ORIGINAL RESEARCH

Variations of superficial veins in the cubital fossa - A cadaveric study in a Sri Lankan population

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Abstract

Objectives: Cubital fossa is important for various clinical procedures. Anatomical variations in the arrangement of cephalic, basilic, and median cubital veins can influence these procedures. Classical patterns in literature are M-type, Y-type, N-type, and W-type, while Charles' 1932 classification gives a more detailed picture. Understanding venous variations is vital to improving procedures and reducing complications. Objective of the study was to describe morphological patterns of superficial cubital veins using preserved cadavers in a Sri Lankan population.

Methods: This study was conducted at the Department of Anatomy, Faculty of Medicine, University of Peradeniya. Both upper limbs of sixteen formalin-preserved cadavers used for undergraduate medical teaching were finely dissected. The patterns of cubital veins were observed, documented, and classified.

Results: The sample consisted of 16 adult cadavers with an equal male-to-female ratio. Two right upper limbs were excluded due to destruction of veins, leaving a final sample size of 30 (14 right, 16 left). Type 1 was the most common cubital vein morphology (33.3%), followed by Type 3 (30%). Females exhibited a higher frequency of Type 1 (35.7%), while males showed a greater occurrence of Type 3 (43.8%). There was no statistically significant association between vein morphology and sex (p=0.389) or laterality (p=1.000).

Conclusion: Type 1 was the most common venous pattern, followed by Type 3, with minimal variation by sex or limb laterality. Knowledge of the superficial veins of the cubital fossa is clinically important. Larger standardized studies are needed for clearer insights.

Keywords: Basilic vein, cephalic vein, median cubital vein, superficial veins of upper limb

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Introduction

The cubital fossa, located on the anterior aspect of the elbow joint, serves as an important anatomical transition area between the arm and forearm. The cubital veins play a crucial role in various clinical procedures, including venipuncture, intravenous cannulation, blood transfusion, and hemodialysis access (1). The configuration of the cephalic, basilic, median antebrachial, and median cubital veins here show considerable variation with close relationship to critical structures (Figure 1). Because of this complex anatomy, it is important to understand the venous patterns in this area to avoid accidental injury during procedures. Inadequate knowledge can lead to complications such as arterial puncture, nerve damage, hematoma formation, or failed cannulation attempts (2). Therefore, understanding venous variations in the cubital fossa is essential to ensure safe and effective venous access procedures.

The cephalic vein runs along the lateral border, and the basilic vein along the medial border of the upper limb. The median cubital vein, which connects these two at the cubital fossa, is typically the most noticeable superficial vein in the body, making it a common choice for various clinical procedures (3,4). The median antebrachial vein starts from the palmar venous plexus and ascends the front of the forearm, ending in the median cubital or basilic vein (5).

Authors have proposed various classification systems to describe venous patterns in this region. Simplified approaches categorize vein configuration based on their resemblance to alphabetical shapes such as N, M, Y, I, or O types (6,7). A comprehensive system, Charles' classification (1932) (Figure 2 and Table 1), categorizes venous patterns into six types (Type 1 to Type 6) with several subtypes reflecting accessory or duplicated venous variations (5, 8). This remains a well-established and widely accepted method for the morphological description of cubital venous patterns. Charles' Type 3 is similar to "M" (or 'Y') shape variation in literature and is considered the classical type. Charles' Type 2 corresponds with "N" or "H" types in the reported literature. Charles' Type 4 doesn't have a communication branch between the cephalic and basilic veins and is classified as either an "I" or "O" type in the literature (7).

Numerous studies have documented different configurations of the superficial cubital veins and their frequencies across populations and ethnic groups (1,8). However, there is a notable lack of data concerning the Sri Lankan population. Therefore, the present study was conducted to describe the morphological variations of superficial cubital veins in a sample of preserved cadavers from a Sri Lankan population, and to investigate possible associations between venous patterns and variables such as sex and limb laterality.

Methods

This was a descriptive cross-sectional cadaveric study conducted at the Department of Anatomy, Faculty of Medicine, University of Peradeniya, Sri Lanka.

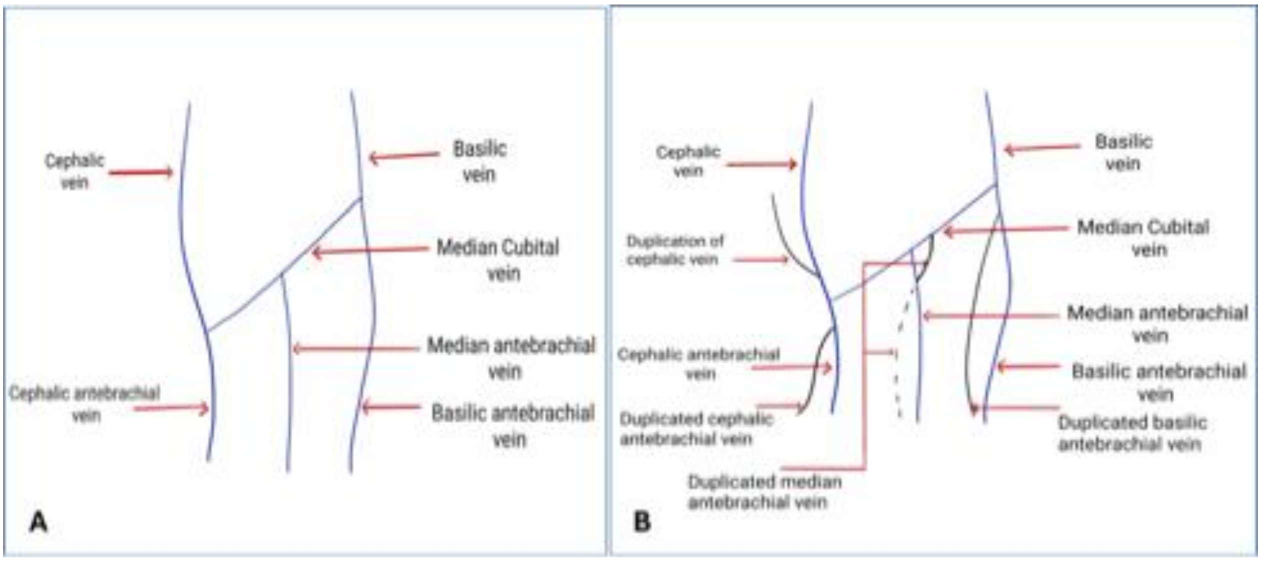

Figure 1: Superficial venous patterns in the cubital fossa: A - Typical pattern, B - Possible variations.

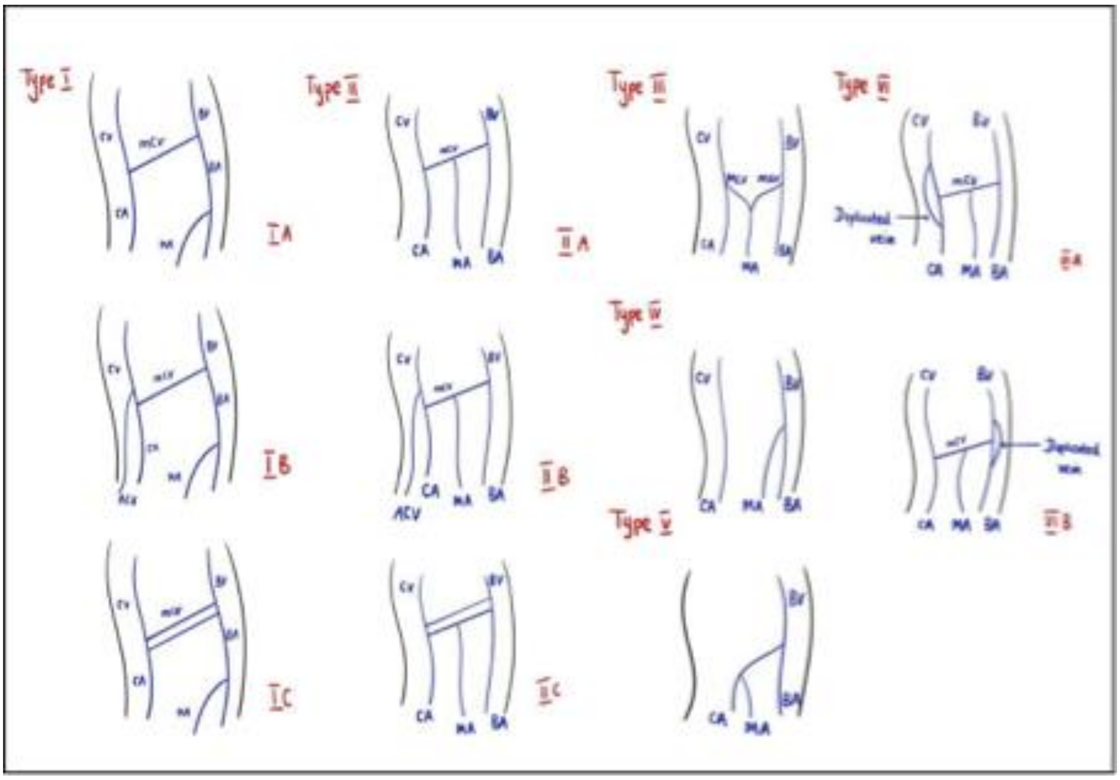

Figure 2: Charles' classification of medial cubital vein variations (CV - Cephalic vein, BV - Basilic vein, mCV - Median cubital vein, CA - Cephalic antebrachial vein, BA - Basilic antebrachial vein, MA - Median antebrachial vein, MCV – Median cephalic vein, MBV – Median basilic vein, ACV - Accessory cephalic vein)

Table 1: Charles' classification of medial cubital vein variations

Type	Subtype	Description
Type 1(N Type)		Presence of an mCV connecting the CV and BV, while the MA drains into the BV
	1A	Classical form of Type 1
	1B	An ACV is present and drains into the CV
	1C	The mCV is duplicated (normal mCV and accessory mCV)
Type 2 (N or H Type)		mCV connects the CV and BV, but the MA drains directly into the mCV
	2A	Classical pattern
	2B	Addition of an ACV draining into the CV
	2C	mCV is duplicated (normal mCV and accessory mCV)
Type 3 (M or Y Type)		Division of the MA into two branches at the cubital fossa. One branch joins the CV (median cephalic vein - MCV). The other joins the BV (median basilic vein - MBV)
Type 4 (I or O Type)		No communication between the CV and BV in the cubital fossa. The MA drains solely into the BV
Type 5		CV is absent. The CA and MA both terminate in the BV
Type 6		Follows the basic pattern of Type 2, but is further complicated by duplicated venous structures
	6A	A duplicated vein is present, connecting the CA to the CV
	6B	A duplicated vein connects the BA to the BV

CV - Cephalic vein, BV - Basilic vein, Median cubital vein – mCV, Median antebrachial vein - MA, Cephalic antebrachial vein – CA, Basilic antebrachial vein – BA, Median cephalic vein – MCV, Median basilic vein – MBV, Accessory cephalic vein – ACV

A total of 16 preserved adult cadavers (32 upper limbs), donated and prepared for academic purposes, were included in the study. Dissection was performed initially according to the instructions given in Grant's Dissector by the medical students on both limbs, and the superficial veins in the cubital fossa were carefully exposed by removing the overlying skin and superficial fascia (9). Fine dissection was performed by investigators when needed. Two right upper limbs were excluded due to significant venous damage during dissections. Demographic data, including age, sex, and ethnicity, were recorded in all included samples.

The prevalence of each venous pattern (Charles' 1932 classification system) was recorded. Data were compiled and analyzed using Microsoft Excel and Jamovi software (10, 11). Descriptive statistics were used to summarize the frequencies and percentages of different venous patterns. Associations between venous pattern and sex or limb laterality were assessed using Fisher's exact test, with a p-value < 0.05 considered statistically significant.

Results

The final sample consisted of 30 upper limbs with an equal number of male and female specimens. The age ranged between 65 and 93 years, with a mean age of 79.71±7.58 years. All were of Sinhalese ethnicity.

The predominant venous pattern observed in the cubital fossa was Charles Type 1, identified in 10 limbs (33.3%), of which Type 1A was the most common subtype, seen in 9 (30%). Type 3 was the second most prevalent, observed in 9 limbs (30%). Type 2 was identified in 4 limbs (13.3%), comprising 2 limbs with Type 2A and 2 limbs with Type 2B. Type 4 was observed in 3 limbs (10%), while Type 6 was noted only in one (3.3%). Type 5 pattern was not found in the present study. The observed venous variations are summarized in Table 2 and depicted in Figures 3 and 4.

Three limbs (10%) demonstrated "other" venous configurations that did not conform to Charles' classification. One exhibited a duplicated median antebrachial vein. Another exhibited a venous arch pattern, characterized by an arched vein with a proximal concavity connecting the cephalic and basilic veins to which the superficial forearm veins drained, and the third limb displayed an accessory vein connecting the basilic vein to the median cephalic vein.

Type 1 was observed more on the left side (37.5% vs 28.7%), whereas Type 3 was slightly more frequent on the right side (35.7% vs 25%). Type 2 showed relatively similar occurrences on both sides, identified in 2 right limbs (14.2%) and 2 left limbs (12.5%). There was no significant association between venous pattern and limb laterality ($p = 1.000$).

Type 1 was equally distributed between males and females, each with 5 limbs (31.3% in males vs 35.7% in females). However, Type 3 was more common in males, seen in 7 limbs (43.8%), while only 2 in females (14.3%).

Table 2: The observed superficial venous variations in the cubital fossa

Type 1A (N)	Type 1B (N)	Type 2A (N)	Type 2B (N)	Type 3 (M)	Type 4	Type 6B	Other	total
9	1	2	2	9	3	1	3	30
30%	3.33%	6.67%	6.67%	30%	10%	3.33%	10%	100%

*N: N-Type, M: M-Type

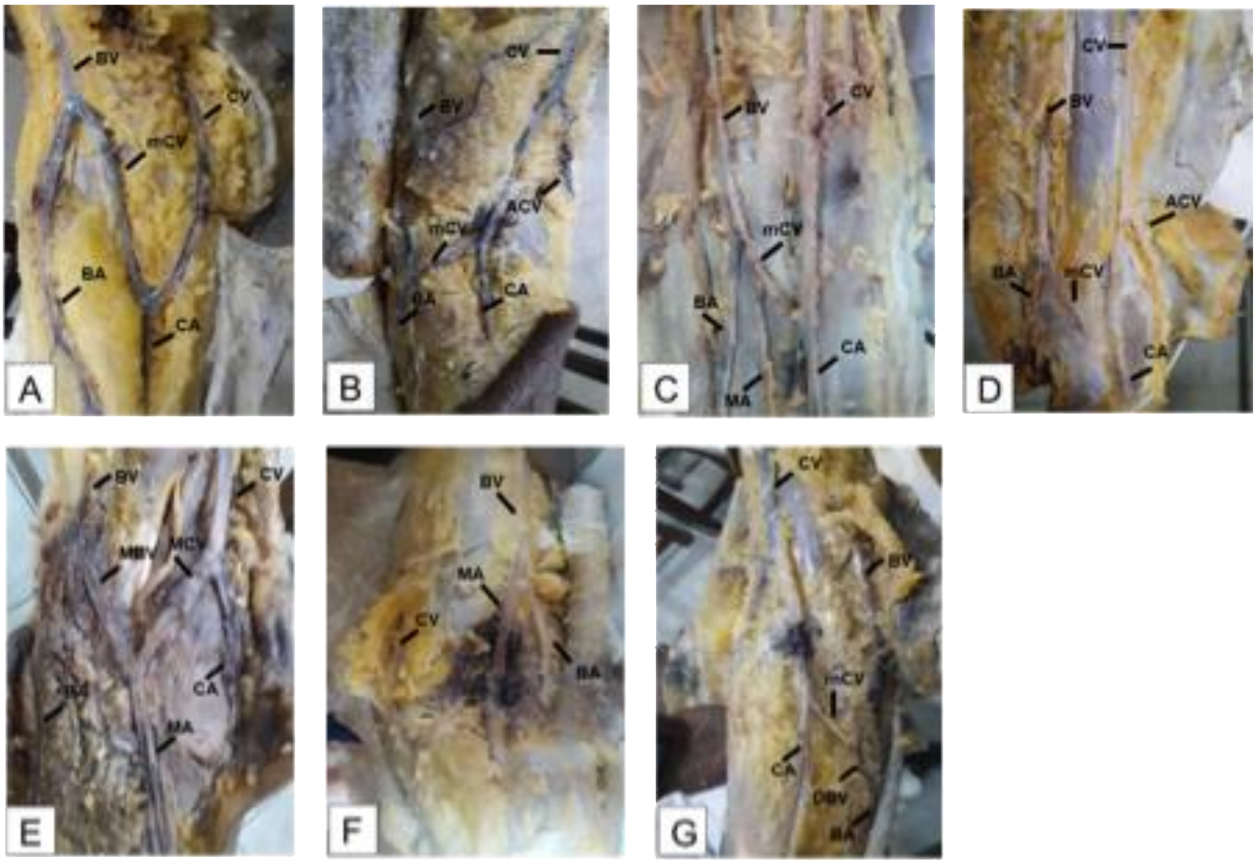

Figure 3: Cubital vein variations observed in the present study according to Charles classification: A - Type 1A, B - Type 1B, C - Type 2A, D - Type 2B, E - Type 3, F - Type 4, G - Type 6B (CV - Cephalic Vein, BV - Basilic Vein, mCV - median Cubital Vein, CA - Cephalic Antebrachial Vein, BA - Basilic Antebrachial Vein, MA - Median Antebrachial vein, MCV - Median Cephalic vein, MBV - Median Basilic vein, ACV - Accessory Cephalic Vein, DBV - Duplicated Basilic Vein, VA - Venous Arch)

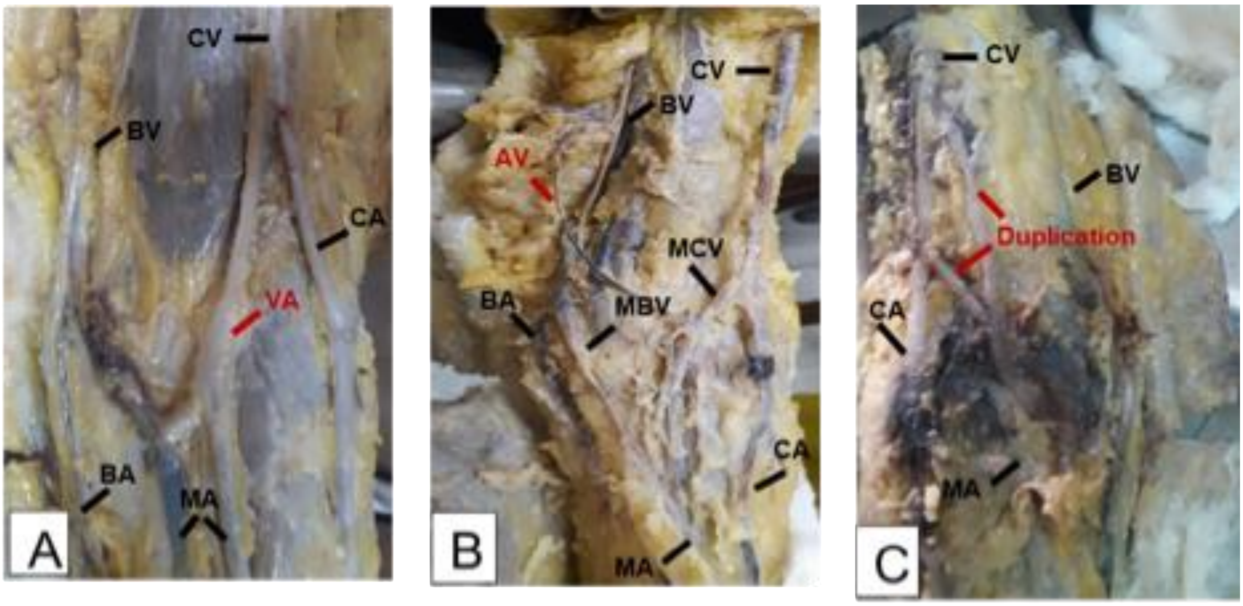

Figure 4: Other patterns observed in the present study: A - Venous arch, B - Basilic vein and median cephalic vein are connected by an accessory vein, C - Duplicated median antebrachial vein (CV - Cephalic Vein, BV - Basilic Vein, CA - Cephalic Antebrachial Vein, BA - Basilic Antebrachial Vein, MA - Median Antebrachial vein, MCV -Median Cephalic vein, MBV - Median Basilic vein, AV - Accessory Vein, VA - Venous Arch)

Table 3: Limb laterality and sex differences in cubital vein variations

Variables		Type 1A (%)	Type 1B (%)	Type 2A (%)	Type 2B (%)	Type 3 (%)	Type 4 (%)	Type 6B (%)	Other (%)	P value
Limb laterality	**Right**	4 (28.6)	0 (0.0)	1 (7.1)	1 (7.1)	5 (35.7)	1 (7.1)	1 (7.1)	1 (7.1)	1.00
	Left	5 (31.3)	1 (6.3)	1 (6.3)	1 (6.3)	4 (25.0)	2 (12.5)	0 (0.0)	2 (12.5)	
Sex	**Male**	5 (31.3)	0 (0.0)	1 (6.3)	0 (0.0)	7 (43.8)	1 (6.3)	0 (0.0)	2(12.5)	0.389
	Female	4(28.6)	1 (7.1)	1 (7.1)	2 (14.3)	2 (14.3)	2 (14.3)	1 (7.1)	1 (7.1)	

*p<0.05 was considered significant

Conversely, Type 2 was more frequently seen in females (21.4%) compared to males (6.3%). Despite these differences in frequencies, no statistically significant association was found between venous pattern and sex (p = 0.389).

A summary of limb laterality and sex differences in cubital vein variations is given in Table 3.

Discussion

Superficial vein variations in the upper limb are common. They develop from embryonic capillary networks that sprout, connect, and fuse to form fewer but larger veins (1).

In our study, the most common venous pattern identified was Type 1 (33.3%), followed by Type 3 (30%) and Type 2 (13.3%) according to Charles' 1932 classification. This is closely associated with what was observed by Charles among Black or African American males but contrasting the results of White males (8).

However, it is important to note that the classification systems used in the literature vary considerably. The Types 1 and 2 patterns in our study correspond to the N-type configuration, and Type 3 corresponds to the M-type described in several other classification systems.

The observed venous patterns correspond with descriptions found in standard anatomy texts, as well as those reported in earlier studies by Melaku et al. and Wasfi et al. using the tourniquet method, Lee et al. using an intravenous illuminator, and Yamada et al. in cadavers (1, 12, 13, 14). A meta-analysis by Yammine et al. also supported our findings with a high percentage of N-type (44-60%), followed by M-type (20-25%) (15). However, some studies found M-type to be more prevalent (16, 17). In India, Dhan et al. found M-type to be more common, followed by N-type in both clinical (M-35%, N-28.75%) and cadaveric (M-35%, N-25%) samples (18).

One of the other variations was a duplicated median antebrachial vein, which was previously reported in Nigeria (17). The second was a venous arch pattern, with an arched vein that had a proximal concavity connecting the cephalic and basilic veins to which the superficial forearm veins drained. This configuration was previously reported by Yammine et al (15). The third variation was an accessory vein connecting the basilic vein to the median cephalic vein, which was previously not reported, according to our knowledge.

In the present study, the most frequent venous pattern on the right side was Type 3 (M-type), observed in 35.7% of limbs, followed by Type 1 (N-type) in 28.7%. Conversely, on the left side, Type 1 was more prevalent (37.5%), with Type 3 coming second (25%). Despite these variations, no statistically significant association with laterality was observed (p = 1.000). These findings are consistent with those of Lee et al. in Korea, who also reported N-type as the most common bilaterally, without a significant relationship between vein pattern and limb side (13). In contrast, Melaku et al. in South Ethiopia reported a significant difference between sides, although N-type remained the most frequent pattern on both (1).

Such variations may reflect underlying anatomical differences among populations.

Previous studies have suggested that genetic and hydrodynamic factors play a significant role in determining venous patterns (19). Melaku et al. suggested that the variations observed in common venous patterns may be attributed to racial differences among different populations (1). A limitation of the present study is the relatively homogenous sample, which comprised only individuals from the Sinhala ethnic group. This is largely due to the limited availability of cadaveric donations from other ethnic communities due to religious and cultural reasons (20). This limitation could be addressed in future studies by employing non-invasive methods in living individuals, allowing the inclusion of participants from all ethnic groups and thereby providing a more accurate representation.

This study observed that the most common venous pattern among males was Type 3 (M-type), followed by Type 1 (N-type) (43.8% and 31.3%, respectively). In contrast, Type 1 was most frequent in females (35.7%), followed by Type 2 (21.4%). However, no statistically significant association was found between venous pattern and sex ($p = 0.389$), aligning with the findings of Lee et al. and Vasudha (13, 19). In contrast, Melaku et al. reported N-type as the most common pattern in both sexes, but interestingly, they identified a statistically significant sex association (1). Additionally, more authors observed the same significant association with sex (15, 16, 17).

Classical N and M-types have been the most well-known types in clinical practice. However, we report additional types in this study, which indicates the necessity to be aware of different types of superficial veins in our region, and to practice a more comprehensive classification to optimize the venous access practice.

A study in Korea noted that the small sample size in their study limited their ability to analyze sex-related differences or draw statistically meaningful conclusions (13). Therefore, increasing the sample size in future studies may help to better identify patterns that were not evident in this limited cohort.

Methodological variations between studies might have influenced the observed findings. Our study, based on cadaveric dissection, enabled direct visualization and accurate classification of venous patterns. In contrast, imaging-based methods such as ultrasound or intravenous illuminators assess veins in vivo, under physiological conditions. These differences in technique can affect how veins appear and are classified, potentially contributing to discrepancies between studies. Furthermore, it is noted that in most studies, small veins were ignored or have not been identified, which may result in misclassification or incomplete documentation of venous patterns (16). Lee et al. noted that compared to cadaveric studies, their study had limitations in visualization of smaller vessels, which may have affected their results (13). Therefore, we recommend a multimodal approach that combines cadaveric dissection with in vivo visualization methods to provide a more comprehensive understanding of venous architecture under both static and physiological conditions.

Given the risk of adjacent nerve injury during venepuncture, we recommend that future studies also examine how superficial veins are positioned in relation to nearby cutaneous nerves in the cubital region. While our study focused on venous pattern variations, it did not explore their relationship with surrounding nerves. Previous cadaveric studies have reported that the medial and lateral cutaneous nerves of the forearm often pass near or across major superficial veins, increasing the risk of nerve damage during procedures (21).

An ultrasound-based study from Sri Lanka reported that the median cubital vein had the largest average diameter among the superficial veins assessed in patients undergoing arteriovenous fistula creation, emphasizing its significance in vascular access planning (22). Including vein diameter measurements in future research, along with pattern classification, may improve clinical applicability and support safer venepuncture and dialysis access.

Conclusion

In conclusion, Type 1 was the most common venous pattern observed, followed by Type 3, with only slight variations based on sex and limb laterality. These findings may be influenced by small sample size, limited population diversity, and differences in study methods. Future research using larger and more diverse samples, along with standardized techniques, could offer clearer and more reliable results.

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Author contributions: MSZJ – Data collection, Drafting original manuscript, Review and editing, NAI - Data collection, Drafting original manuscript, Review and editing, SAAD - Data collection, Review and editing, NWLD - Data collection, Review and editing, BKMVK - Data collection, Review and editing, EWK - Data collection, Drafting original manuscript, Review and editing, MJSJ - Data collection, Data analysis, Drafting original manuscript, Review and editing

Data accessibility statement: All the data gathered is included in this article

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