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Case Report

CASE REPORT

Exploring an Anatomical Variation of the Cephalic Vein: Implications for Physiological Function and Surgical Outcomes

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Abstract

Background: In surgical practice, the precise implantation of Cardiac Implantable Electronic Devices (CIED), starting central lines, and several other procedures can rely heavily on the cephalic vein's typical anatomy. However, deviations from this norm, as uncovered in this cadaveric case report, can yield unexpected clinical findings. This report spotlights a unique anatomical variation, an anomaly characterized by its superficial course and connection to the external jugular vein. While vascular variations aren't uncommon, this variant's rarity and potential impact on surgical procedures are significant. **Methods:** Ten formalin-fixed cadavers were dissected of cadaveric specimens and this variant was discovered in one donor of the ten available. High-resolution photographs were methodically taken to document the cephalic vein's anatomy and its connections. Photographs were taken from two 77-year-old females and a 70-year-old male. A literature review was completed exploring embryologic origins and clinical implications of the supraclavicular vein. **Results:** This anomalous supraclavicular cephalic vein anatomy, documented in 2-5% of cases, presents various variations, such as anastomoses with the external jugular vein. Exploring the embryological origins of the persistent supraclavicular cephalic vein provides insights into evolutionary biology, reflecting an atavistic feature seen in lower vertebrates. This sheds light on the reversed development of jugular veins in higher vertebrates like primates, offering valuable clues to vascular development. **Discussion:** Anatomical variations underscore the importance of detailed preoperative planning in surgical procedures involving the cephalic vein. The abnormal cephalic vein can impede procedures such as CIED implantation, peripheral lines, and others that can utilize the cephalic vein. Understanding these variations is crucial for safe device placement and surgery. This case also highlights the importance of diagnostic and treatment strategies, urging surgeons to adapt their approach in abnormal cases.

Key words: cephalic vein anatomy, anatomical variations, surgical outcomes

Cephalic Vein Anatomy and Physiology

The cephalic vein is an integral part of the upper limb's venous system, playing a crucial role in the drainage of blood from the superficial structures of the upper limb. Alongside its counterpart, the basilic vein, it forms a key component of the superficial venous system of the upper extremity. The cephalic vein originates from the radial aspect of the superficial venous network within the anatomical snuffbox, a small depression located on the dorsal aspect of the hand. From there, it travels through the forearm and arm, initially arching around the radial aspect of the distal forearm before traversing the anterolateral forearm.

As the cephalic vein ascends, it passes over the anterior elbow region, continuing its trajectory through the anterolateral arm. It is positioned laterally to the biceps muscle and is delineated by the deltopectoral groove, a key anatomical landmark. Throughout its course, the cephalic vein may be joined by accessory cephalic veins arising from the venous plexus on the dorsum of the forearm or the medial aspect of the dorsal venous network of the hands. These supplementary vessels typically coalesce with the cephalic vein near the elbow, further contributing to its venous supply.

The cephalic vein eventually pierces the clavipectoral fascia and anastomoses with the axillary vein after piercing through the anterior wall of the axilla. This junction is a critical point in the venous drainage of the upper limb, as the cephalic vein plays a vital role in siphoning blood from the lateral side of the superficial venous network of the dorsum. Its extensive network extends its reach to encompass the lateral aspect of the upper limbs through an array of small superficial veins. These veins play a crucial role in maintaining venous return from the upper limb, making the cephalic vein an important vessel in both anatomical and clinical contexts.[1-5]

Fig. 1. Normal cephalic vein that anastomoses with the axillary vein.

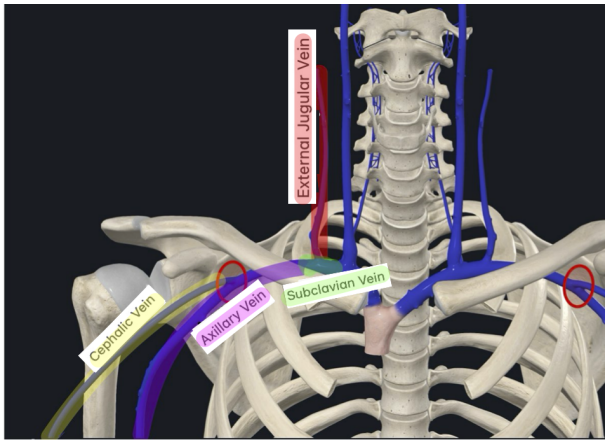


Fig. 2. Normal cephalic vein of a 77-year-old female that anastomoses with the axillary vein on the left side. In this image, the axillary vein has been cut where the dissection probe is shown piercing the vein.

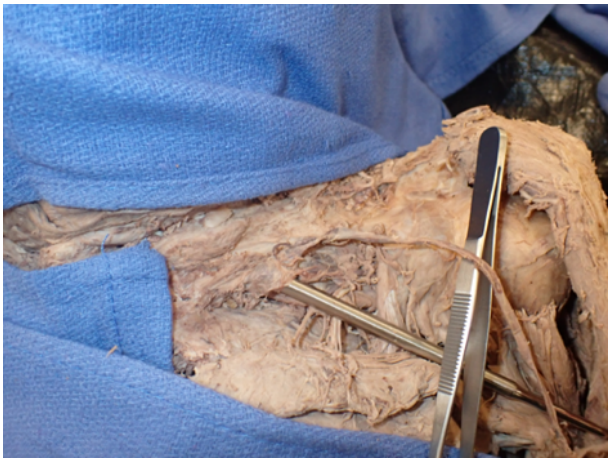
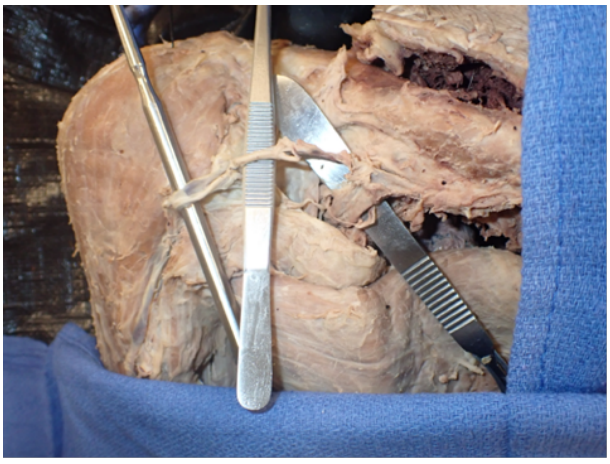


Fig. 3. Normal cephalic vein of a 70-year-old male that anastomoses with the axillary vein on the right side.



Materials and Methods

This study involved the dissection of ten formalin-fixed cadavers over approximately one month. The dissections were conducted by first-year osteopathic medical students during the Musculoskeletal Course at the Rocky Vista University, Montana College of Osteopathic Medicine (MCOM). The anatomical donors were acquired through the Colorado Anatomical Board's Anatomical Gift Program, ensuring ethical and regulated access to cadaveric materials for educational and research purposes.

Superficial dissections of the thoracic wall and shoulder regions were performed using the RVUANATOMY online anatomical dissector. This digital tool provided a standardized approach to the dissections, ensuring consistency in the documentation process. The anatomy of the cephalic veins was recorded bilaterally and photographed in detail, focusing on the course, connections, and any observed variations.

Of the ten available cadavers, four were documented in detail, with two of them presenting only unilateral intact cephalic vein anatomy. High-resolution photographs were systematically taken to document the cephalic vein anatomy and its connections, providing a visual record for further analysis. The collected data was then analyzed in conjunction with existing literature to identify and document instances of abnormal cephalic vein anatomy. This comprehensive approach allowed for a detailed comparison with known anatomical variations and provided insights into the clinical implications of the observed variants.

Results

The detailed dissections revealed significant variations in cephalic vein anatomy among the examined cadavers. Four specimens were identified with intact cephalic veins, with two exhibiting unilateral intact vasculature and the other two showing bilateral intact cephalic veins. The majority of the donors, three out of four, displayed the typical anatomical course of the cephalic vein, where it anastomoses with the axillary vein after passing through the clavipectoral fascia.

However, one donor presented with a notable anatomical variation: the cephalic vein was observed anastomosing with the external jugular vein instead of the axillary vein. This variant was associated with visible bilateral varicosities in both the cephalic and external jugular veins, suggesting an underlying alteration in venous pressure or flow dynamics. Additionally, a persistently normal cephalic vein was observed anastomosing with the axillary vein, passing deep to the anomalous vein through the deltoid and bicep regions. This dual venous drainage pattern highlights the complexity and variability of the cephalic vein's anatomy.

These findings underscore the importance of recognizing anatomical variations in the cephalic vein, particularly in clinical settings where venous access is required. The presence of such variations can have significant implications for surgical procedures, particularly those involving the placement of CIEDs, central venous catheters, or other intravascular devices.

Fig. 4. Variant cephalic vein that anastomoses with the external jugular vein.

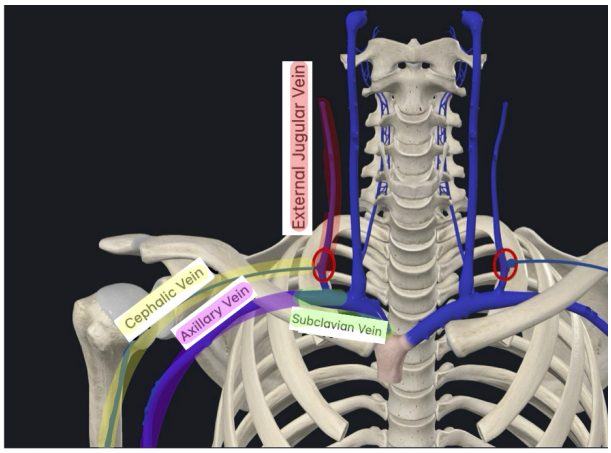


Fig. 5. Variant cephalic vein of a 77-year-old female that anastomoses with the external jugular vein on the left side. In this image, the axillary vein has been cut where the dissection probe is shown piercing the vein.

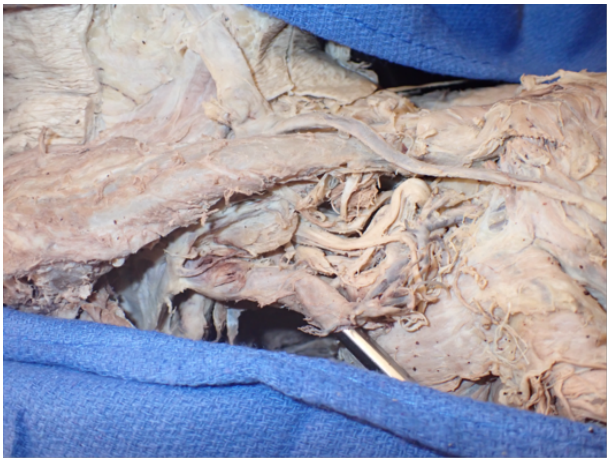
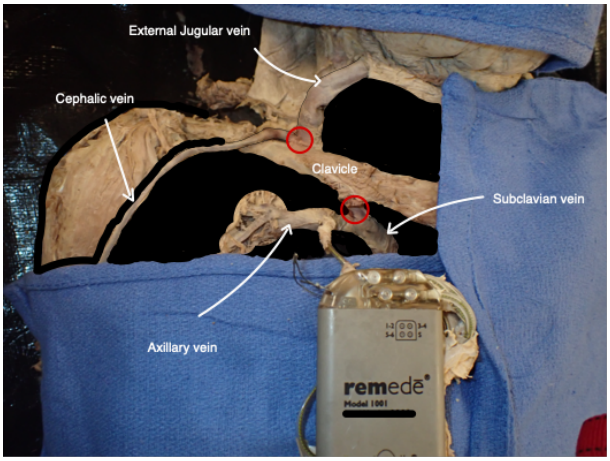


Fig. 6. Variant cephalic vein of a 77-year-old female identified on the right side along with a Central Sleep Apnea device that is implanted through the subclavian vein. Red circles indicate anastomosis.



Clinical Significance of Variant Anatomy

The presence of a variant supraclavicular cephalic vein, with a reported frequency of 2-5% in the general population, presents unique challenges in clinical practice.[6] The most commonly reported variant involves the cephalic vein traversing superficially to the clavicle and anastomosing with the external jugular vein. This variant is often referred to as a jugulocephalic vein (JCV). Other notable anomalous venous patterns may exist including the cephalic vein draining into transverse cervical and suprascapular veins by way of communicating branches before draining into the external cephalic vein.[7] Understanding the prevalence and implications of such variations is critical for clinicians, particularly those involved in surgical procedures requiring venous access.

In cardiac device implantation surgeries, the cephalic vein cutdown technique is often preferred as the initial approach to avoid complications such as pneumothorax and subclavian crush syndrome.[8] However, the presence of a variant supraclavicular cephalic vein can complicate this procedure. Inserting a guide wire through the cephalic vein in such cases can lead to accidental damage to the thoracic inlet region, increasing the risk of complications such as arterial puncture, pneumothorax, or hemothorax.[9] Additionally, the course of the variant cephalic vein can result in increased procedural complexity, potentially necessitating alternative access points or surgical techniques.

The implications of these anatomical variations extend beyond just cardiac device implantation. As the demand for central venous catheterization increases, particularly in critically ill patients or those requiring long-term intravenous therapies, the presence of a variant cephalic vein can pose significant risks. Traditional percutaneous approaches to the subclavian or internal jugular veins carry inherent risks, including arterial puncture, pneumothorax, hemothorax, and other serious complications.[9] Thus, the identification of a superficial access point, such as the external jugular vein or a variant cephalic vein, becomes crucial in minimizing these risks.

In cases where a variant supraclavicular cephalic vein anastomoses with the external jugular vein, special caution must be taken during catheter insertion. The potential for damaging adjacent structures, particularly in the thoracic inlet, necessitates a thorough understanding of the patient's venous anatomy. This understanding can be achieved through preoperative imaging or intraoperative exploration, allowing for more informed decisions and potentially reducing the risk of complications.

Possible Evolutionary or Embryologic Origins

The presence of a supraclavicular cephalic vein that anastomoses with the external jugular vein may also have evolutionary and embryological significance. In lower vertebrates, the external jugular vein is more developed, while the internal jugular vein is less prominent. This relationship is reversed in higher vertebrates, including primates, where the internal jugular vein becomes dominant, reflecting the increased metabolic demands of the brain.[10]

The cephalic vein is embryologically derived from the external jugular vein, which is less developed in

higher vertebrates. During early fetal development, the cephalic vein initially drains into a venous plexus in the neck, which also gives rise to the external jugular vein. As development progresses, the cephalic vein typically establishes a connection with the axillary vein, leading to the loss of its connection with the external jugular vein. However, if this connection persists, it results in a persistent jugulocephalic vein, a condition that can be viewed as an atavistic feature, a vestige of ancestral venous patterns observed in lower vertebrates.[11]

The persistence of this anatomical variant may suggest a failure of the normal regression of the embryonic venous channels, leading to the retention of an abnormal venous pathway. This anomaly could be influenced by genetic, environmental, or developmental factors, although the precise mechanisms remain largely speculative. Further research into the embryological development of the venous system, coupled with comparative studies across species, could provide valuable insights into the evolutionary significance of these variations.

Common Surgical Techniques

The cephalic vein is commonly utilized in a variety of surgical procedures, particularly in the placement of CIEDs. The traditional cephalic vein cutdown technique is favored for its lower risk of complications compared to other venous access methods, such as axillary or subclavian vein punctures.[12] However, the presence of an abnormal cephalic vein, such as a supraclavicular variant, can complicate this procedure and may require modifications to the surgical approach.

When a supraclavicular cephalic vein is encountered during surgery, alternative venous access points may need to be considered. For instance, a jugular vein cutdown or the use of the contralateral cephalic vein may be necessary before resorting to more invasive techniques like axillary or subclavian vein punctures. This adaptability is crucial in ensuring the success of the procedure and minimizing patient risk.

Moreover, the cephalic vein is increasingly being used for venous access in oncology patients, particularly for the long-term infusion of chemotherapy. While the internal jugular vein is commonly used for central venous access, it can cause discomfort and inconvenience to patients. The cephalic vein offers a less invasive alternative with comparable outcomes, reducing the need for specialized equipment and lowering medical expenses.[13] However, the presence of cephalic vein anatomical variations, such as a supraclavicular variant, can pose significant risks, including environmental impingement and complications related to its anastomosis with the external jugular vein. These factors must be carefully considered when selecting the most appropriate venous access route for oncology patients.

The challenges presented by anatomical variations of the cephalic vein underscore the importance of preoperative planning and intraoperative adaptability. Surgeons must be prepared to identify and respond to anatomical variations, utilizing alternative techniques and access points as necessary to ensure patient safety and procedural success.

Conclusion

The dissection and study of ten formalin-fixed cadavers provided valuable insights into the anatomical variations of the cephalic vein, highlighting their clinical significance in various surgical and medical procedures. While the cephalic vein typically serves as a reliable conduit for venous access, particularly in the placement of cardiac devices and central venous catheters, variations in its anatomy, such as anastomosis with the external jugular vein, can pose significant challenges.

These anatomical variations, though relatively rare, have important implications for surgical practice. The presence of a supraclavicular cephalic vein, for example, can complicate procedures that rely on traditional venous access techniques, necessitating alternative approaches to avoid complications. Understanding these variations is, therefore, critical for clinicians, as it allows for more informed decision-making and enhances patient safety. Moreover, the evolutionary and embryological perspectives on cephalic vein variations provide a deeper understanding of the underlying mechanisms that contribute to these anomalies. By exploring the persistence of ancestral venous patterns in modern humans, we can gain insights into the factors that drive anatomical variation and their potential impact on clinical outcomes.

In conclusion, this study underscores the need for continued research into the anatomical variations of the cephalic vein and their clinical implications. Such research is essential for improving surgical techniques, enhancing patient outcomes, and advancing our understanding of human anatomy.

Competing Interests

No competing interest is declared.

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