

MORPHOLOGICAL CHARACTERISTICS OF UPPER LIMB SUPERFICIAL VEINS IN ADULTS

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ABSTRACT

Background

Anatomical variability of the superficial veins of the upper limb is an important and clinically significant topic in contemporary anatomy. Despite well-established basic schemes of venous drainage, numerous studies demonstrate a high frequency of individual and population-specific variations in vein course, calibre, branching patterns, and the structure of anastomoses.

These variations have direct clinical relevance, influencing the outcome of venepuncture, catheterization, vascular access placement, as well as reconstructive and microsurgical procedures. Particular attention is given to variations in the cubital fossa and the presence of atypical venous connections, which are important for planning venous grafts, arteriovenous fistulas, and complex surgical interventions.

Modern investigative methods, including anatomical, ultrasonographic, and angiographic studies, demonstrate a broad spectrum of variations, often influenced by demographic and population-specific factors. Studying these variations is also essential for medical education, as standard anatomical textbooks often fail to reflect the true diversity of the venous system.

Systematic documentation of such data improves training of healthcare professionals and enhances the safety and effectiveness of clinical and surgical procedures. The aim of the study was to identify morphological variations of the superficial veins of the upper limb in adults for their application in clinical practice.

Material and methods

A study was conducted on 75 healthy young adults (36 females, 39 males, aged 18–23) for visualization of the superficial veins of the upper limb. A sphygmomanometer cuff was applied to the upper arm (130–140 mmHg) while participants repeatedly clenched and unclenched their fists, allowing the veins to fill and become visible through the skin. The veins were recorded using a digital camera. Macroscopic examination and statistical analysis were performed.

Results

The study identified multiple anatomical variants of the superficial veins of the anterior upper limb (SVASUL), differing in prominence, connectivity, symmetry, and morphology.

Among 75 upper limbs, 87% were asymmetrical. Well-developed veins were observed in 60% of cases, with the most common variant (24%) showing all major veins prominent, whereas in 40% the veins were poorly developed or absent. Specific patterns included a well-developed median cubital vein (10%), well-developed lateral and medial superficial veins of the arm (14%), and combinations with the median forearm vein (6%).

The prominence and continuity of venous anastomoses were classified into continuous networks (77%) with large anastomosing veins, and discontinuous networks (23%) linked by smaller veins and microcirculatory vessels. Venous anastomoses were further classified by shape, with the V-shaped type being the most frequent (29%), followed by N-, M-, H-, W-, U-, Y-, O-, X-shaped, network-like forms, and mixed types. This classification provides a comprehensive framework for describing SVASUL variability, which has clinical relevance for venous access procedures and surgical interventions.

Conclusions

SVASUL are characterized by bilateral asymmetry in 87% of cases, continuous venous networks in 77% of cases, and well-developed veins in 60% of cases.

Among the well-developed veins, the most common variant includes prominent lateral and medial superficial veins of the arm together with the median cubital vein (24% of cases), while the most frequent shape of the venous anastomosis is the V-shaped type (29% of cases).

Key words: anatomical variations, upper limb, superficial veins, clinical anatomy.

RELEVANCE

Anatomical variability of the superficial veins of the upper limb represents one of the most debated and clinically significant topics in contemporary clinical anatomy. Although the basic scheme of venous drainage of the upper limb has been described and extensively studied, numerous investigations conducted over the past decades convincingly demonstrate that variations in their configuration occur with high frequency and carry fundamental implications for clinical practice.

These variations are not merely academic curiosities; they directly influence procedural outcomes in a wide range of medical specialties, from routine intravenous access to complex reconstructive and microsurgical interventions [1].

The upper limb superficial veins display not only individual variability in their course, caliber, and branching patterns but also considerable diversity in the presence and structure of anastomoses. This variability is particularly important when performing venipuncture, catheterization, or placement of vascular access devices, as well as during reconstructive and microsurgical procedures that require precise knowledge of venous anatomy.

For example, anatomic studies have shown that the prevalence of different cubital fossa patterns, such as the M-type and N-type configurations, ranges between 29 % and 34 % among adults, emphasizing the need for clinicians to be aware of population-specific variations [1].

Clinical experience consistently confirms that the anatomical characteristics of the superficial venous system largely determine the outcome of diagnostic and therapeutic interventions. In daily practice, the success of peripheral catheter placement, intravenous chemotherapy, and other infusion procedures often depends on the accessibility, diameter, and course of the veins. Furthermore, autologous venous grafts, commonly harvested from the vena cephalica or vena basilica, and the creation of arteriovenous fistulas for patients with chronic kidney disease require meticulous preoperative evaluation to minimize the risk of complications and ensure long-term patency [2].

The clinical significance of studying superficial venous variability is also evident in the field of reconstructive surgery. In procedures involving musculocutaneous flaps or free tissue transfer, precise mapping of the venous network allows surgeons to prevent venous congestion and tissue necrosis, which are common complications in cases where anomalous venous anatomy is not recognized preoperatively. Variants such as cephalica-basilica anastomoses, accessory veins, or atypical tributaries can significantly alter venous outflow and thus impact surgical outcomes [2].

Recent years have witnessed a marked increase in interest regarding the variability of the venous network of the upper limb, driven by advances in endovascular surgery, transplantation medicine, and microsurgery. Cadaveric studies, ultrasonographic assessments, and angiographic investigations have revealed a wide spectrum of variants, with frequencies dependent on population demographics, methodological approach, and clinical context [3].

Such research highlights that superficial venous patterns are not merely individual traits but may exhibit population-specific trends that are critical for planning surgical interventions or vascular access procedures.

From an educational standpoint, understanding these variations is essential for both medical students and healthcare professionals. Standard anatomical textbooks often present a simplified version of venous anatomy, which may not accurately reflect the true diversity encountered in clinical practice.

Therefore, continuous documentation and systematization of superficial venous variants are vital for updating curricula and training programs, ensuring that future practitioners are well-prepared for anatomical diversity encountered in patients.

In conclusion, the study of anatomical variability of the superficial veins of the upper limb remains a pressing challenge not only for morphological science but also for clinical medicine. Systematic analysis and synthesis of contemporary data refine fundamental knowledge of venous anatomy and provide clinicians with evidence-based recommendations for the safe and effective performance of diagnostic, therapeutic, and surgical procedures.

Recognition of these anatomical variations directly contributes to improved patient safety, reduces procedural complications, and enhances the success rates of interventions ranging from routine venipuncture to advanced reconstructive and vascular surgery [4].

The aim of the present study was to identify the morphological variations of the superficial veins of the upper limb in adults for their application in clinical practice.

MATERIAL AND METHODS

A living visual study of the superficial veins of the upper limb was conducted in 75 individuals (36 females and 39 males) aged 18–23 years. For this purpose, a mechanical sphygmomanometer cuff was applied to the upper third of the arm, and air was inflated to a cuff pressure of approximately 130-140 mmHg.

The subjects repeatedly clenched and unclenched their fists, resulting in venous filling of the forearm superficial veins, which became visible through the skin.

These veins were then documented using a Nikon D3100 digital camera.

The patients had no any connective tissue disorders or vascular pathology of the upper limbs.

The methods of investigation included macroscopic examination and statistical evaluation.

RESULTS AND DISCUSSION

The study revealed several anatomical variants of the superficial veins on the anterior surface of the upper limb (SVASUL), differing in prominence, connectivity patterns, symmetry, and other morphological features.

Based on the study findings, all observed variants of the SAUL veins were classified as follows:

1. Classification of SVASUL by symmetry within individuals (comparing right and left upper limbs): symmetrical (8 individuals, 13%) and asymmetrical veins: 52 individuals (87%)
2. Classification of SVASUL according to the prominence of major veins: well-developed veins were observed in 60% of upper limbs, subdivided as follows:
 - the lateral and medial superficial veins of the arm, together with the median cubital vein, well-developed (24%, n=36);
 - only the median cubital vein well-developed (10%, n=15);
 - only the lateral and medial superficial veins of the arm well-developed (14%, n=21);
 - presence of additional prominent veins in combination with well-developed lateral, medial superficial veins of the arm and median cubital vein: median vein of the forearm (6%, n=9), additional lateral superficial vein of the arm (2%, n=3), median lateral superficial vein of the arm (2%, n=3), median medial superficial vein of the arm (2%, n=3).

Poorly developed or absent major veins: 40% of upper limbs (n=60).

This classification provides a comprehensive framework for describing the variability of superficial venous anatomy in the anterior upper limb, which may have clinical relevance for venous access procedures and surgical interventions.

Analysis of the collected data demonstrated that in 40% of cases (n=60 upper limbs), the superficial veins of the upper limb were poorly visible or not visible at all through the skin (Fig. 1).

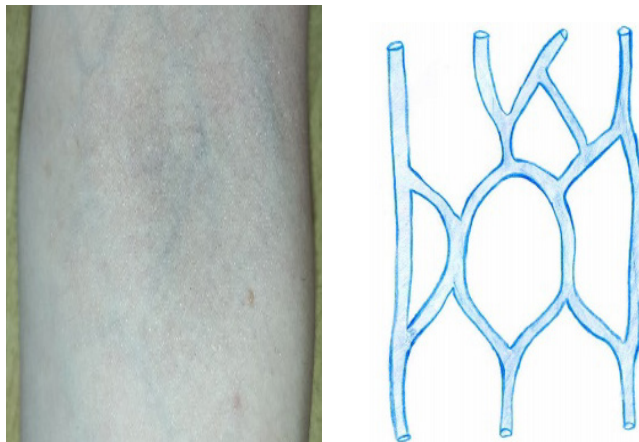


Fig. 1. Poorly developed superficial veins of the anterior aspect of the upper limb in a 21-year-old female (40%, n=60)

60% of upper limbs exhibited well-developed superficial veins.

These were further categorized according to the degree of transcutaneous visualization of specific veins. Among the well-developed SVASUL, the most common variant was characterized by the prominence of all major veins (24%, n=36) (Fig. 2).

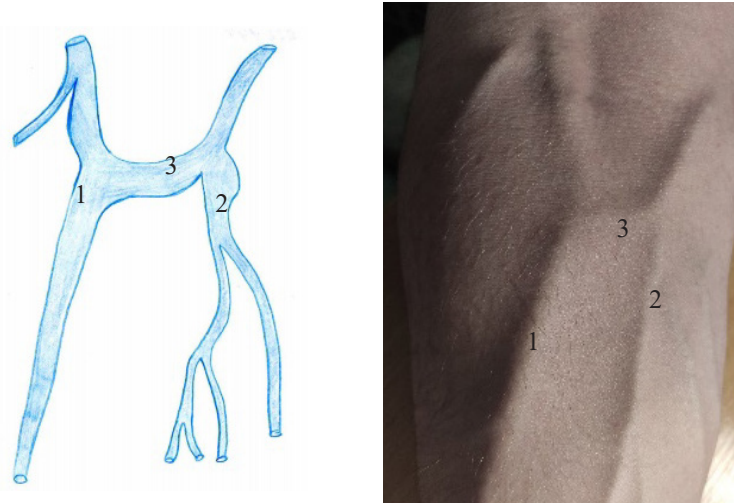


Fig. 2. All major veins prominent (24%, n=36) in an 18-year-old male: 1 – lateral superficial vein of the arm; 2 – medial superficial vein of the arm; 3 – median cubital vein

10% of upper limbs (n=15) exhibited a well-developed median cubital vein (Fig. 3A). In 14% of cases (n=21), variants of SVASUL were observed in which the lateral and medial superficial veins of the arm were well-developed (Fig. 3B).

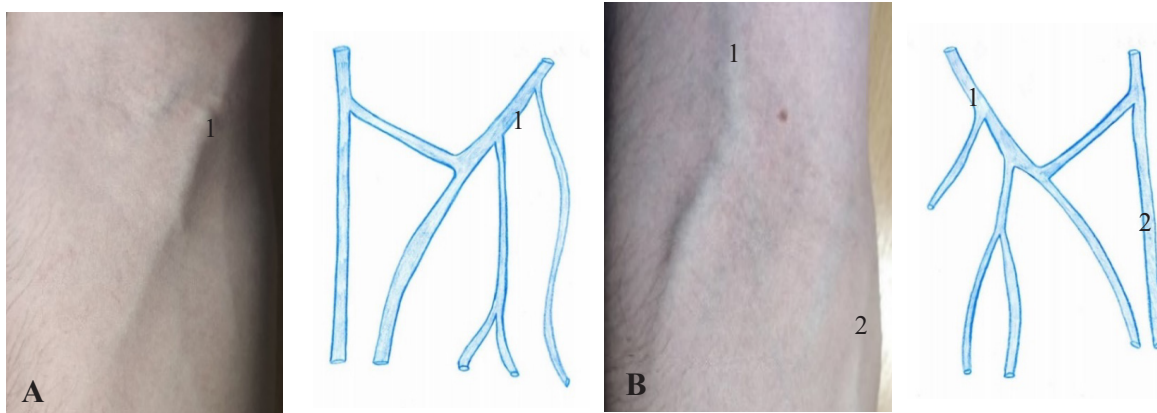


Fig. 3. Variants of SVASUL anatomy: A – well-developed median cubital vein (1) (10%, n=15) in a 20-year-old male; B – well-developed medial (1) and lateral (2) superficial veins of the arm (14%, n=21) in a 20-year-old male

The SVASUL variant with a well-developed median vein of the forearm (6%, n=9) was most frequently observed in combination with a prominent median medial vein of the arm (2%, n=3) and a median lateral vein of the arm (2%, n=3).

During the examining of the prominence of anastomoses between the lateral and medial superficial veins of the arm, it was found that they may connect via a large anastomosis (a well-developed vein) or through smaller veins and microcirculatory vessels.

Based on these observations, a classification of SAUL veins according to continuity was proposed, distinguishing between: a continuous venous network (77%, n=69) and a discontinuous venous network (23%, n=21).

The study demonstrated that in 77% of cases (n=69), the continuous type predominates, characterized by the presence of a large anastomosing vein, such as the median cubital vein. In 23% of cases (n=21), the discontinuous type was observed, in which a large anastomosing vein is absent, and connections between major veins most likely occur at the level of smaller veins and microcirculatory vessels.

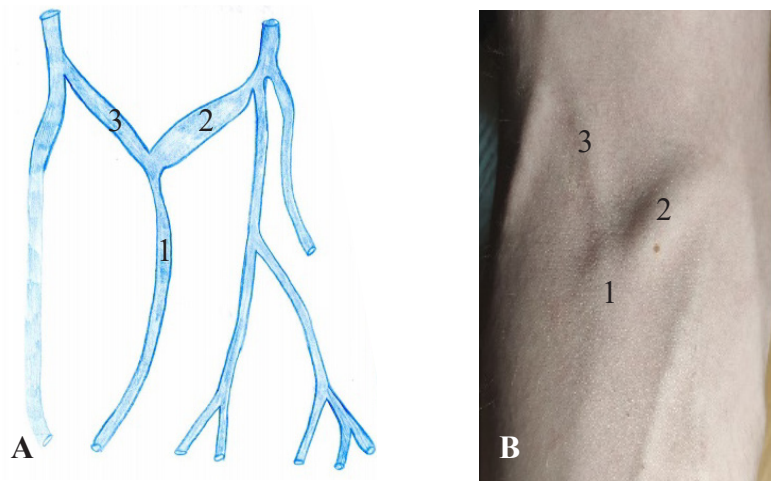


Fig. 4. Upper limb demonstrating a combination of several SAUL vein variants: well-developed median vein of the forearm (1), median medial (2), and median lateral (3) superficial veins of the arm in an 18-year-old male

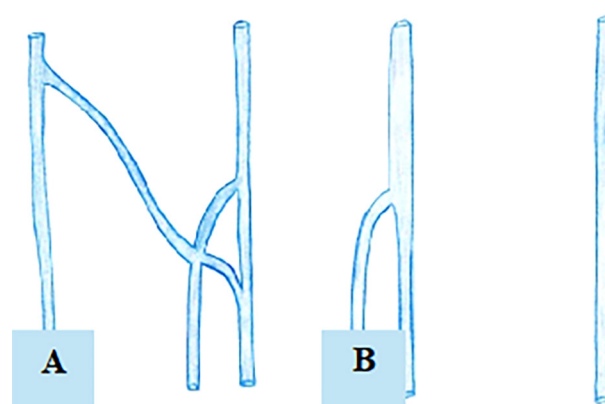


Fig. 5. Schemes of continuous (left) and discontinuous (right) venous networks

Classification of SVASUL according to the shape of the venous anastomosis connecting the lateral and medial superficial veins of the arm: V-shaped type (29%, n=20), N-shaped type (16%, n=11), M-shaped type (13%, n=9), H-shaped type (9%, n=6), W-shaped type (9%, n=6), U-shaped type (9%, n=6), Y-shaped type (4%, n=3), O-shaped type (4%, n=3), Network-like type (4%, n=3), X-shaped type (2%, n=2) and combination of several types (1%, n=1).

CONCLUSION

In adults SVASUL are characterized by bilateral asymmetry in 87% of cases, continuous venous networks in 77% of cases, and well-developed veins in 60% of cases.

Among the well-developed veins, the most common variant includes prominent lateral and medial superficial veins of the arm together with the median cubital vein (24% of cases), while the most frequent shape of the venous anastomosis is the V-shaped type (29% of cases).

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