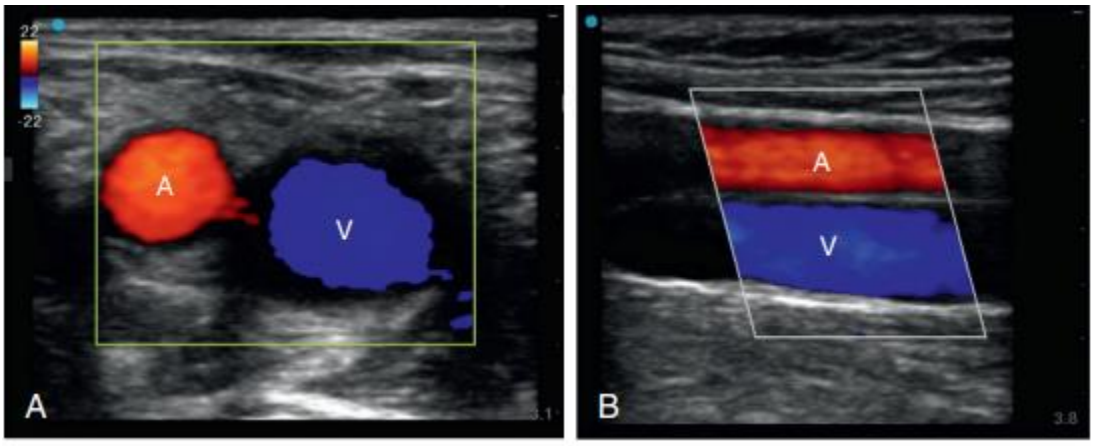


FIGURE 21: COLOR FLOW DOPPLER SHOWING FLOW AND VELOCITY.

Color flow Doppler displays the direction and velocity of flow. An artery and vein are shown in transverse (A) and longitudinal (B) views. Using the conventional color flow map, blood flow toward the transducer appears red, whereas blood flow away from the transducer appears blue.

Review of Literature

1. Jeffrey LA, Stephen MR, and Avery T conducted a comparative study on USG-guided internal jugular vein (IJV) cannulation, evaluating the SAX, LAX, and OAX approaches in a cohort of 220 patients. Their findings indicated that the SAX technique had a significantly higher first-pass success rate compared to the LAX approach, with a P-value of 0.005, confirming statistical significance. Despite this, both groups achieved a similar overall cannulation success rate of 97%.Additionally, the time required for guidewire insertion was notably shorter in the SAX group (35 seconds) than in the LAX group (46.1 seconds), with the difference being statistically significant (P = 0.039). However, unlike our study, their research reported a higher incidence of carotid artery puncture in the SAX group (11%) compared to the LAX group (0%), which was also statistically significant (P = 0.001).One notable limitation of their study was the variability in experience levels among anesthesiologists performing the ultrasound-guided IJV cannulation, which may have influenced the outcomes of each technique[20].

2. Parienti J-J, Mongardon N, Mégarbane B, Mira J-P, Kalfon P, Gros A, and colleagues conducted a study comparing the SAX and long-axis LAX approaches for ultrasound-guided internal jugular vein (IJV) cannulation in a sample of 99 patients. Their findings demonstrated a higher first-pass success rate in the SAX group (98%) compared to the LAX group (78%), with a statistically significant difference (P < 0.006). Despite this difference, both approaches achieved a 100% overall cannulation success rate.The time required for guidewire insertion was also shorter in the SAX approach (39.6 seconds) than in the LAX approach (46.9 seconds), though this difference was not statistically significant (P = 0.59). Additionally, the incidence of carotid artery puncture was lower in the SAX group (0%) compared to the LAX group (4%), but this difference did not reach statistical significance (P = 0.48).A key limitation of the study was the inability to blind the operators to the ultrasound-guided techniques being used, which could have introduced an element of bias in procedural execution and outcome assessment[21].

3. Lal J, Bhardwaj M, Verma M, and Aggrawal T conducted a prospective, randomized, comparative study to evaluate the effectiveness of three different ultrasound-guided internal jugular vein (IJV) cannulation approaches: the long-axis (LAX), short-axis (SAX), and medial

oblique-axis (M-OAX) techniques. The study assessed parameters such as overall success rates, the number of needle passes, first-pass success rates, and procedural timing.The findings revealed that all three approaches had comparable overall success rates and needle pass attempts. However, the first-pass success rate was highest in the M-OAX group (97.2%), followed by the SAX group (88.9%) and the LAX group (77.8%). Despite this variation, the differences were not statistically significant among the groups.When examining procedural efficiency, the M-OAX approach demonstrated the shortest mean venous access time, guidewire insertion time, and total catheterization time, followed by the SAX approach, with the LAX technique being the longest. The differences in procedural timing between the LAX and SAX groups and between the LAX and M-OAX groups were statistically significant ($P < 0.001$).In terms of complications, carotid artery puncture was observed in two patients from the LAX group, whereas no such incidents were reported in the SAX or M-OAX groups.However, the study had certain limitations. The varying levels of experience among anesthesiologists in handling different techniques could have introduced bias in the results. Additionally, the study was limited in terms of sample size and duration, which may affect the generalizability of the findings[20].

4. Tang J, Wang L, Nian W, Tang W, Tang X, Xiao J, and Liu H (2022) conducted a comparative study on ultrasound-guided right internal jugular vein (IJV) cannulation, evaluating the short-axis (SAX) and medial oblique-axis (M-OAX) approaches in a sample of 80 patients. Their findings closely aligned with our study, showing that the first-attempt success rate was higher in the M-OAX group (87.5%) compared to the SAX group (85%), but the difference was not statistically significant ($P = 0.289$). Additionally, both approaches achieved a 100% overall success rate for cannulation.Regarding procedural efficiency, the mean venous access time (VAT) and total catheterization time were shorter in the M-OAX group (14.35 ± 8.93 seconds; 93.22 ± 26.02 seconds) compared to the SAX group (17.72 ± 12.59 seconds; 98.1 ± 27.75 seconds). However, these differences were not statistically significant ($P = 0.376$). Interestingly, unlike our study, their results showed a longer guidewire insertion time in the M-OAX group (36.02 ± 22.92 seconds) compared to the SAX group (31.12 ± 13.12 seconds), but this difference also lacked statistical significance. The authors attributed this variation to differences in head and trunk angulation in the SAX technique, which they identified as a potential limitation.Importantly, no cases of carotid artery puncture or hematoma were reported in either the SAX or M-OAX groups. However, one notable limitation of the study was that the use of

ultrasound guidance during catheter insertion was not randomized, which could have influenced the results[22].

5. Dimitrios Karakitsos et al. (Critical Care 2006, 10:R162) conducted a study comparing real-time ultrasound-guided internal jugular vein (IJV) cannulation with the traditional landmark-guided technique in two groups of 450 critically ill patients. Their findings demonstrated a 100% success rate for IJV cannulation in the ultrasound-guided group, whereas the landmark-guided group achieved a success rate of 94.4%, a statistically significant difference ($P < 0.001$).Furthermore, the average time required from skin puncture to vein localization (skin-to-vein time) and the number of attempts needed were significantly lower in the ultrasound-guided group compared to the landmark-guided group ($P < 0.001$).Complication rates were also notably higher in the landmark-based approach. The study reported carotid artery puncture (10.6%), hematoma formation (8.4%), hemothorax (1.7%), and pneumothorax (2.4%) in the landmark group, and these complications were statistically significant when compared to the ultrasound group ($P < 0.001$). This study highlights the superior safety and efficacy of ultrasound guidance over the conventional landmark method in critically ill patients[23].

6. Dodge KL et al. (J Ultrasound Med. 2012 Oct; 31(10):1519-26) conducted a study comparing ultrasound-guided central venous catheter (CVC) insertion with the traditional landmark-based technique, specifically evaluating the performance of junior residents. The study included 480 patients and was carried out by 115 residents to assess success rates and procedural efficiency.The results indicated that the first-attempt cannulation success rate was significantly higher in the ultrasound-guided group (49%) compared to the landmark-based group (27%), with this difference being statistically significant ($P < .01$). Additionally, the overall success rate for the ultrasound-guided technique (80%) was considerably greater than that of the landmark technique (55%), again showing a statistically significant difference ($P < .01$).Based on these findings, the authors concluded that ultrasound guidance significantly improves first-pass success rates and overall procedural success compared to the landmark method, making it a more effective technique, particularly for less-experienced practitioners[24].

7. Keenan SP et al. (J Crit Care. 2002 Jun; 17(2):126-37) conducted a study comparing ultrasound-guided central venous cannulation with the traditional landmark-based technique in

critically ill patients. Their findings revealed that the first-attempt success rate was notably higher when using ultrasound guidance compared to the landmark method. The risk difference was 24% (95% confidence interval), indicating a significant improvement in procedural accuracy and efficiency with ultrasound assistance.These results emphasize the superiority of ultrasound guidance in enhancing the success of central venous cannulation, particularly in critically ill patients where precision is crucial. The study highlights the advantages of ultrasound in reducing the number of attempts required, ultimately minimizing patient discomfort and procedural complications[25].

8. Akoglu H et al. (Nephrology (Carlton). 2012 Sep; 17(7):603-6) conducted a study involving 323 patients who required internal jugular vein (IJV) cannulation for dialysis. The study aimed to evaluate the efficacy and safety of real-time ultrasound-guided cannulation in these patients.The findings revealed a first-attempt success rate of 80.8%, indicating a high level of procedural accuracy. Additionally, the overall complication rate was relatively low, at 3.2%, demonstrating the safety of ultrasound guidance in vascular access procedures.Based on their results, the authors concluded that real-time ultrasound-guided IJV cannulation is a highly effective and safe technique, offering high success rates while minimizing procedural risks and complications[26].

9. Susan T. Varghese et al. (Anesthesiology: July 1999 - Volume 91 - Issue 1 - p 71–77) conducted a study comparing ultrasound-guided internal jugular vein (IJV) cannulation with the traditional landmark-guided technique in infants. The study included 52 infants in the landmark-guided group and 43 infants in the ultrasound-guided group, aiming to assess success rates, complication rates, and procedural efficiency.The results demonstrated a 100% success rate for the ultrasound-guided approach, significantly higher than the 76.9% success rate observed in the landmark-guided group. Additionally, carotid artery puncture occurred in 25% of cases using the landmark technique, whereas no carotid punctures were reported with ultrasound guidance, highlighting its safety advantage.Furthermore, the ultrasound-guided method significantly reduced both the number of attempts and the total cannulation time, making the procedure more efficient and precise. The authors concluded that ultrasound guidance is a safe, accurate, and effective alternative to the landmark-based approach for IJV cannulation in infants. By providing real-time visualization, ultrasound helps minimize anatomic variations and reduces the risk of carotid artery puncture, making it particularly beneficial in pediatric patients[27].

10. Slama M et al. (Intensive Care Med. 1997 Aug; 23(8):916-9) conducted a study comparing real-time ultrasound-guided (USG) internal jugular vein (IJV) cannulation with the traditional landmark-guided approach in an intensive care unit (ICU) setting. The study involved 79 patients, assessing the success rates and efficiency of both techniques.The results showed a 100% success rate in the ultrasound-guided group, significantly higher than the 76% success rate observed in the landmark-guided group. Additionally, the first-pass success rate was 43% with ultrasound guidance, compared to 26% in the landmark method, indicating that ultrasound improved procedural efficiency and reduced the number of attempts required[27].Based on their findings, the authors concluded that ultrasound guidance significantly enhances the success rate of IJV cannulation in ICU patients. They recommended that USG should be used when the landmark-guided approach fails to achieve successful cannulation within three minutes, as it offers greater precision, reduces complications, and improves patient safety in critical care settings[28].

MATERIALS AND METHODS

Source of Data: Patients aged 18-75 years of either gender who need IJV cannulation at KLE'S Dr.Prabhakar Kore Hospital and Medical Research Center, Nehru Nagar, Belagavi-590010

Study Period: One year

Study Design: Randomised controlled trial

CRITERIA FOR SELECTION:

Inclusion Criteria:

-18-75yrs old

-Patients who need right IJV catheterization

Exclusion Criteria:

-Failure to provide consent

-Possible structural abnormalities in the neck

-History of previous surgical intervention or radiotherapy near the cannulation site

-Recent cervical trauma with present neck immobilization

-Patients with huge masses or lymph nodes in the right neck

-Infection signs,neck scar,subcutaneous emphysema or subcutaneous haematoma close to puncture site

-History of right IJV catheterization during the past 1 month

-Presence of Superior vena cava syndrome

-IJV plaque thrombosis

-Patients with anatomical variations and no right Internal Jugular Vein.

Sample Size:

The sample size was calculated based on the formula given in monographers on statistics and applied probability

Sample size at 95% confidence interval and 80%power was given by

$$N = \frac{(Z_{1-\alpha/2}+Z_{1-\beta})^2(P_1q_1+P_2q_2)}{(P_1-P_2)^2}$$

Z1-α/2 = 1.96 (5% alpha level of significance)

Z1-β=0.85 (80% power)

P1=97.2%

q1=100-97.2=2.8

P2=72.8%

q2=100-72.8=27.2

N=29.9

N=30

Required sample size=30×2=60

Sample size is taken as 60 patients, 30 in each group.

After proper screening for the inclusion and exclusion criteria, the patients were informed about the purpose of the study and the procedure. An informed consent was obtained.

The materials needed for the study includes,

1. Ultrasound machine with high frequency probe (10 MHz).
2. Sterile gel, sterile transducer cover
3. Central venous catheter
4. Monitors – pulse oximeter, ECG, NIBP
5. All emergency drugs

METHODOLOGY

This is a Prospective Randomised controlled clinical trial which will be conducted after getting approval for the study protocol by the institutional review board.An written informed consent will be obtained from everyone enrolled in the study.

In this study a total of 60 participants will be recruited and randomized to two groups for the study. Eligible participants will receive one of two methods by Computer-generated randomization (1) MCSL (2) OA-IP for Right Internal jugular vein (IJV) catheterization. Participants will be evaluated for outcomes
On puncture indicators, ultrasound anatomy and safety risk. Because of the specificity of the puncture procedure, patients and investigators will not be blinded to group assignment.

Patient is put in Trendelenburg position with a thin pillow under the head to extend the neck tilt the head to left and lowers the head. All imaging will be done with a portable ultrasound machine using a linear array
Transducer (frequency of 6-15 Hz, depth of 3.5cm). Internal jugular vein (IJV) catheterization will be performed using the Seldinger technique. An 18-gauge,6.35cm long needle and a 7 French x 16cm, triple dual lumen catheter will be used in all the study cases.

Oblique Axis In-Plane method: In this group, the ultrasound probe is placed on the jugular vein at mid-neck level to capture a transverse cross-sectional image of the common carotid Artery (CCA) and Internal jugular vein (IJV) together. Once the short axis view is obtained, the probe is rotated 45 degrees clockwise with the orientation marker medially and the needle will be inserted from lateral to medial by using in plane technology.

Modified Combined Short and Long Axis Method: In this group, the ultrasound probe is placed in the supraclavicular fossa to determine the plane of needle puncture. The needle is inserted at an angle of 30 degrees to the skin with the short axis out of plane technique and visualize the needle tip as a white spot between the two shadows on the ultrasound screen. Rotate the ultrasound probe 90 degrees clockwise and puncture the anterior wall of the IJV with long axis in-plane technique. And the following observations will be made.

Time taken to identify/locate the vein/Puncture the vein: _____seconds.

(The needle is considered to be in the internal jugular vein when there is free aspiration of dark coloured blood)

No of attempts to identify the vein

Duration for cannulation: _____seconds.

(Time from puncture of vein to catheter insertion into the internal jugular vein)

Complications YES/NO

Haematoma

Pneumothorax

Catheter displacement

Arterial puncture

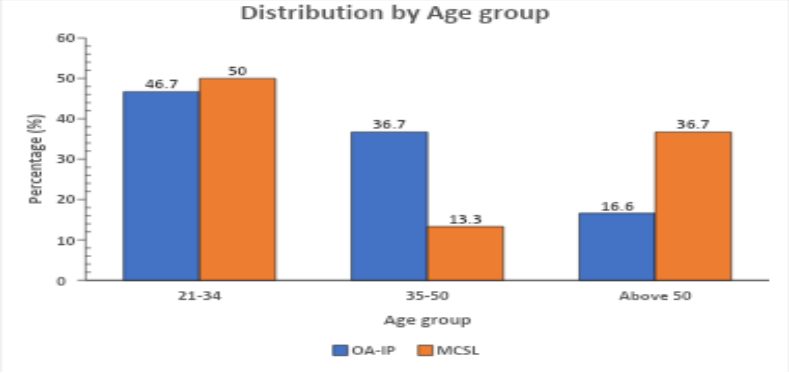
RESULTS

Table 1: Age Distribution Between OA-IP and MCSL Groups

Variables	Oblique axis in plane (OA-IP) (n=30)	Modified combined short and long axis (MCSL) (n=30)
	n (%)	n (%)
Age		
21-34	14 (46.7)	15 (50)
35-50	11 (36.7)	4 (13.3)
50+	5 (16.6)	11 (36.7)
Mean±SD	37.96±12.83	42.4±16.14

p-value = 0.347, Statistical test: Mann-Whitney U Test

The age distribution shows that in the OA-IP group, 46.7% of patients were between 21 and 34 years old, 36.7% were in the 35–50 range, and 16.6% were above 50, with a mean age of 37.96±12.83 years. In contrast, the MCSL group had 50% of patients in the 21–34 range, 13.3% in the 35–50 range, and a notably higher 36.7% above 50, resulting in a higher mean age of 42.4±16.14 years. However, the p-value of 0.347 from the Mann-Whitney U Test indicates that these **differences are not statistically significant.**



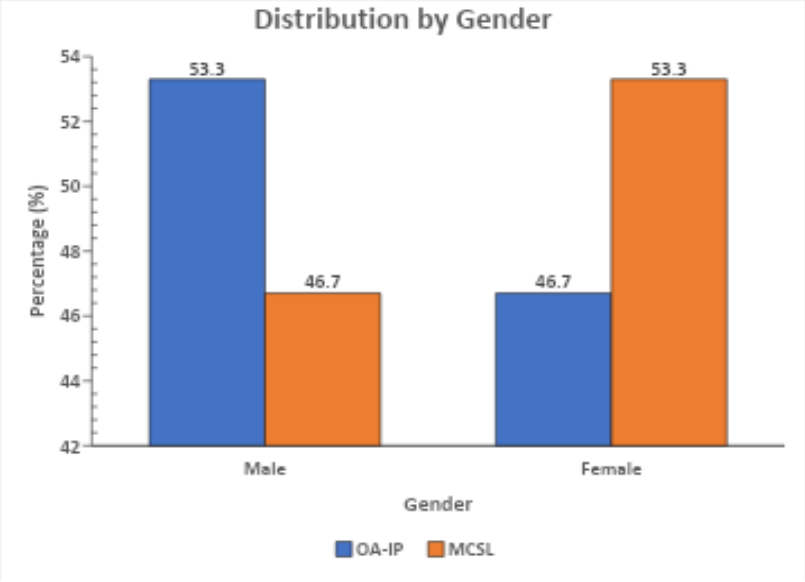
Graph 1: Distribution by Age group

Table 2: Gender Distribution Between OA-IP and MCSL Groups

Variables	Oblique axis in plane (OA-IP) (n=30)	Modified combined short and long axis (MCSL) (n=30)
	n (%)	n (%)
GENDER		
Male	16 (53.3)	14 (46.7)
Female	14 (46.7)	16 (53.3)

p-value = 0.797, Statistical test: Chi-square test

The gender distribution between the groups is nearly equal, with the OA-IP group comprising 53.3% males and 46.7% females, while the MCSL group consists of 46.7% males and 53.3% females. This near balance in gender representation is further supported by a p-value of 0.797 from the Chi-square test, demonstrating that there is no statistically significant difference in gender distribution between the two methods. Overall, **both groups are similar in terms of gender composition.**



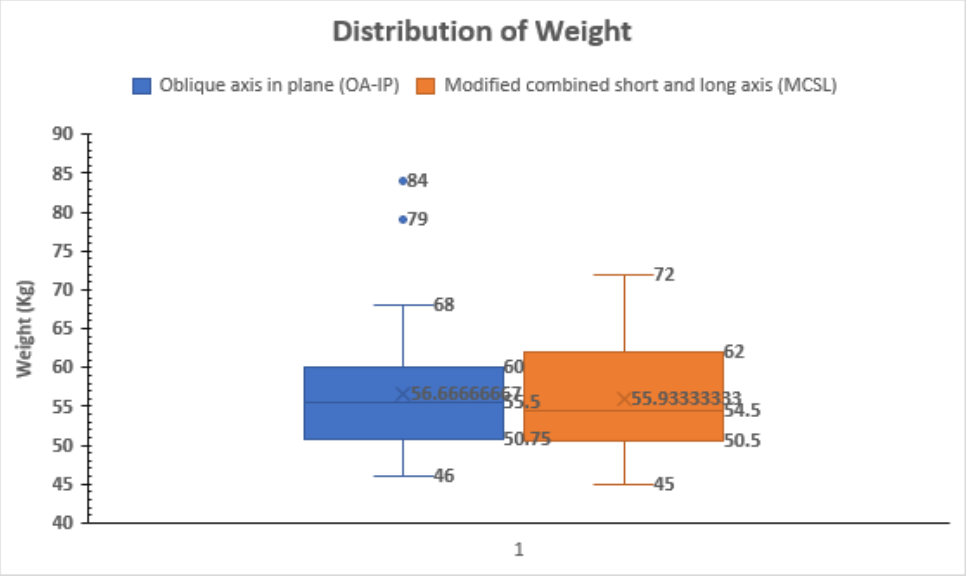
Graph 2: Distribution by Gender

Table 3: Comparison of Weight Between OA-IP and MCSL Groups

Variables	Oblique axis in plane (OA-IP)			Modified combined short and long axis (MCSL)		
	Mean±SD	Minimum	Maximum	Mean±SD	Minimum	Maximum
Weight (Kg)	56.67±9.10	46	84	55.93±7.54	45	72

P-value = 0.976, Statistical test: Mann-Whitney U Test

In Table 3, the mean weight for the OA-IP group is 56.67±9.10 kg with a range of 46 to 84 kg, while the MCSL group has a mean weight of 55.93±7.54 kg with a range of 45 to 72 kg. The Mann-Whitney U Test produced a p-value of 0.976, indicating that there is no statistically significant difference in weight between the two groups.



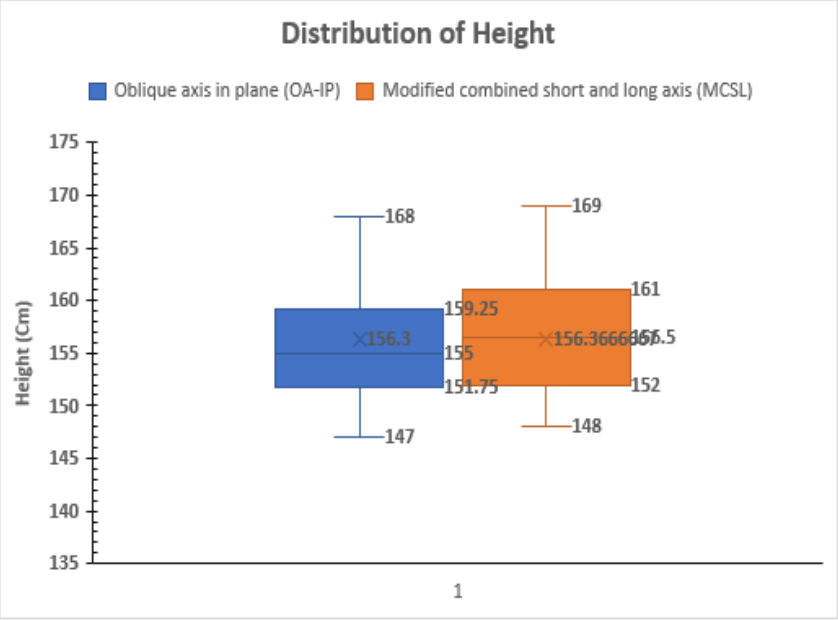
Graph 3: Comparison of Weight Between OA-IP and MCSL Groups

Table 4: Comparison of Height Between OA-IP and MCSL Groups

Variables	Oblique axis in plane (OA-IP)			Modified combined short and long axis (MCSL)		
	Mean±SD	Minimum	Maximum	Mean±SD	Minimum	Maximum
Height (Cm)	156±5.70	147	168	156.37±5.10	148	169

P-value =0.962, Statistical test: two-sample t-test

Table 4 shows that the OA-IP group has an average height of 156±5.70 cm (range 147–168 cm), whereas the MCSL group has an average height of 156.37±5.10 cm (range 148–169 cm). The two-sample t-test yields a p-value of 0.962, suggesting no significant difference in height between the groups.



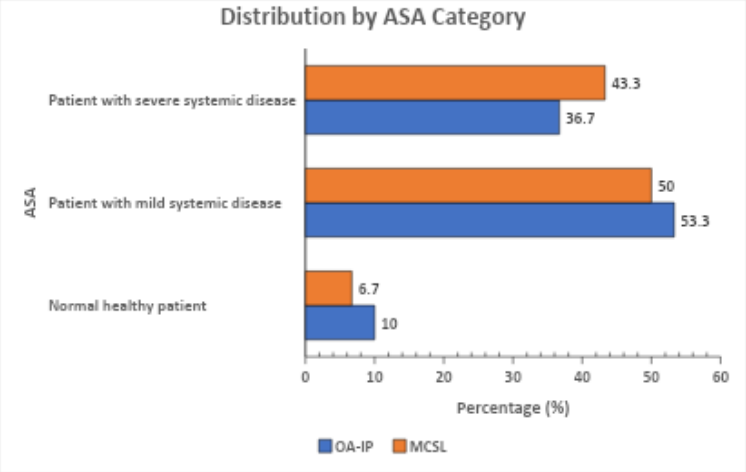
Graph 4: Comparison of Height Between OA-IP and MCSL Groups

Table 5: ASA Classification in OA-IP and MCSL Groups

Variables	Oblique axis in plane (OA-IP) (n=30)	Modified combined short and long axis (MCSL) (n=30)
	n (%)	n (%)
ASA		
Normal healthy patient (1)	3 (10)	2 (6.7)
Patient with mild systemic disease (2)	16 (53.3)	15 (50)
Patient with severe systemic disease (3)	11 (36.7)	13 (43.3)

p-value = 0.863, Statistical test: Fisher Exact test

The ASA classification data indicates that a small percentage of patients are normal healthy, with 10% in the OA-IP group and 6.7% in the MCSL group, while the majority fall into the categories of mild systemic disease (53.3% vs. 50%) and severe systemic disease (36.7% vs. 43.3%) in the OA-IP and MCSL groups, respectively. The p-value of 0.863 from Fisher's Exact Test confirms that there is **no significant difference in ASA classifications** between the groups.



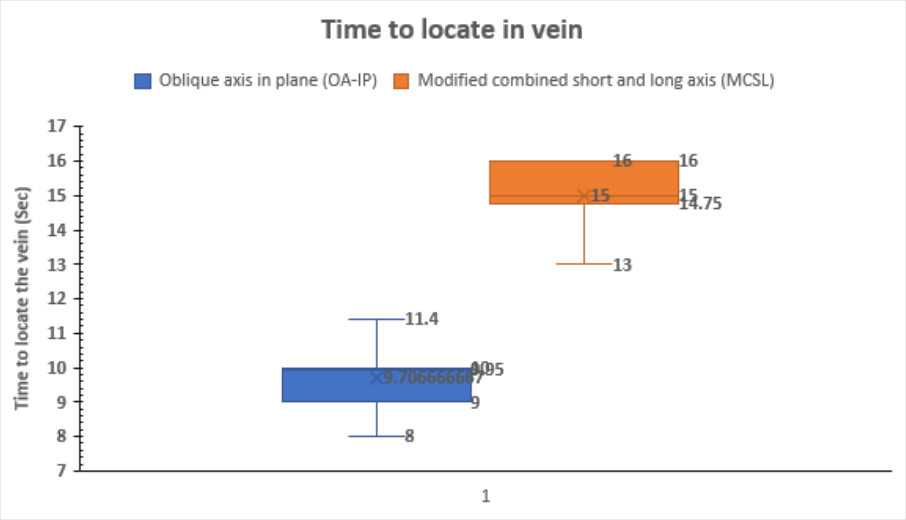
Graph 5: Distribution by ASA Category

Table 6: Comparison of Time to Locate the Vein Between OA-IP and MCSL Groups

Variables	Oblique axis in plane (OA-IP)			Modified combined short and long axis (MCSL)		
	Mean±SD	Minimum	Maximum	Mean±SD	Minimum	Maximum
Time to locate the vein(sec)	9.70±0.7	8	11.4	15±0.78	13	16

p-value = 0.000*, Statistical test: Mann-Whitney U Test, *significant difference

In Table 6 the OA-IP group demonstrated a markedly faster time to locate the vein, with a mean of 9.70 seconds (±0.7) and a range from 8 to 11.4 seconds, compared to the MCSL group, which had a mean time of 15 seconds (±0.78) with a range from 13 to 16 seconds. The difference between the two methods is highly statistically significant (p = 0.000) according to the Mann-Whitney U Test, indicating that the OA-IP technique is considerably more efficient in identifying the vein for cannulation.



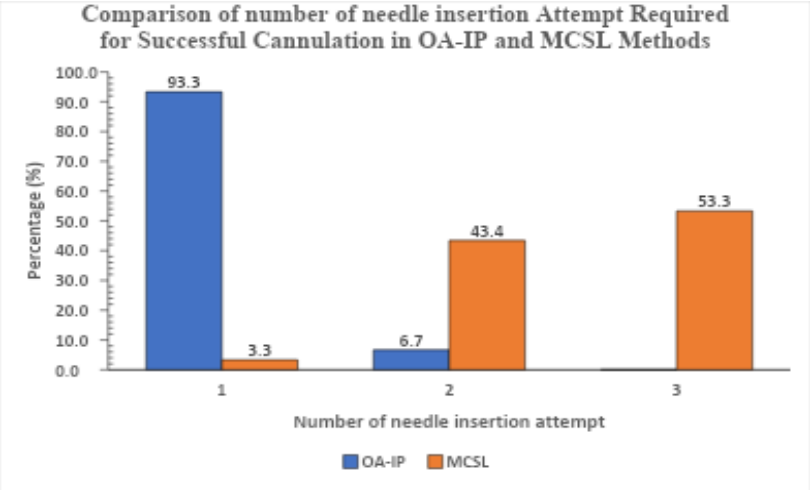
Graph 6: Comparison of Time to Locate the Vein Between OA-IP and MCSL Groups

Table 7: Comparing the number of needle insertion Attempt Required for Successful Cannulation in OA-IP and MCSL Methods

Variables	Oblique axis in plane (OA-IP)	Modified combined short and long axis (MCSL)
	n (%)	n (%)
No. of Attempts		
1	28 (93.3)	1 (3.3)
2	2 (6.7)	13 (43.4)
3	0 (0.0)	16 (53.3)

p-value = 0.000*, Statistical test: Fisher Exact test, *significant difference

In Table 7, 93.3% of patients achieved successful cannulation on the first attempt, with only 6.7% requiring a second attempt and none needing a third attempt. In contrast, the MCSL group had a dramatically different distribution, with only 3.3% succeeding on the first attempt, 43.4% requiring two attempts, and 53.3% needing three attempts to achieve success. The highly significant p-value (p = 0.000) from Fisher's Exact Test indicates that the difference in the number of needle insertion attempts between the two methods is statistically significant.



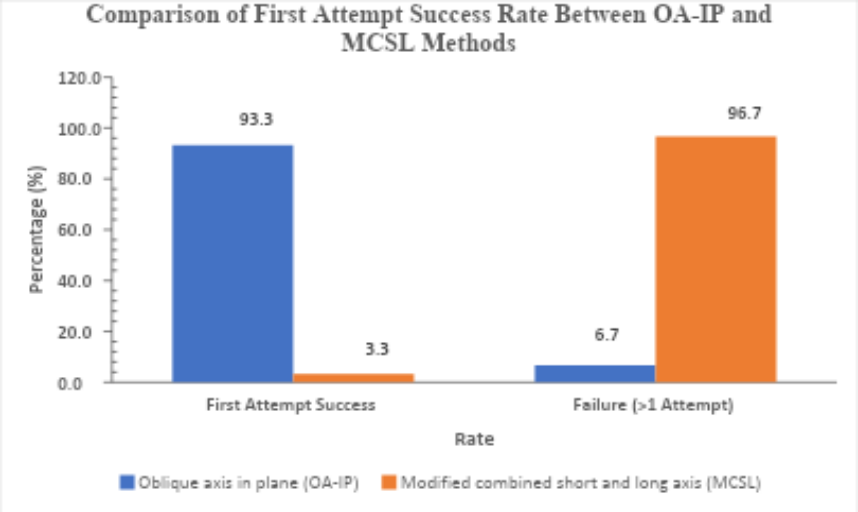
Graph 7: Comparison of number of needle insertion attempts required for Successful Cannulation in OA-IP and MCSL Methods

Table 8: Comparison of First Attempt Success Rate Between OA-IP and MCSL Methods

Group	Total Case	First Attempt Success	Failure (>1 Attempt)	p-value
	N	n (%)	n (%)	
Oblique axis in plane (OA-IP)	30	28 (93.3)	2 (6.7)	0.000*
Modified combined short and long axis (MCSL)	30	1 (3.3)	29 (96.7)	

***Significant difference, p-value is obtained by Fisher Exact test**

In Table 8 the OA-IP group, 93.3% of patients (28 out of 30) achieved successful cannulation on the first attempt, whereas in the MCSL group, only 3.3% (1 out of 30) succeeded on the first try, with 96.7% (29 out of 30) requiring more than one attempt. The Fisher Exact test yielded a p-value of 0.000, indicating that this difference is highly statistically significant.



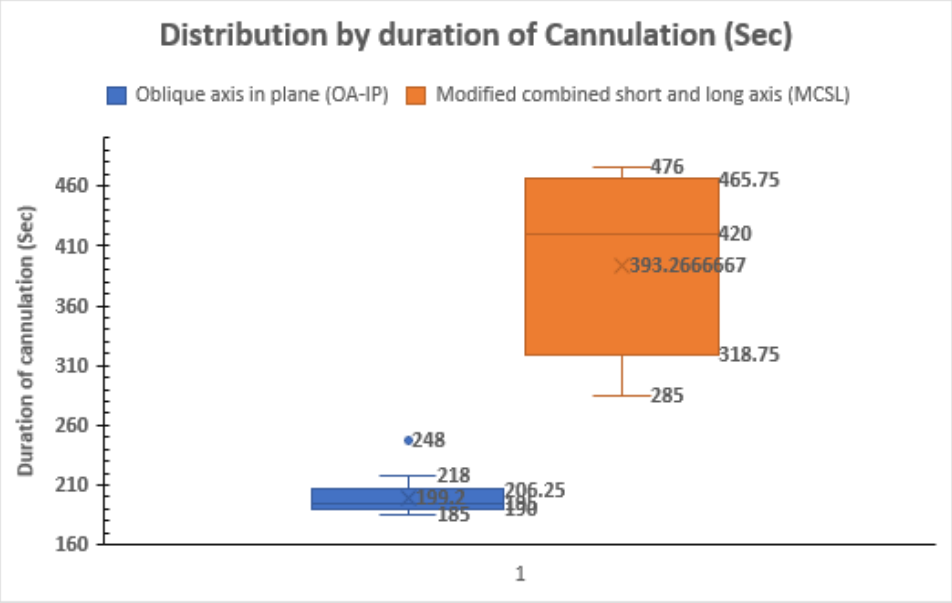
Graph 8: Comparison of First Attempt Success Rate Between OA-IP and MCSL Methods

Table 9: Comparison of Duration of Cannulation Between OA-IP and MCSL Groups

Variables	Oblique axis in plane (OA-IP)			Modified combined short and long axis (MCSL)		
	Mean±SD	Minimum	Maximum	Mean±SD	Minimum	Maximum
Duration of Cannulation (Sec)	199.2±13.33	185	248	393.2±70.7	285	476

p-value = 0.000*, Statistical test: Mann-Whitney U Test, *significant difference

Table 9 indicates that the duration of cannulation is significantly shorter in the OA-IP group, with a mean of 199.2±13.33 seconds (ranging from 185 to 248 seconds), compared to a considerably longer mean duration of 393.2±70.7 seconds (ranging from 285 to 476 seconds) in the MCSL group. The p-value of 0.000 from the Mann-Whitney U Test confirms that this difference is highly statistically significant, indicating that the OA-IP method allows for much faster cannulation.



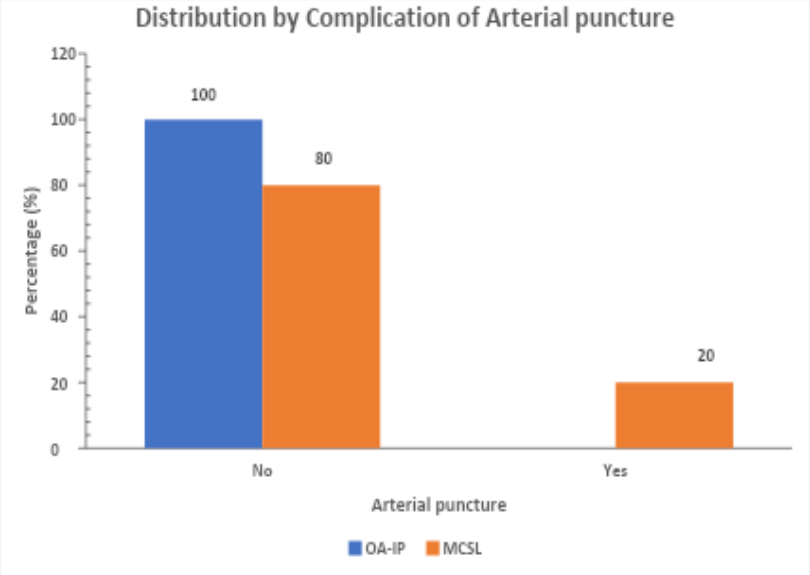
Graph 9: Comparison of Duration of Cannulation Between OA-IP and MCSL Groups

Table 10: Incidence of Arterial Puncture in OA-IP and MCSL Groups

Variables	Oblique axis in plane (OA-IP) (n=30)	Modified combined short and long axis (MCSL) (n=30)
	n (%)	n (%)
Arterial puncture		
No	30 (100)	24 (80)
Yes	0 (0)	6 (20)

p-value = 0.02*, Statistical test: Fisher Exact test, *significant difference p-value <0.05

The incidence of arterial puncture was markedly different between the two groups, with the OA-IP group reporting no cases (0%) and the MCSL group showing a 20% incidence. This statistically significant difference is supported by a p-value of 0.02 from Fisher's Exact Test, indicating that the **MCSL method is associated with a higher risk of arterial puncture** compared to the OA-IP method.



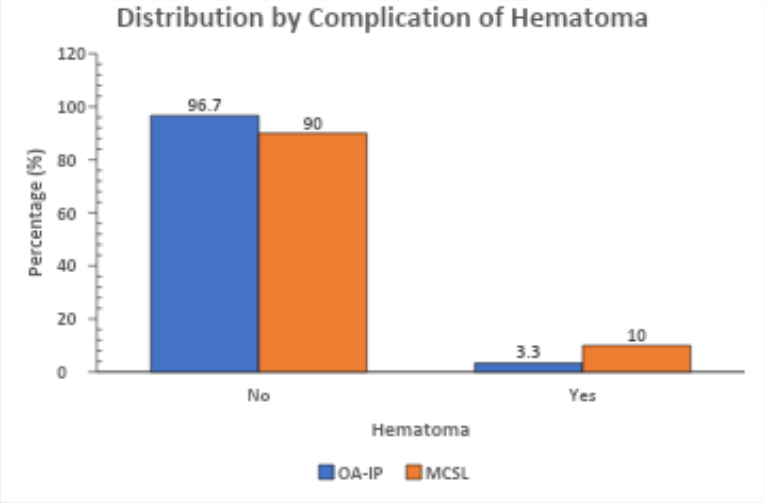
Graph 10: Distribution by Complication of Arterial Puncture

Table 11: Hematoma Occurrence in OA-IP and MCSL Groups

Variables	Oblique axis in plane (OA-IP) (n=30)	Modified combined short and long axis (MCSL) (n=30)
	n (%)	n (%)
Hematoma		
No	29 (96.7)	27 (90)
Yes	1 (3.3)	3 (10)

p-value = 0.612, Statistical test: Fisher Exact test

In Table 11, hematoma was observed in only 3.3% of patients in the OA-IP group compared to 10% in the MCSL group. Although the MCSL group shows a slightly higher incidence of hematoma, the difference is not statistically significant (p = 0.612) as determined by Fisher's Exact Test. This indicates that **both methods have a comparable safety profile** regarding the risk of hematoma formation.

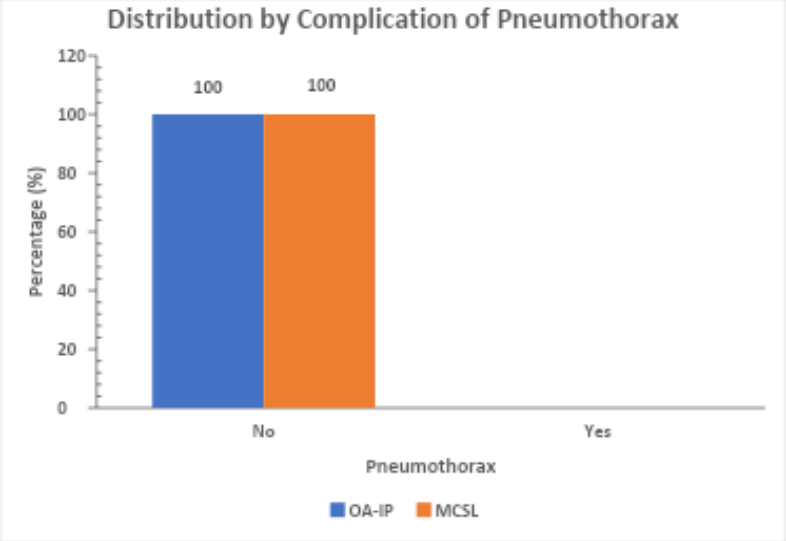


Graph 11: Distribution by Complication of Hematoma

Table 12: Pneumothorax Incidence in OA-IP and MCSL Groups

Variables	Oblique axis in plane (OA-IP) (n=30)	Modified combined short and long axis (MCSL) (n=30)
	n (%)	n (%)
Pneumothorax		
No	30 (100)	30 (100)
Yes	0 (0)	0 (0)

The table demonstrates that **neither group experienced any cases of pneumothorax**, which underscores that both techniques are equally safe with respect to avoiding this complication.



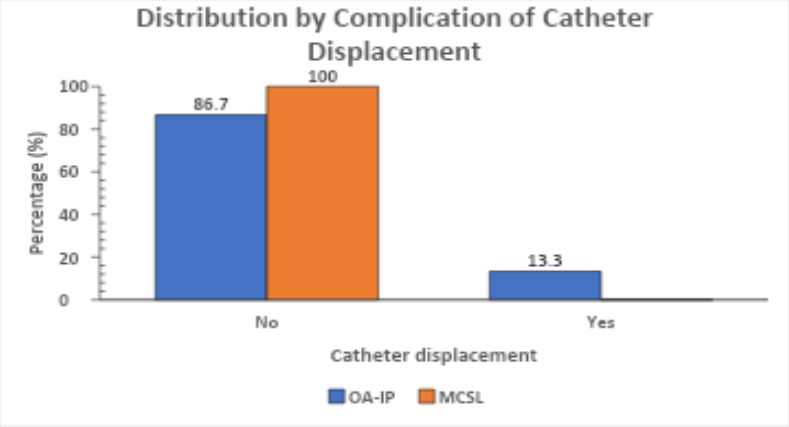
Graph 12: Distribution by Complication of Pneumothorax

Table 13: Catheter Displacement in OA-IP and MCSL Groups

Variables	Oblique axis in plane (OA-IP) (n=30)	Modified combined short and long axis (MCSL) (n=30)
	n (%)	n (%)
Catheter displacement		
No	26 (86.7)	30 (100)
Yes	4 (13.3)	0 (0)

p-value = 0.112, Statistical test: Fisher Exact test

Table 13 illustrates that catheter displacement occurred in **13.3% of cases in the OA-IP group,** while no displacements were recorded in the MCSL group. Despite this apparent difference, the p-value of 0.112 from Fisher's Exact Test suggests that the variation is not statistically significant.



Graph 13: Distribution by Complication of Catheter Displacement

Table 14: Comparison of Complications Between OA-IP and MCSL Methods

Complications	Oblique axis in plane (OA-IP) (n=30)	Modified combined short and long axis (MCSL) (n=30)	p-value
	n (%)	n (%)	
Arterial puncture			
No	30 (100.0)	24 (80.0)	0.024*
Yes	0 (0.0)	6 (20.0)	
Hematoma			
No	29 (96.7)	27 (90.0)	0.612
Yes	1 (3.3)	3 (10)	
Pneumothorax			
No	30 (100.0)	30 (100)	
Yes	0 (0.0)	0 (0.0)	
Catheter displacement			
No	26 (86.7)	30 (100)	0.112
Yes	4 (13.3)	0 (0.0)	

*Significant difference $p<0.05$ and p-value is obtained by Fisher exact test

Arterial puncture was observed in 20% of patients in the MCSL group, while no cases were reported in the OA-IP group. The p-value of 0.024 indicates that this difference is statistically significant, suggesting a higher risk of arterial puncture with the MCSL method. Hematoma was slightly more frequent in the MCSL group (10%) compared to the OA-IP group (3.3%), but the difference was not statistically significant ($p = 0.612$). Pneumothorax was not observed in either group. Catheter displacement was reported in 13.3% of cases in the OA-IP group but was not observed in the MCSL group, though the difference did not reach statistical significance ($p = 0.112$). These findings suggest that while the MCSL method may have a higher risk of arterial

puncture, it appears to reduce the likelihood of catheter displacement compared to the OA-IP method.

Statistical Methods: Descriptive and inferential statistical analysis has been carried out in the present study, Results on continuous measurements are presented on Mean±SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5% level of significance. The following assumptions on data is made. **Assumptions:** 1. Dependent variables should be normally distributed. Samples drawn from the population should be random, Cases of the samples should be independent.

Fisher Exact test has been used to find the significance of study parameters on categorical scale between two or more groups, non-parametric test was used when data is not following normal distribution. Fisher Exact test used when cell samples are very small. Statistical software: The Statistical software namely SPSS 26.0 version were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

DISCUSSION

IJV cannulation is a common approach for central venous access, typically performed on the right side due to its straighter path to the superior vena cava. It offers reliable access with ultrasound (USG) guidance, improving safety and success rates. Short-Axis (Out-of-Plane) Approach- Provides a cross-sectional view, easily identifying vessel position. However due to Limited needle visualization, increasing arterial puncture risk. Long-Axis (In-Plane) Approach- Allows full needle visualization, reducing arterial injury risk, Due to narrow field of view may make vein compression harder to assess. Oblique Axis In-Plane (OA-IP) Approach-Combines benefits of short- and long-axis views, ensuring continuous needle tracking and reduced complications. There is potential for catheter displacement. Modified Combined Short & Long Axis (MCSL) Approach- Provides dynamic, multi-angle visualization. It is a complex technique with frequent probe adjustments, leading to longer procedure times and increased arterial puncture risk. While USG guidance enhances safety, technique selection should balance ease of use, complication risk, and procedural efficiency.

Central venous catheterization (CVC) is a critical procedure in modern medicine, offering essential access for hemodynamic monitoring, fluid resuscitation, and medication administration. With the increasing use of ultrasound guidance to improve safety and procedural efficiency, various techniques have emerged, each with unique advantages and potential risks. This study sought to compare the oblique axis in-plane (OA-IP) method with the modified combined short and long axis (MCSL) approach in right internal jugular vein (RIJV) cannulation. Our findings highlight significant differences between these methods, with the OA-IP approach demonstrating superior safety, efficiency, and overall success rates.

The results of our study indicate a clear advantage of the OA-IP method in multiple procedural aspects. The most striking difference was the arterial puncture rate, with 20% in the MCSL group compared to 0% in the OA-IP group ($p=0.02$). This suggests that the complexity of the MCSL method may contribute to an increased risk of arterial puncture, potentially due to the necessity of switching between short and long-axis views, which can introduce alignment errors and impair real-time needle tracking. Similar concerns have been raised in previous studies, where techniques involving frequent probe and needle reorientation were associated with increased complication rates (Lal et al., 2020; Tang et al., 2022).

Furthermore, our study demonstrated significantly shorter procedural times with the OA-IP method, including the time to locate the vein (9.70 ± 0.7 seconds vs. 15 ± 0.78 seconds, $p=0.000$) and overall cannulation duration (199.2 ± 13.33 seconds vs. 393.2 ± 70.7 seconds, $p=0.000$). The efficiency of the OA-IP technique is likely attributable to its continuous visualization of the needle within the vein, minimizing the need for probe repositioning and realignment. Studies by Karakitsos et al. (2006) and Keenan et al. (2002) have previously confirmed that techniques allowing for continuous real-time tracking of the needle improve procedural speed and success rates, reinforcing our findings.

The first-attempt success rate was also dramatically higher in the OA-IP group (93.3%) compared to the MCSL group (3.3%, $p=0.000$). This statistic is particularly important as multiple cannulation attempts have been associated with increased risks of hematoma, arterial injury, and patient discomfort. Our findings align with research by Dodge et al. (2012), which demonstrated that ultrasound guidance improves first-pass success rates by providing better needle

visualization and reducing operator dependence on anatomic landmarks.

Aside from arterial puncture, other complications were also examined. The hematoma occurrence was slightly higher in the MCSL group (10% vs. 3.3%), though this difference did not reach statistical significance (p=0.612). While hematoma formation can result from multiple needle passes, our results suggest that the primary determinant in arterial injury was the technique itself rather than repeated attempts. The absence of pneumothorax in both groups reinforces the overall safety of ultrasound-guided CVC placement, a finding consistent with studies by Varghese et al. (1999), which reported a reduced pneumothorax incidence with ultrasound compared to landmark-based techniques.

Interestingly, catheter displacement was observed exclusively in the OA-IP group (13.3%, p=0.112). Although this difference was not statistically significant, it warrants further investigation. One possible explanation is that the OA-IP technique, while providing enhanced initial success rates, may allow for minor catheter movement post-placement. However, as catheter malposition was not a primary outcome measure, future studies should explore this factor more comprehensively.

Our findings align with an extensive body of literature supporting ultrasound guidance in CVC placement. Karakitsos et al. (2006) and Dodge et al. (2012) demonstrated that ultrasound guidance significantly reduces complications compared to traditional landmark-based techniques. Furthermore, studies by Keenan et al. (2002) confirmed that ultrasound-guided CVC placement in critically ill patients improves success rates while minimizing adverse outcomes.

Specifically, studies examining different ultrasound-guided techniques provide further context for our results. Research by Lal et al. (2020) and Tang et al. (2022) investigated the medial oblique axis (M-OAX) approach, similar to our OA-IP method, and found that it resulted in shorter procedural times and higher success rates than short-axis or long-axis methods alone. These studies support our observation that an oblique in-plane approach offers significant procedural benefits.

Conversely, some studies have reported mixed findings. For example, Jeffrey et al. (2014) and Parienti et al. (2006) compared short-axis and long-axis techniques and found no consistent

superiority of one method over the other. These discrepancies highlight the importance of operator experience and technique refinement in determining the effectiveness of different approaches.

The oblique axis in-plane method's superiority in our study can be attributed to several factors:

1. Enhanced Visualization: The oblique axis provides a more comprehensive view of the vein and surrounding structures, allowing for precise needle guidance.
2. Real-Time Needle Tracking: The in-plane technique ensures continuous visualization of the entire needle shaft, reducing the likelihood of arterial puncture.
3. Efficiency and Ease of Use: The straightforward nature of the OA-IP method simplifies the procedure, making it easier to learn and perform even for less experienced clinicians.

While our study provides valuable insights, several limitations must be acknowledged. The single-center design may limit the generalizability of our findings. Future multi-center studies with larger sample sizes are necessary to confirm these results.

Another limitation is the potential variability in operator experience. While all practitioners in this study had similar levels of training, subtle differences in skill level could have influenced the outcomes. Future studies should stratify results based on operator experience to provide a more nuanced understanding of technique efficacy.

Additionally, our study focused primarily on procedural efficiency and immediate complications. Long-term complications such as catheter-related infections and thrombosis were not evaluated. Future research should incorporate a more comprehensive assessment of both short- and long-term outcomes.

Finally, technological advancements such as real-time 3D ultrasound and automated needle guidance systems could further enhance CVC safety and efficacy. Exploring the integration of these technologies into clinical practice represents an exciting avenue for future investigation.

Our findings have important clinical implications. Given the superior safety and efficiency profile of the OA-IP method, this technique should be considered the preferred approach for ultrasound-guided RIJV cannulation. Clinicians should exercise caution when using the MCSL

technique, particularly in patients with complex vascular anatomy or higher risk of complications. Training programs should prioritize proficiency in the OA-IP method to enhance patient safety and procedural success rates.

In conclusion, this study provides compelling evidence that the oblique axis in-plane ultrasound-guided approach is a safe and effective technique for RIJV cannulation. Compared to the modified combined short and long-axis method, the OA-IP technique offers significant advantages in reducing arterial puncture risk, improving procedural efficiency, and enhancing first-attempt success rates. These findings underscore the importance of adopting evidence-based practices in CVC procedures to optimize patient safety and clinical outcomes. This single-center study may limit generalizability due to variations in patient populations, operator experience, and institutional protocols. Despite similar training, operator skill variability could have influenced outcomes. A larger sample size would enhance statistical power. The focus on immediate outcomes excludes long-term complications like infections and thrombosis. Technological advancements, such as 3D ultrasound, were not considered. Findings are specific to RIJV cannulation and may not apply to other sites. Catheter displacement in the OA-IP group requires further investigation. Anatomical variability was not extensively analyzed, warranting future imaging-based studies.

CONCLUSION

"Our research demonstrates that using an oblique, in-plane ultrasound-guided technique for central venous cannulation offers significant advantages over the modified combined short and long axis (MCSL) method. Specifically, the oblique approach resulted in higher first-attempt success rates, fewer overall attempts, and quicker vein location. It also reduced the time required for the procedure and led to fewer complications, including carotid puncture, hematomas, and pneumothorax.

While the MCSL method remains a widely used and often effective technique, particularly in straightforward cases, our findings suggest that the oblique in-plane approach offers a more efficient and safer alternative. The oblique method, though requiring some initial training and practice, proves particularly beneficial for patients with challenging anatomy, such as those with obesity or short necks, where traditional landmark-based methods, and even the MCSL method, can be difficult. Furthermore, it serves as a valuable alternative when central approaches, including MCSL, fail. The oblique angle allows for more precise catheter placement, particularly in deeper or unusually angled vessels, minimizing the need for extensive needle manipulation and potentially improving patient comfort. This enhanced control and accuracy make the oblique in-plane technique a superior choice for difficult cannulation scenarios, and a valuable adjunct to the standard MCSL approach."

SUMMARY

This one-year randomized controlled trial aimed to compare the Modified Combined Long and Short Axis (MCSL) approach with the Oblique Axis In-Plane approach for ultrasound-guided right internal jugular vein (IJV) cannulation in adult patients. The primary focus was to evaluate key clinical parameters such as time to locate the vein, number of attempts required, total duration of cannulation, and the incidence of complications associated with each technique.

A total of 60 adult patients, aged 18–80 years, classified under ASA grades I, II, and III, were included in the study. Patients undergoing elective or emergency surgeries and those in critical care settings were randomly assigned to two groups:

- Group 1 (MCSL Approach): Underwent IJV cannulation using the Modified Combined Long and Short Axis approach.
- Group 2 (Oblique In-Plane Approach): Underwent IJV cannulation using the Oblique Axis In-Plane approach.

The study found that the Oblique In-Plane approach had distinct advantages over the MCSL approach in several key areas:

- Time to locate the IJV was significantly shorter in the Oblique In-Plane approach group.
- Number of attempts for successful puncture was lower in the Oblique approach group, indicating improved efficiency.
- Total duration of cannulation was shorter in the Oblique In-Plane approach group.
- Complication rates varied, with lower incidence of carotid artery puncture and hematoma formation in the Oblique approach group compared to the MCSL approach group.
- No cases of pneumothorax or hemothorax were observed in either group.
- Catheter tip malposition was noted only in the Oblique In-Plane approach group, whereas it was absent in the MCSL approach group.

The study concluded that the Oblique In-Plane approach is as efficient as, if not better than, the MCSL approach for ultrasound-guided right IJV cannulation. It demonstrated improved

procedural efficiency, a reduced number of attempts, shorter duration of cannulation, and lower complication rates such as carotid artery puncture and hematoma formation. While catheter tip malposition was an issue in the Oblique approach, the overall safety and efficacy profile favored this technique.

Future studies with larger sample sizes and within patients under general anaesthesia may further validate these findings and help refine techniques for better clinical outcomes in critical care and surgical settings.

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ANNEXURE I : INFORMED CONSENT FORM

"MODIFIED COMBINED LONG AND SHORT AXIS VERSUS OBLIQUE AXIS IN PLANE METHOD FOR USG GUIDED RIGHT IJV CANNULATION IN ADULT PATIENTS-A ONE YEAR RANDOMIZED CONTROL TRIAL"

Objective: To study and further the application of different USG guided IJV catheterization and find an effective and safe USG guided puncture technique.

Introduction:

Central venous catheterization plays an important role in clinical treatment, including rapid blood transfusion and fluid infusion, measurements of hemodynamic variables, delivery of medications and nutritional support. The right internal jugular vein is most commonly selected for its straight course to the right side of the heart, lack of valves and ease of cannulation. There are many approaches and techniques for USG guided IJV catheterization. The short axis out of plane method can clearly see the adjacent relationship between IJV and common carotid artery (CCA), but because the entire needle body is not visible there is still the possibility of accidental posterior vessel wall puncture and arterial puncture. The long axis in plane method ensures the view of the entire needle, including tracking of the needle tip, but it has some disadvantages including not suitable for short necked patients and the relationship between the CCA and IJV is usually lost. The current clinical research is mainly about the comparative study of modified short axis and long axis method and oblique axis method in order to seek a safer and more effective USG guided IJV puncture method.

Purpose of study:

The study is undertaken to find out the better method MCSL or OA-IP method in terms of first attempt success rate, number of punctures to do so, duration of cannulation and complications for right IJV catheter placement.

Explanation of procedure:

If you agree to participate in my study I will ask you for your present, past and family history. Then you will be clinically examined in detail and routine investigations like hemoglobin, platelet count will be done accordingly. You will be randomly allotted into one of the two groups by computer generated software.

Group A: Patients will receive MCSL Method of IJV catheterization.

Group B: Patients will receive OB-IP Method of IJV catheterization.

Withdrawal from participation in the study:

Participation in this study is involuntary. You will be free to decide whether to participate in this study or continue participation once enrolled. In case you decide to withdraw your participation, you are free to do so. However, please convey the decision to the principal investigator.

Possible benefits from participating in the study: You will not get any benefits by participating in this study. The data gathered will help the population at large.

Possible risks from participating in the study: The risks like inadvertent puncture of the carotid artery leading to haematoma formation and puncture of pleura leading to pneumothorax are inherent to the procedure. All precautions will be taken to avoid the same.

Privacy and confidentiality: The information collected from you will be coded, to prevent any person from identifying you. The data collected from you will be kept confidential and only processed or aggregated data will be used for publication.

Your identity will never be revealed without your permission except:

1.In emergency to protect your rights and welfare.

2. If required by the law.

Financial incentives: You will not receive any payment for participating in this study.

Authorization for publication of aggregated data:

Results obtained after processing of the aggregated data will be published for scientific purposes and or presented to scientific groups. However, your identity will never be revealed.

Questions: In case of any questions with regard to this study, you are free to contact:

-*+	

If you have any question or complaints with regard to your right as a study participant you may contact **Dr Harsha Hegde**, Chairperson, Ethical committee of JNMC, 0831-2473777 Extension 4052.

Legal rights: By signing this consent form, we are not waving any of your legal rights

CONSENT STATEMENT

I am making a voluntary decision to participate in the study **MODIFIED COMBINED LONG AND SHORT AXIS VERSUS OBLIQUE AXIS IN PLANE METHOD FOR ULTRASOUND GUIDED RIGHT INTERNAL JUGULAR VEIN CANNULATION IN ADULT PATIENTS-A ONE YEAR RANDOMIZED CONTROL TRIAL.**

My signature below indicates that I have decided to participate and I have read the information provided above or the information provided above has been read to me in the language that I understand best. I was given the opportunity to ask questions and that they have been answered to my satisfaction.

Name of the participant:

Signature or left thumb impression of the participant:

Name of the witness:

Signature or left thumb impression of the witness:

Name of the investigator:

Signature of the investigator:

ANNEXURE - II: PROFORMA

"MODIFIED COMBINED LONG AND SHORT AXIS VERSUS OBLIQUE AXIS IN PLANE METHOD FOR ULTRASOUND GUIDED RIGHT INTERNAL JUGULAR VEIN CANNULATION IN ADULT PATIENTS-A ONE YEAR RANDOMISED CONTROL TRIAL"

Name and Address of the patient:

Age:

Sex:

IP No:

Anaesthesiologist:

Chief Complaints:

Past History:

Family History:

On Examination:

Weight: Height: BMI:

PR: BP: RR: SpO2:

Temp:

SYSTEMIC EXAMINATION:

Cardiovascular system:

Respiratory system:

Central Nervous system:

INVESTIGATIONS: Hb% Platelet count:

PT-Control APTT-Control

Test Test

INR Ratio

Any Other:

ASA STATUS: Grade 1 2 3 4

DIAGNOSIS:

OBSERVATIONS:

Technique used:

Group:

Time	**Heart rate**	**Spo2**

Time taken to identify/locate the vein/Puncture the vein:_____seconds.

(The needle is considered to be in the internal jugular vein when there is free aspiration of dark coloured blood)

No of attempts to identify the vein	
1.	
2.	
3.	

Duration for cannulation: _____seconds.

(Time from puncture of vein to catheter insertion into the internal jugular vein)

Complications	**YES/NO**
Haematoma	
Arterial Puncture	
Pneumothorax	
Catheter displacement	
Others	

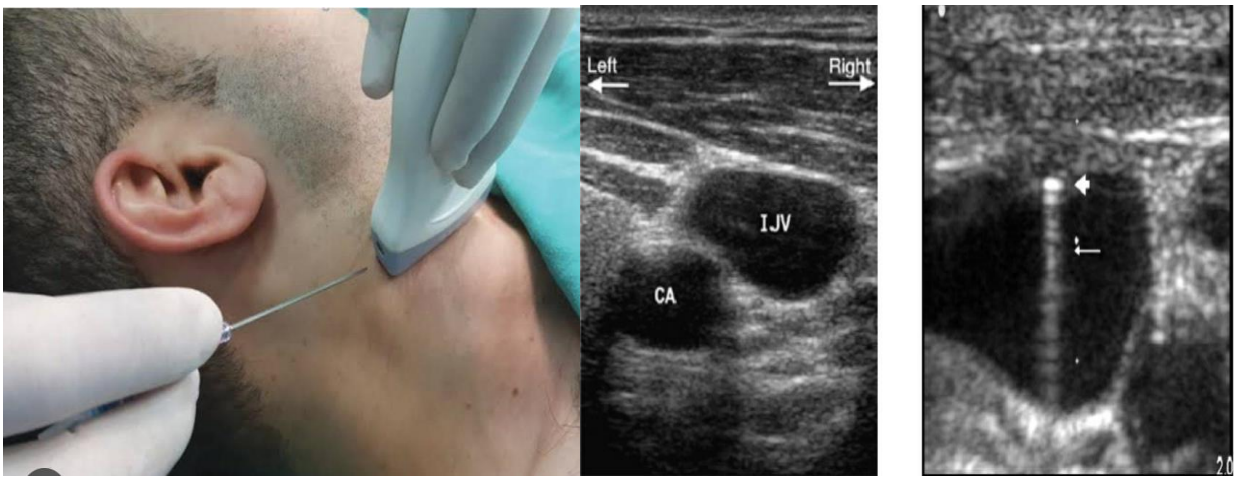
Signature of staff in charge: Signature of Guide:

ANNEXURE III- PHOTOGRAPHS

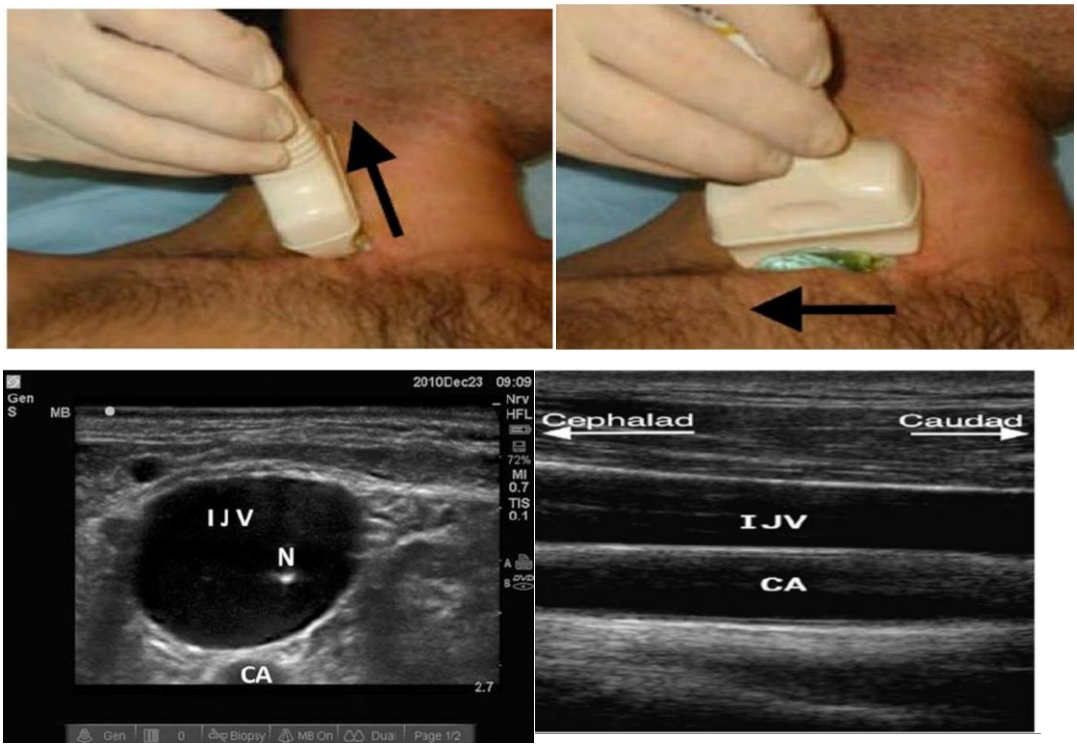
PHOTOGRAPH 1: USG Machine.

PHOTOGRAPH 2: Linear ultrasound probe

PHOTOGRAPH 3&4:Oblique In plane(USG Probe Placement)



PHOTOGRAPH 5&6: Modified combined short and long Axis (USG Probe Placement)



ANNEXURE IV- MASTER CHART

KEY TO MASTER CHART

ALD Alcoholic liver disease

AKI Acute kidney injury

ASA American society anaesthesiology (Grades I-V)

CA Carcinoma

CABG Coronary artery bypass graft

cm Centimeter

DCM Dilated cardiomyopathy

F Female

HTN Hypertension

HELLP Hemolysis, low platelet, elevated liver enzymes

IUD Intrauterine death

LSCS Lower segment cesarean section

M Male

MI Myocardial infarction

Kg kilogram

MR Mitral regurgitation

PPH Postpartum haemorrhage

MS **Mitral stenosis**

RTA **Road traffic accident**

SDH **Subdural hematoma**

	AGE	GENDER	WEIGHT	HEIGHT	ASA	DIAGNOSIS	TIME TO LOCATE THE VEIN(SECONDS)	NO OF ATTEMPTS	DURATION OF CANNULATION(SECONDS)	ARTERIAL PUNCTURE	HEMATOMA	PNEUMOTHORAX	CATHETER DISPLACEMENT
GROUP A													
1	54	M	67	166	2	RTA	10.1	1	3:10	NO	NO	NO	NO
2	36	F	51	154	2	PPH	11.1	1	3:24	NO	NO	NO	NO
3	26	F	47	147	2	PUERPERAL SEPSIS	9.6	1	3:15	NO	NO	NO	NO
4	58	M	68	165	2	CABG	9	1	3:25	NO	NO	NO	NO
5	31	F	55	159	1	BURNS	9.5	1	3:05	NO	NO	NO	NO
6	26	F	51	152	2	ECLAMPSIA	9	2	3:22	NO	NO	NO	NO
7	26	M	56	158	2	POLYTRAUMA	9.5	1	3:38	NO	NO	NO	NO
8	46	F	48	151	2	SEPSIS	9	1	3:10	NO	NO	NO	NO
9	36	M	58	164	2	MI	10	1	3:32	NO	NO	NO	NO
10	31	F	48	153	2	MI	9	1	3:10	NO	NO	NO	NO
11	28	M	60	155	2	CABG	10	1	3:15	NO	NO	NO	YES
12	64	M	57	150	2	DCM	10	2	4:08	NO	NO	NO	NO
13	22	F	52	154	3	HELLP	11.4	1	3:15	NO	NO	NO	NO
14	41	M	67	167	3	CRUSH INJURY	10	1	3:10	NO	NO	NO	NO
15	28	M	46	154	2	WHIPPLES PROCEDURE	9.9	1	3:10	NO	NO	NO	NO
16	29	M	52	157	3	MI	9.5	1	3:10	NO	NO	NO	NO
17	43	M	79	159	2	CEREBRAL ANEURYSM	8	1	3:05	NO	NO	NO	NO
18	30	F	50	152	2	HEELP	10	1	3:05	NO	NO	NO	NO
19	26	F	52	149	2	ECLAMPSIA	9	1	3:20	NO	NO	NO	NO
20	64	F	46	150	2	PPH	9	1	3:38	NO	NO	NO	YES
21	42	M	84	168	3	CABG	9.4	1	3:30	NO	NO	NO	NO
22	40	F	52	160	3	RTA	11	1	3:30	NO	NO	NO	NO
23	45	F	56	151	3	SDH	8	1	3:15	NO	NO	NO	NO
24	48	M	59	159	3	DCM	10	1	3:15	NO	YES	NO	NO
25	41	M	61	155	1	CA STOMACH	10	1	3:12	NO	NO	NO	NO
26	44	M	60	161	3	ALD	9.5	1	3:10	NO	NO	NO	NO
27	27	F	54	153	3	CABG	10.7	1	3:20	NO	NO	NO	NO
28	62	M	56	159	1	HEELP	10	1	3:32	NO	NO	NO	NO
29	23	M	60	157	3	PPH	10	1	3:15	NO	NO	NO	NO
30	22	F	48	150	3	SDH	10	1	3:10	NO	NO	NO	YES

GROUP B:

SERIAL NUMBER	AGE(YEARS)	GENDER	WEIGHT(KG)	HEIGHT(CM)	ASA	DIAGNOSIS	TIME TO LOCATE THE VEIN (SECONDS)	NO OF ATTEMPTS	DURATION OF CANNULATION (MINUTES)	ARTERIAL PUNCTURE	COMPLICATIONS		
											HEMATOMA	PNEUMOTHORAX	CATHETER DISPLACEMENT
1	52	M	68	163	2	CA OESOPHAGUS	13	1	4:45	NO	NO	NO	NO
2	29	M	55	152	2	CRUSH INJURY	16	2	4:52	YES	YES	NO	NO
3	56	M	64	161	2	MI	15	2	4:55	NO	NO	NO	NO
4	26	F	51	161	2	PPH	16	2	4:52	YES	YES	NO	NO
5	25	F	45	148	2	ECLAMPSIA	15	2	4:58	NO	NO	NO	NO
6	32	F	59	156	3	PUERPERAL SEPSIS	15	2	4:56	NO	NO	NO	NO
7	32	F	51	154	3	POLYTRAUMA	14	2	5:20	NO	NO	NO	NO
8	34	M	61	169	3	RTA	15	2	6:10	YES	NO	NO	NO
9	46	F	46	148	3	MI	15	2	6:08	YES	YES	NO	NO
10	56	F	49	157	2	SDH	15	2	6:12	NO	NO	NO	NO
11	29	F	52	157	3	CRUSH INJURY	16	3	7:15	NO	NO	NO	NO
12	42	M	68	161	2	PPH	16	2	5:15	NO	NO	NO	NO
13	71	F	51	151	3	BURNS	16	3	7:20	NO	NO	NO	NO
14	46	M	62	158	2	SDH	15	2	5:45	YES	NO	NO	NO
15	34	F	48	152	3	PPH	14	3	7	NO	NO	NO	NO
16	24	M	62	150	1	BURNS	14	2	5:25	NO	NO	NO	NO
17	44	M	58	155	2	POLYTRAUMA	14	3	7	YES	NO	NO	NO
18	73	F	52	148	3	MI	16	3	7:20	NO	NO	NO	NO
19	61	F	54	152	2	CABG	15	3	7:15	NO	NO	NO	NO
20	23	M	56	155	2	BURNS	14	3	7:20	NO	NO	NO	NO
21	52	M	68	157	2	CRUSH INJURY	15	2	6:10	NO	NO	NO	NO
22	72	M	72	160	2	DCM	14	3	7:45	NO	NO	NO	NO
23	62	F	52	162	3	CEREBRAL ANEURYSM	15	3	7:55	NO	NO	NO	NO
24	24	M	56	155	3	ACUTE PANCREATITIS	15	3	7:56	NO	NO	NO	NO
25	61	F	46	160	1	RTA	16	3	7:49	NO	NO	NO	NO
26	24	F	48	160	3	ECLAMPSIA	16	3	7:52	NO	NO	NO	NO
27	23	F	52	161	3	SDH	15	3	7:56	NO	NO	NO	NO
28	51	F	48	152	3	DCM	15	3	7:49	NO	NO	NO	NO
29	34	M	60	155	2	POLYTRAUMA	15	3	7:35	NO	NO	NO	NO
30	34	M	64	161	2	CA STOMACH	15	3	7:48	NO	NO	NO	NO