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VARIABILITY OF THE ARTERIES OF THE AXILLA AND ARM IN MORPHOCLINICAL ASPECT

311.01. HUMAN ANATOMY

Summary of the PhD Thesis in Medical Sciences

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The thesis was elaborated at the Department of Anatomy and Clinical Anatomy of Nicolae Testemitanu SUMPh

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INTRODUCTION

Actuality and importance of the assessed problem. Variational anatomy is the major morphological domain, where every detail has application value, especially when referred to the cardiovascular system. Arterial variability is caused by embryological disorders, which occur in the vascular system and usually does not show functional disorders, but under certain conditions can become fatal [1, 2].

Knowledge on the anatomical variants of the upper limb's blood vessels has become more important in recent years due to the gradual increase in number of radiological procedures, vascular surgeries and, last but not least, reconstructive surgeries, as the axilla and the arm are the site of numerous traumatic vascular injuries caused by weapons, humerus fractures and shoulder dislocations, with a frequency of up to 12% [3, 4].

Description of situation in the domain and identification of the research problem. The morphological aspect of the upper limb arteries individual variability has not been thoroughly studied, despite the fact that in recent years the number of diagnostic procedures and surgeries, performed at this level, has increased considerably [5].

It is important to note that most authors, almost without exception, reported a general presentation, paying no attention to description of the axilla and brachial artery variants details [6, 7, 8]. The majority of the research papers are on case presentations, but not on thorough studies on large samples [9, 10, 11, 12, 13]. There are very few works in the field that report on the individual aspect of these variants, taking into account gender, laterality and constitutional type [2, 5, 7], thus, a research based on a vast study is needed to assess the individual variability of the axilla and arm arteries.

Working hypothesis. The stringent scientific and practical need on morphological and clinical applicative knowledge building, studying the individual anatomical variability of the axilla and arm arteries and creating arterial hemodynamics mathematical model at this level.

Research purpose. Determining the peculiarities of the general and individual variability of the axilla and arm arteries, according to gender, constitutional type and laterality, supplemented by an individual mathematical hemodynamic model for the given segment.

Research specific objectives

1. Studying the literature referred to the variational aspects of the axilla and arm arteries and analyzing the data of theoretical and experimental research on the modalities of three-dimensional mathematical modeling of hemodynamics in the given arterial bed.
2. Establishing the anatomical variants of the axilla and arm arteries by macroscopic and imaging methods according to the criteria related to origin, trajectory, number, type of branching, highlighting the most variable domains at this level.
3. Determination of the individual arterial variability of the axilla and arm arteries applying somatometric and morphometric parameters related to gender, constitutional type and laterality.
4. Comparative analysis of the obtained results with those present in the bibliographic sources.
5. Assessment of the axillary artery segment necessary for puncture and/or catheterization manipulations by reasoned identification of topographic landmarks.

Research design. The study was an epidemiological, retrospective, descriptive, with reports and series of cases, conducted during 2016-2020. The scientific research was carried out at Nicolae Testemitanu SUMPh Department of Anatomy and Clinical Anatomy with the

approval of the Scientific Council of the Consortium and the Research Ethics Committee according to no. 68 of 16.03.2017 favorable opinion and in compliance with the International Legislation on Biomedical Research on the involvement of human beings and national legal provisions.

Axilla and arm arteries macroscopic, imaging, somatometry and morphometric study methods with subsequent mathematical-statistical processing of the obtained data were used in the research process to achieve the purpose and objectives. The mathematical modeling of the hemodynamics of the axillary and brachial arteries was performed, at the same time, according to gender and constitutional type.

The macroscopic study was performed on cadaveric material (upper limbs selected from the Anatomy and Clinical Anatomy Department of Nicolae Testemitanu SUMPh), by fine dissection method, which allowed us to identify anatomical variants of the arteries of the axilla and arm, studying their topographic and etiologic peculiarities, as well as their relationship to adjacent vasculonervous structures.

The imaging study included the study of angiographies of the arteries of the upper limb and doplerographies at this level, taken from the database of Euromed Diagnostic Medical Center, IMSP SCM „Sfanta Treime", IMSP SCR „Timofei Mosneaga" and IMSP Republican Medical Diagnostic Center. By studying the angiographies of the upper limb, the individual architecture of the blood vessels of the given region was determined with the identification of their variability and determination of their morphometric parameters, and by studying the Dopplers, the functional indices necessary to model their hemodynamics were obtained.

Scientific novelty and originality. A complex study of the morphoclinical aspect of the individual anatomical variability of the axillary and brachial arteries, as well as of their branches was performed, after which the obtained data were compared with those reflected in international bibliographic sources, but those obtained for the first time, such as the:

- bifurcation of the axillary artery into two trunks, one of them continued with the brachial artery which had high bifurcation, and the second trunk – launched collateral branches characteristic of it and the brachial artery;
- quadrifurcation of the subscapular artery;
- common trunk consisting of 5 arteries: thoracodorsal; circumflex scapular; posterior circumflex humeral; deep brachial and superior ulnar collateral;
- common trunk consisting of 4 branches: anterior/posterior circumflex humeral arteries and subscapular, and a secondary common trunk, consisting of deep brachial arteries and superior ulnar collateral; from the last then started the second deep brachial artery;
- the double presence of the deep brachial artery, where the second artery starts from the superior ulnar collateral artery;
- the double presence of the superior ulnar collateral artery, where the second artery arises from the deep brachial artery;
- low origin of the superior ulnar collateral artery at the level of the distal third of the arm;
- high origin of the inferior ulnar collateral artery at the level of the proximal third of the arm, etc.,

will complement the existing data and altogether will be the basis of a practical guide that will be useful for the imaging doctors and vascular surgeons in the therapeutic conduct.

As a result of the imaging study, a bony landmark was established that will provide safety in performing catheterization of the axillary artery, thus avoiding possible iatrogenic complications that may occur as a result of its puncture.

Mathematical modeling of the hemodynamics of the axillary and arm arteries allowed obtaining important hydrodynamic parameters for the segments concerned according to gender and constitutional type.

Main scientific results submitted for support

1. Determining the individual variability of the axilla and arm arteries according to gender, constitutional type and laterality.
2. Evaluation of the morphometric parameters of the axillary and brachial arteries and their branches depending on gender and constitutional type.
3. Establishing the anatomical variants of the axilla and arm arteries according to the criteria: origin, trajectory, number, branching method and, determining the variational frequency of each artery.
4. Mathematical modeling of the hemodynamics of the axillary and brachial arteries at the level of the branching of their main collaterals and at the level of the bifurcation of the brachial artery.

Theoretical significance and applicative value of research. The current study highlighted new morphological features of the axilla and arm arteries, with medical applicative value. Based on the obtained results, objective criteria of vascular exploration were developed, which will contribute to solving the uncertainty in initiating the investigation procedure or surgical tactics in the axilla and arm, when at this level is present one of the arterial anatomical variants. The obtained results will considerably complete the contemporary morphological scientific basis in the practical guidance of the new diagnostic and interventional methods at the level of the axilla and arm that will contribute to maintaining and strengthening the health of patients.

Approval of scientific results. The research results were presented and discussed at various scientific forums: The annual scientific conference of collaborators and students of Nicolae Testemitanu State University of Medicine and Pharmacy (Chisinau, 2017, 2018, 2019); MedEspera 2018: 7th International Medical Congress for Students and Young Doctors (Chisinau, 2018); 19th Congress of the Romanian Society of Anatomy (Cluj-Napoca, Romania, 2018); 10th International Symposium of Clinical and Applied Anatomy (Moscow-Russia, 2018); The XXIV National Congress of the Bulgarian Anatomical Society (Stara-Zagora, Bulgaria, 2019); Scientific and practical conference with international participation dedicated to the 90th anniversary of the birth of Professor P. I. Lobko, „Modern morphology: problems and development prospects" (Minsk, Belarus, 2019); Scientific-practical conference with international participation: Actual problems of morphology in theoretical and practical medicine is timed to the 75th anniversary of the founding of the Higher State Educational Institution of Ukraine „Bukovynian State Medical University" (Cernauti, Ucraina, 2019); Timisoara Anatomical Days. First Edition With International Participation (Timisoara, Romania, 2019); MedEspera 2020: 8th Intern. Medical Congr. for Students and Young Doctors (Chisinau, 2020); The XIth International Symposium on Clinical Anatomy (Varna, Bulgaria, 2020); Congress dedicated to the 75th anniversary of the founding of Nicolae Testemitanu State University of Medicine and Pharmacy (Chisinau, 2020).

Thesis publications. The research results were reflected in 24 scientific papers, including 9 articles (1 article in reviewed foreign journals, 3 articles in journals from the National Register of profile journals, 5 articles in international collections) and 15 theses in the papers of scientific national and international conferences and congresses. There were obtained 2 certificates of innovator and 6 acts of implementation in practice of scientific results.

The thesis was discussed, approved and recommended for defense at the meeting of the Department of Anatomy and Clinical Anatomy of Nicolae Testemitanu State University of Medicine and Pharmacy (minutes no. 8 of 21.04.2021) and the Scientific Profile Seminar 311. Anatomy and Morphology (minutes no. from 24.05.2021).

Summary of thesis compartments. The thesis is presented on 196 pages. The basic section of the thesis is exposed on 118 pages and consists of the introduction, 6 chapters, general conclusions and recommendations. The iconographic material includes 6 tables and 61 figures. The bibliography contains 282 sources, and the annexes – 58 figures and 8 tables.

Keywords: axillary artery, brachial artery, anatomical variants, individual variability, axilla, arm.

SYNTHESIS OF CHAPTERS

1. Morphology of the axilla and arm arteries

In this chapter it was made the classical description of the morphology of the axillary and brachial arteries and their branches according to the data presented in the literature, assessing their topography, origin and branching, as well as morphometric, by indicating the length and external diameter of them. Particular attention was paid to the correlation between the studied arteries and the anatomical structures around them. The main anastomotic arterial circles at the level of the axilla and arm (periscapular, perihumeral and periarticular arterial network of the elbow) and their importance in maintaining efficient arterial circulation were mentioned.

The variability of the arteries of the upper limb can be caused by genetic factors or the disorder of the development of the primary arterial axis at this level during embryonic conception, by vasculogenesis, arteriogenesis and factors that drive these processes come with explanation and arguments in various anatomical variants.

Technological developments, as well as the improvement of digital subtraction angiography techniques and accessibility, have led to the establishment of new diagnostic standards for the morphological and/or pathophysiological status of arteries.

Angio-CT 3D is one of the best techniques for investigating blood vessels, through which we get a detailed description of the structure of vascular walls, all morphometric indices, blood flow dynamics, all possible anatomical variants of arteries at this level and all deviations from the norm that may occur in case of pathology.

Using clinical data obtained from medical imaging and knowledge of anatomy, electrophysiology and biomechanics it is possible to create a model of the hemodynamics of the circulatory system, so all the hydraulic processes underlying fluid theory were described in detail, the main blood flow values were indicated and the necessary formulas for the mathematical calculation of the produced phenomena with the obtaining of the final results.

2. Organizing and conducting research

The organization of the research was based on the methodological conditions that followed the research hypothesis and included the place where the research was performed, the duration and periodicity of the measurements, obtaining in fact true data.

The scientific research was carried out at the Department of Anatomy and Clinical Anatomy of Nicolae Testemitanu State University of Medicine and Pharmacy during the years 2016-2020.

The variability of the axilla and arm arteries was investigated on 70 upper limbs, from human adult cadavers, of both genders, as well as on 210 angiographies of the upper limb arteries (104 selective angiographies and 106 3D angio-CT).

The cadaveric material was selected from the Department of Anatomy and Clinical Anatomy of Nicolae Testemitanu State University of Medicine and Pharmacy, and angiographic records of the arteries of the upper limb from the database of Euromed Diagnostic Medical Center, IMSP SCM „Sfanta Treime", IMSP SCR „Timofei Mosneaga" for the 2010-2020 years.

To model of the hemodynamics of the axillary and brachial arteries, 60 Dopplers were studied, taken from the database of the IMSP Republican Center for Medical Diagnosis.

The surveyed sample was distributed according to the gender, age and laterality criteria (table 1).

Table 1. **The studied material and its distribution by gender, age and laterality**

The studied material	Total	Male gender	Female gender	Body part		Age, years				
				Left	Right	<20	21-40	41-60	61-80	>81
Macropreparations	70	37	33	25	45	-	-	-	70	-
Angiography	210	116	94	116	94	3	16	83	103	5
Dopplers	60	30	30	30	30	-	6	32	21	1
Total	340	183	157	171	169	3	22	115	194	6

Macroscopic and imaging methods were used in combination with quantitative and mathematical-statistical methods. The method of fine anatomical dissection allowed us to follow the arteries of the axilla and arm from the origin to their penetration into the muscles. The anatomical pieces were photographed and digitally processed, and those that represented anatomical arterial variants were represented graphically and annotated according to their morphological characteristics. The imaging study included the study of angiographic inscriptions of the arteries of the upper limb. Selective angiography, as well as angio-CT provided us with precise radioanatomical details about the angioarchitectonics of the upper limb in the axial plane and reconstructed in the sagittal and coronal planes and highlighted the angiographic arterial segments. Quantitative estimation of the dimensions of the arteries of the formalized upper limbs was performed by morphometry, using the metric band, the cadaveric anatomical probe provided with units of measurement, the caliper with vernier and the compass with slider (calibration certificate MD 10 3.5 – 253/2019), and those on the angiographic images – via the *RadiAntDICOM Viewer 3.42* program, having the ribs I and III, the surgical neck of the humerus and the neck of the radius as reference points. The length of the axillary and brachial arteries, their external/internal diameter, as well as all their branches were determined, then the obtained results were processed and statistically analyzed using *Microsoft Office Excel 2010* and *IBM SPSS 22.*

The statistical methods allowed us to apply very useful numerical and statistical evaluations and reporting. The systematization of the data led to the obtaining of the primary indicators, and the use of different statistical comparison procedures to the obtaining of the derived indicators, which highlighted the qualitative aspects, aiming at different characteristics and interdependencies between variables. The confidence intervals at the 95% significance threshold were used in the data presentation, and the $\chi 2$, ANOVA, Kolmogorov-Smirnov and Fisher tests were used to test the differences.

Using the method of mathematical modeling it has been studied the three-dimensional field of velocity of blood flow and the distribution of blood pressure at the launch by the axillary and brachial arteries of its main collaterals, and following calculations performed using the software package *COMSOL Multiphysics 3.3* their mathematical model was created.

3. Morphometric study of the axillary and brachial arteries

By calculating the anthropometric indices, the constitutional type was determined for the cadavers whose upper limbs were included in the study group, and the data obtained were grouped according to the constitutional type/gender criteria. In 34,3%, the dolichomorphic constitutional type was determined, of which 25,7% belonged to the male gender and 8,6% to the female gender. The mesomorphic constitutional type was established in 40,0% – in 14,3% being of male gender and in 25,7% of female gender, and the brahimorphic type in 25,8% – in 12,9% for each gender. The constitutional type of the patients was determined based on the data of the angiographic inscriptions, finding the following: in 42,9% the mesomorphic constitutional type was determined (21,0%/21,9%, male/female), in 34,7 % – the brahimorphic type (17,1%/17,6%, male/female) and in 22,3% – the dolichomorphic type (17,1%/5,2%, male/female).

The mean values of the dimensions of the axillary and brachial arteries determined in the sublot subjected to the macroscopic and imaging study are indicated in tables 2-3.

Table 2. **Mean values of axillary and brachial arteries dimensions obtained in the sublot subjected to the macroscopic study**

Morphometric indices	MG	GM	GF	TCD		TCM		TCB	
				GM	GF	GM	GF	GM	GF
The length AA, cm	9,2±0,16	9,7±0,19	8,6±0,21	10,1±0,31	9,8±0,10	9,7±0,18	8,6±0,33	9,1±0,29	8,0±0,10
DEP AA, mm	6,13±0,13	6,54±0,17	5,67±0,15	6,12±0,26	5,13±0,31	6,82±0,35	5,67±0,17	6,94±0,23	5,99±0,30
DED AA, mm	5,52±0,11	5,82±0,16	5,17±0,13	5,43±0,30	4,5±0,35	6,02±0,49	5,29±0,16	6,24±0,75	5,37±0,17
The length AB, cm	20,8±0,36	21,94±0,49	19,4±0,40	23,75±0,56	22,3±0,73	20,75±0,64	19,35±0,38	19,11±0,30	17,43±0,35
DEP AB, mm	4,54±0,14	4,9±0,17	4,09±0,18	4,62±0,23	3,7±0,20	5,02±0,52	4,09±0,28	5,38±0,28	4,40±0,33
DED AB, mm	3,68±0,11	3,94±0,13	3,35±0,13	3,66±0,14	3,0±0,27	3,93±0,31	3,25±0,25	4,51±0,27	3,81±0,22

Note: MG – general average; GM – male gender; GF – female gender; TCD – dolichomorphic constitutional type; TCM – mesomorphic constitutional type; TCB – brahimorphic constitutional type; AA – axillary artery; DEP AA – proximal external diameter of the axillary artery; DED AA – distal outer diameter of the axillary artery; AB – brachial artery; DEP AB – proximal external diameter of the brachial artery; DED AB – the distal outer diameter of the brachial artery.

Table 3. Angiographic morphometric parameters of the axillary and brachial arteries

Morphometric indices	MG	GM	GF	TCD		TCM		TCB	
				GM	GF	GM	GF	GM	GF
The length AA, cm	8,7±0,15	8,98±0,18	8,25±0,25	10,22±0,29	9,55±0,64	8,57±0,19	8,05±0,38	8,22±0,24	8,0±0,32
DIP AA, mm	7,82±0,16	8,08±0,20	7,40±0,24	7,95±0,36	7,04±0,70	8,08±0,35	7,24±0,32	8,19±0,33	7,82±0,45
DID AA, mm	6,38±0,14	6,60±0,19	6,03±0,20	6,44±0,38	5,63±0,74	6,59±0,36	5,79±0,22	6,76±0,25	6,62±0,36
The length AB, cm	19,86±0,22	19,99±0,30	19,64±0,30	20,79±0,53	20,65±0,50	19,88±0,47	19,75±0,46	19,38±0,52	19,01±0,47
DIP AB, mm	6,39±0,15	6,70±0,20	5,91±0,22	6,44±0,41	5,63±0,74	6,59±0,36	5,79±0,34	6,63±0,29	6,43±0,43
DID AB, mm	5,25±0,99	5,36±0,14	5,08±0,12	5,08±0,27	4,90±0,30	5,46±0,31	5,03±0,12	5,53±0,15	5,21±0,28

Note: MG – general average; GM – male gender; GF – female gender; TCD – dolichomorphic constitutional type; TCM – mesomorphic constitutional type; TCB – brahimorphic constitutional type; AA – axillary artery; DIP AA – proximal internal diameter of the axillary artery; DID AA – distal internal diameter of the axillary artery; AB – brachial artery; DIP AB – proximal internal diameter of the brachial artery; DID AB – the distal internal diameter of the brachial artery.

4. Macroscopic and imaging study of the arteries of the axilla and arm

While studying the topographic aspect of the axillary artery, its typical location was found in 88,58%, superficial location in 2,9% and deep location – in 8,6%. Anatomical variants of the axillary arteries were identified on 16 upper limbs (22,9%) of the total anatomical pieces studied. According to the constitutional type, 8 upper limbs were established of dolichomorphic type (11,4%), 5 corresponded to the mesomorphic type (7,1%) and 3 – to the brahimorphic type (4,3%). The distribution according to gender, laterality and numerical presence of the arterial variants identified in the axilla is shown in figure 1.

Taking into account that on some upper limbs were present from 2 to 4 variants, the frequency of variability of the axillary artery and its branches in the macroscopic study was 40,0%: the variants of origin were determined in 11,4%; numerical variants – in 12,9%; branching variants – in 5,7% and the presence of common trunks – in 10%. In the male gender they settled in 31,4%, and in the female gender in 8,6%.

The most variable branch of the axillary artery turned out to be the anterior humeral circumflex artery, showing a variability of 14,3%: in 7,1% it doubled; in 4,3% – derived from common trunks and the remaining 2,9% – were variants of origin. The posterior circumflex humeral and subscapular arteries showed variations in 10,0% of cases. The first was involved in the formation of common trunks in 8,6% and in 1,4% variants of origin, and the second formed common trunks in 5,7% and branching variants were in 4,3%. The lateral thoracic artery had a variability of 8,6%: there were numerical variants in 4,3%; a component part of the common trunks was in 2,9% and variants of origin were reported in 1,4%. The thoracoacromial artery and circumflex scapular artery showed a variability of 2,9%, which equally proved variants of number and origin, and the thoracodorsal artery with a variability of 1,4%, demonstrating only variants of origin.

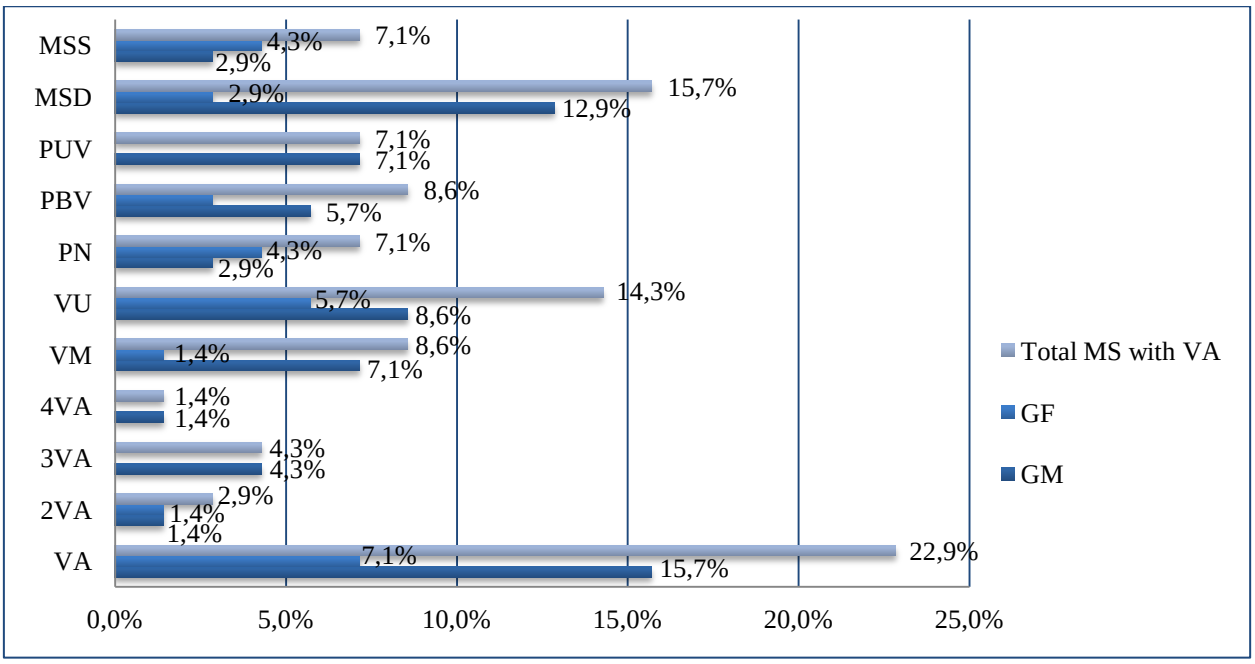


Figure 1. **Distribution of the upper limbs identified with variants of the arteries of the axilla depending on gender, laterality and number in the sublot subjected to the macroscopic study**

Note: MSS – left upper limb; MSD – right upper limb; PUV – unilateral presence of variants; PBV – bilateral presence of variants; PN – indeterminate presence; VU – unique variants; VM – multiple variants; VA – anatomical variants; MS – upper limb; GF – female gender; GM – male gender.

Variants of the brachial artery and its branches were established on 20 upper limbs, constituting 28,6%: 13 were male (18,6%) and 7 – female (10,0%). The dolichomorphic type corresponded to 10 of these upper limbs (14,3%), another 8 were of the mesomorphic type (11,4%) and the remaining 2 belonged to the brahimorphic type (2,9%).

The distribution of the variants according to the given criteria is shown in figure 2.

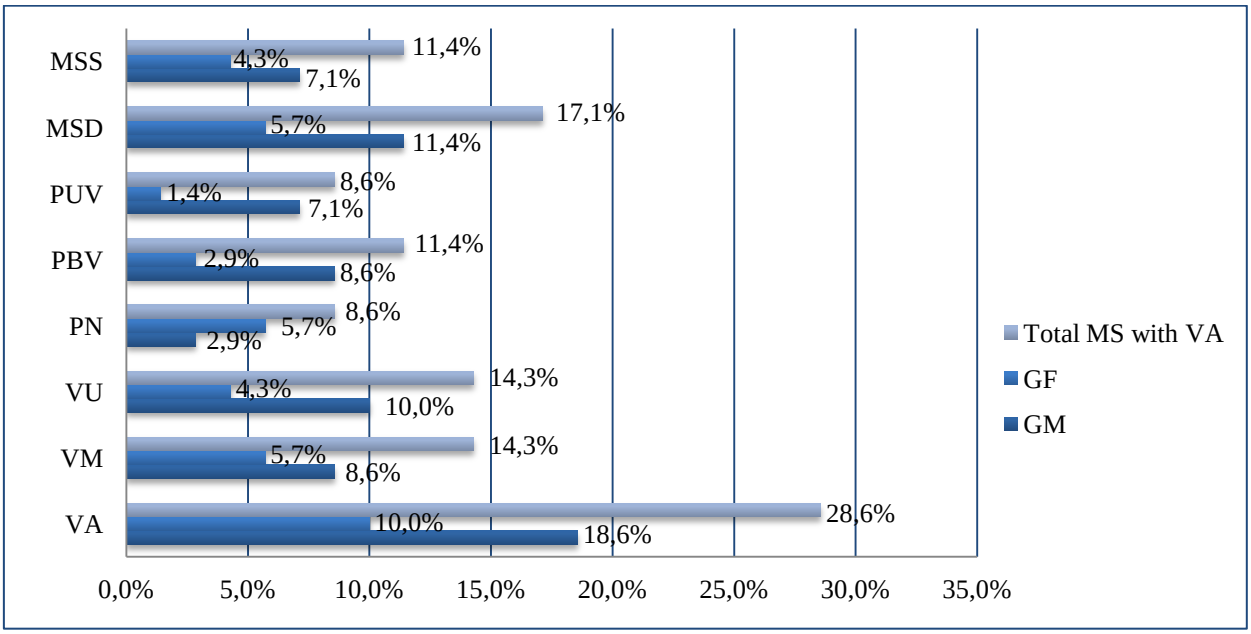


Figure 2. **Distribution of the upper limbs identified with variants of the brachial artery and its branches according to gender, laterality and number in the sublot subjected to the macroscopic study**

The upper limbs on which multiple variants of the brachial artery were determined were found with 2 or 3 variants; those with 2 variants were set at 10,0%, and those with 3 variants – at 4,3%. In total, the frequency of variability of the brachial artery and its branches was determined in 44,3%, which according to the types of variants identified were distributed according to the data mentioned in figure 3.

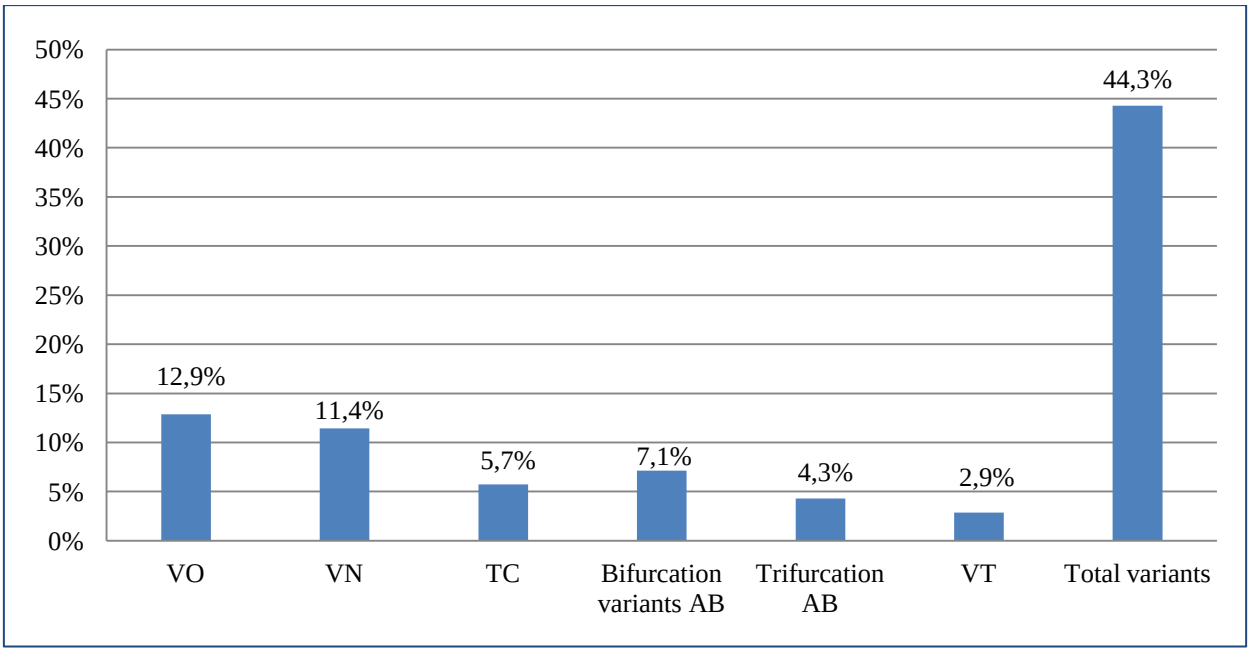


Figure 3. **Frequency of the types of variants of the brachial artery and its branches in the sublot subjected to the macroscopic study**

Note: VO – origin variants; VN – numerical variants; TC – common trunk; AB – brachial artery; VT – variants of the trajectory.

Among the collateral branches of the brachial artery, the most variable was the deep brachial artery, with a variability of 14,3%: in 8,6% it showed a double presence, and in 5,7% – it was a component part of the common trunks. The variability of the superior ulnar collateral artery was determined in 10,0%: in 5,7% it represented variants of origin, in 2,9% it was a component of the common trunks, and in 1,4% its double presence was determined. The variability of the inferior ulnar collateral artery was established in 5,7%: the origin variants being present in 4,3% and the numerical ones in 1,4%. The radial and ulnar arteries were found to have a variability of 2,9% for each, both describing high origin, starting from the axillary or brachial artery.

The imagistic identification of the individual variability of the axilla and arm arteries was performed by transferring their anatomical data, from the virtual model to the real one, based on the descriptive criterion.

The variational architecture of the axillary artery was determined on 61 angiographies (29,0%): 36 (17,1%) of them were male and 25 – female (11,9%). According to the constitutional type, 16 patients to whom the angiographies belonged were of the dolichomorphic type (7,6%), 24 were of the mesomorphic type (11,4%) and 21 were of the brahimorphic type (10,0%).

Unique variants of the axillary artery and its branches were established on 40 angiographies (19,0%): 24 (11,4%) belonged to the male, 12 (5,7%) from both upper limbs and 16 (7,6%) – female, 7 (3,3%) of the left upper limb, and 9 (4,3%) of the right. Multiple variants

of the axillary arteries were visualized on 21 (10,0%) angiographies: 12 (5,7%) of them belonged to the male gender and the remaining 9 (4,3%) – were of the female gender. The presence of 2 variants, identified at the level of the same axilla, was determined on 19 angiographies (9,0%): 11 (5,2%) belonged to the male gender (4 of the left upper limb and 7 of the right) and 8 (3,8%) – female gender (5 of the left upper limb and 3 of the right), and 3 variants were established on 2 (1,0%) angiographies: one for both genders, which belonged to the left upper limb.

Variants of origin of the branches launched by the axillary artery were determined on 10 (4,8%) angiographies: 6 belonged to the right upper limb, male and 4 – to the female (3 from the right and 1 from the left). The sinuous trajectory of the lateral thoracic, thoracodorsal and posterior circumflex humeral arteries was established on 4 angiographies (1,9%): 3 were of the male gender (of a left upper limb and 2 of the right one) and one – of the female gender, on the right. Numerical variants of the axillary artery branches were identified on 17 angiographies (9 of the male gender and 8 of the female gender); on one of the angiographies of the left upper limb, of the male gender, 2 variants were found, so their frequency in total was 8,6%. Common trunks originating from the axillary artery were visualized on 44 angiographies: 27 belonged to the male gender (13 of the left upper limb and 14 of the right), of which on 3 of them, all on the right, 2 common trunks were present, so their frequency is 14,3%. The remaining 17 angiographies belonged to the female gender (8 of the left upper limb and 9 of the right), on 2 of them (1 on both sides) 2 common trunks were identified, constituting in this gender a total frequency of 9,0%. The bifurcation of the axillary artery was followed on 3 angiographies (1,4%) of the female gender: two of them belonged to the left upper limb and one – to the right.

The frequency of variability of the axillary artery branches according to all types of variants is indicated in figure 4.

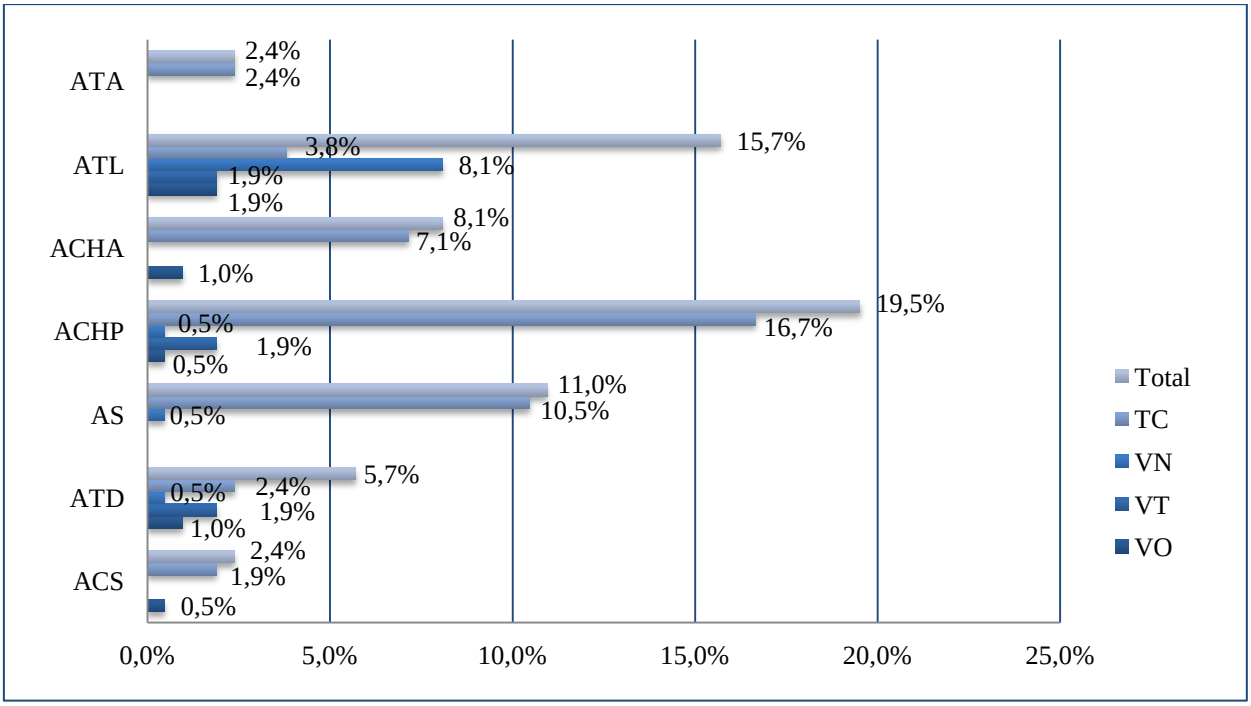


Figure 4. **Frequency of variability of the axillary artery branches in the sublot subjected to imaging study**

Note: ATA – thoracoacromial artery; ATL – lateral thoracic artery; ACHA/ACHP – anterior/posterior circumflex humeral artery; AS – subscapular artery; ATD – thoracodorsal artery; ACS – circumflex scapular artery; TC – common trunk; VN – numerical variants; VT – route variants; VO – original variants.

In the figures below (macroscopic and angiographic images) variants of the axillary and arm arteries identified for the first time are demonstrated.

Figure 5. **Quadrifurcation of the subscapular artery:** 1 – subscapular artery; 2 – the first muscular branch; 3 – the second muscular branch; 4 – thoracodorsal artery; 5 – circumflex scapular artery; 6 – posterior circumflex humeral artery; 7 – anterior circumflex humeral artery.

Figure 6. **Common trunk formed by deep brachial and superior ulnar collateral arteries; presence of a double deep brachial artery:** 1 – the brachial artery; 2 – common trunk; 3 – the first deep brachial artery; 4 – superior ulnar collateral artery; 5 – muscle branch; 6 – the second deep brachial artery; 7 – radial nerve.

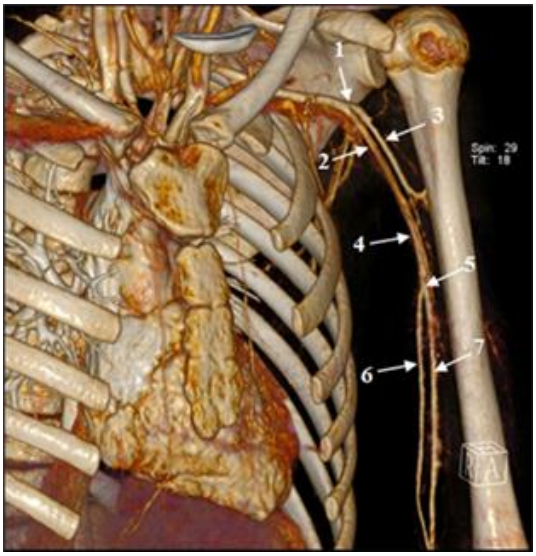


Figure 7. **Bifurcation of the axillary artery and high bifurcation of the brachial artery:** 1 – bifurcation of the axillary artery; 2 – anterior trunk; 3 – posterior trunk; 4 – brachial artery; 5 – bifurcation of the brachial artery; 6 – radial artery; 7 – ulnar artery; image, angio-CT 3D.

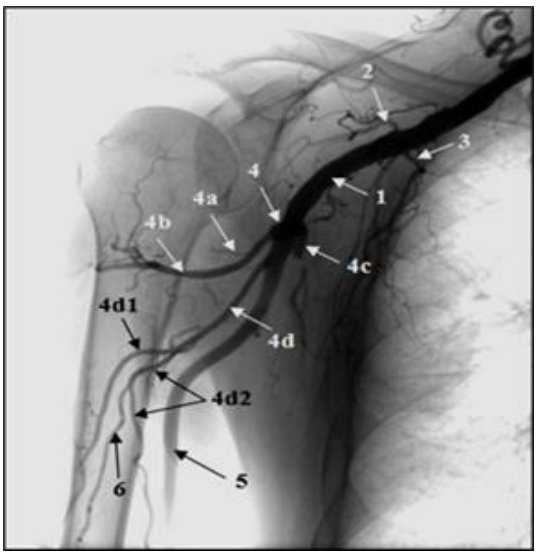


Figure 8. **Common trunk (4) consisting of the anterior (4a)/posterior (4b) circumflex humeral arteries, subscapular artery (4c) and a secondary common trunk (4d), consisting of the deep brachial arteries (4d1) and the superior ulnar collateral (4d2), presence of a double deep brachial artery:** 1 – axillary artery; 2 – thoracoacromial artery; 3 – lateral thoracic artery; 5 – brachial artery; 6 – the second deep brachial artery, image, selective angiography.

At the same time, a significant landmark, in performing the puncture and catheterization of the axillary artery, which proved to be the lower edge of the glenoid cavity, was established.

The level of the given margin corresponds to the proximal extremity of the infrapectoral portion of the axillary artery, which in front is not covered by the brachial plexus fascicles or by roots of the median nerve, so in the given artery approach the risk of iatrogenic lesions is relatively lower.

The variational architecture of the arteries of the arm was identified on 32 angiographic inscriptions, constituting 15,2%: 19 (9,0%) of them were of male patients (8 of the left upper limb and 11 of the right) and 13 (6,2%) – of the female ones (8 of the left upper limb and 5 of the right one).

According to the constitutional type, 6 of the patients (2,9%) to whom the given angiographies belonged were men of dolichomorphic type, 16 patients (7,6%) were mesomorphic (10 men and 6 women) and 10 patients (4,8%) – brahimorphic type (3 men and 7 women).

On 27 angiographies (12,9%) unique variants of the arm arteries were found – 16 belonged to the male gender and 11 to the female gender, and on 5 (2,4%) angiographies multiple variants were established – 3 were male and 2 were female.

Two variants of the nominated arteries were identified on 2 angiographies of the female gender, of the left upper limb (1,0%); 3 variants were established on 2 angiographies, of the male gender (1,0%), one from the left and another from the right, and 4 variants each – on an angiographic inscription of a right upper limb (0,5%).

Variants of origin of the branches of the brachial artery were determined on 11 angiographies (5,2%): 9 male upper limbs (3 from the left and 6 from the right) and 2 of the female left upper limb. Trajectory variants of the brachial artery and its branches were found in 8,1%; those of the brachial artery were established in 4,3%, and of its branches – in the rest of the cases. Numerical variants of the brachial artery branches were established in 3,3%, on 8 angiographies: 5 (2,4%) of male origin (2 from the left and 3 from the right) and the rest 2 (1,0%) – of upper left limb, female. The common trunk originating from the brachial artery, consisting of the posterior circumflex humeral and the deep brachial arteries, was identified on an angiography of a female right upper limb, and constituted a frequency of 0,5%.

Brachial artery bifurcation variants (high, low and atypical) were determined on 10 angiographies (4,8%): 6 (2,9%) were male (2 left and 4 right) and 4 (1,9%) – female (3 left and 1 right).

Brachial artery trifurcation was established in 1,0% – on 2 angiographies of the right upper limb, one of both sides.

The frequency of deep brachial artery variability was 3,8%: in 2,9% it presented numerical variants, and in 1,0% – atypical origin and the formation of common trunks.

The frequency of variability of the superior ulnar collateral artery was similar to that of the deep brachial artery: in 2,4% it demonstrated variants of origin, in 1,0% – common trunks and in the rest – numerical variants.

The inferior ulnar collateral artery had a variability of 1,0%, being identified only with an atypical origin.

The ulnar artery was variable in 2,9%, and the radial one in 2,4%; both branches had a sinuous trajectory in 1,4% and a high origin was established in 1,4% for the ulnar artery and in 1,0% for the radial one.

5. Analysis and interpretation of results

The frequency of axillary and brachial artery variability in the researched group was determined based on the results obtained in macroscopic and imaging studies, according to all the criteria described above.

The unilateral presence of the axillary artery variants was established with a frequency of 2,5%, and the bilateral one – of 2,1%; for the brachial artery the first of them constituted 5,4%, and the other – 3,6%. The frequency of single variants of the axillary artery was 17,9% and multiple – 9,6% (with 2 variants – 7,5%; with 3 variants – 1,8% and with 4 – 0,4%), and for the brachial artery, the single variants constituted 13,2% and the multiple ones – 5,4% (with 2 variants – 3,2%; with 3 variants – 1,8% and with 4 – 0,4%).

The variants of the axillary artery constituted 39,6%, of which those of number were estimated at 9,6%; origin variants – at 6,8%; common trunks originating from the axillary artery – at 20,4%; trajectory variants (sinuous) – at 1,4% and branching variants (axillary artery bifurcation) – at 1,4%.

The variants of the brachial artery constituted 26,4%; of them, the number variants represented the value of 5,7%; origin variants – 7,8%; common trunks originating from the brachial artery – 1,8%; the trajectory variants – of 3,6% and the branching variants – of 7,5%.

The analysis of the results highlighted a higher share of cases of anatomical variants of the axillary and brachial arteries, established on the right upper limb, in male gender.

Depending on the laterality, the difference of their frequency in the axilla was 1,8% and a ratio of 1,1: 1, and in the arm, corresponding to 5,0% and a ratio of about 1,5: 1, in favor of the upper right limb. Depending on gender, the difference in the armpit was 10,4% and a ratio of 1,7: 1, and in the arm – 7,1% and a ratio of 1,75: 1, in favor of the male gender. Depending on the constitutional type, the studied arteries are prone to variations more frequently in mesomorphic type (11,8%), and for the others, they are found with an insignificant difference between them – 7,5% for dolichomorphic type and 7,1% for brahimorphic type

From the branches of the axillary artery, the highest variability was characteristic of the posterior circumflex humeral artery, followed by the lateral thoracic and subscapular arteries, and from the types of variants identified in the study group – the presence of common trunks predominates followed by number and origin variants.

Of the collateral branches of the brachial artery, the most variable proved to be the deep brachial and the superior ulnar collateral arteries; the first most frequently manifested by numerical variants, and the second one – by origin variants.

Analyzing the frequency of the axillary and brachial artery branches and making a comparison between the obtained results, it can be mentioned that the axillary branches were more frequently identified with anatomical variants than the brachial artery branches; of the basic branches of the axillary artery, three of them: the posterior circumflex humeral, lateral thoracic and subscapular arteries represented an incidence of their variability greater than 10,0%; between the branches of the brachial arteries – the variability of the deep brachial artery was 6,4% and of the superior ulnar collateral artery – of 5,4%, and for the rest of the branches – less than 3,0%. Among the types of variants, the common trunks to all branches of the axillary artery have priority, being between 1,4%-14,6%. In the branches of the brachial artery, all demonstrated variants of origin with values between 0,4%-3,1%.

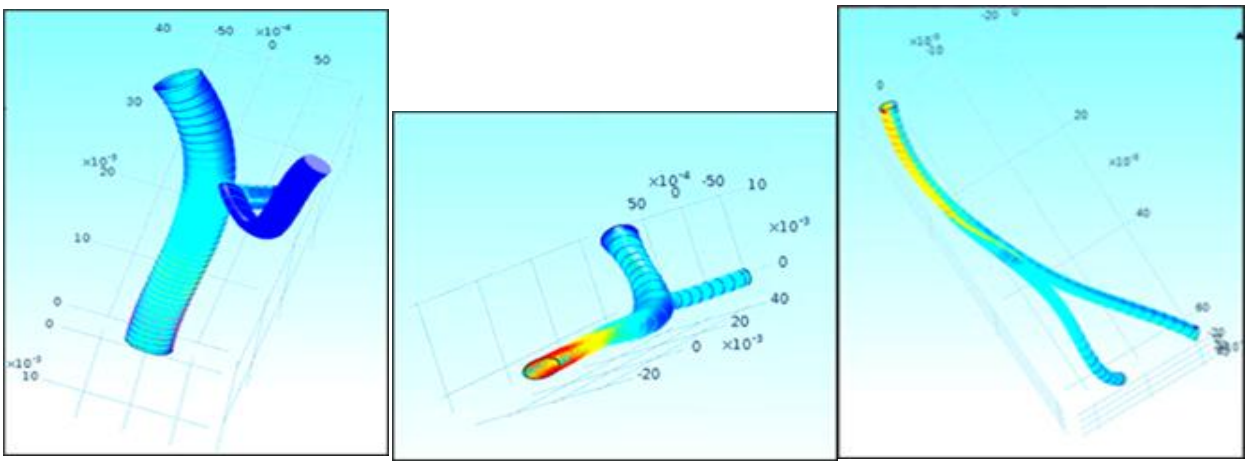
Referring to the total number of variants of the axillary and brachial arteries and making a comparison between their frequency obtained by macroscopic and imaging study, for the axillary

artery we established a significant value in terms of statistical veracity, because $\chi 2$=9,893, gl=4 and p=0,042, and for the brachial artery a statistically highly significant value – $\chi 2$=18,198, gl=4 and p=0,001.

These values show the correctness of the research, performed by different methods – macroscopic and imaging, each of them giving us the opportunity to determine and report separately about some specific morphological features of the studied arteries, but also to draw clearly the individual criteria and highlight the types of variants and their frequency over the whole researched group.

6. Mathematical modeling of the hemodynamics of the axillary and brachial arteries according to gender and constitutional type

During the circulation of blood through the blood vessels, the vascular wall always opposes resistance to blood flow. On the parts of the arteries with a rectilinear trajectory where the blood fluid has a laminar flow regime, the hydraulic resistance is a linear one. In the segments of the arteries with curved trajectory, at the level of the starting angles of the branches that launch them and at the level of their bifurcation – local hydraulic resistance appears, which leads to diminished functionality of the vascular wall and contributes to disorders of the physiological and biochemical processes of the vascular bed. By mathematical modeling of the hemodynamics of the axillary and brachial arteries, indicated in figures 9-11, we tried to determine the risk of cardiovascular disease for the constitutional types and gender.



Figures 9-11. **Segments of the axillary and brachial arteries in 3D at the launch of its main collateral branches and at the bifurcation of the brachial artery in the radial and ulnar arteries**

Thus, dolichomorphic subjects had the largest pressure difference, both at the level of the launch by the axillary and brachial arteries of their main collateral branches, and at the bifurcation of the brachial artery in its terminal branches. Brahimorphic subjects were found with the slightest pressure difference in these arteries. Depending on the gender, the given difference reached higher values in women and lower in men.

The greater the pressure difference between the ends of a blood vessel, the greater the hydraulic resistance, which leads to an increased effort of the heart activity. Therefore, in people of dolichomorphic type, the risk of developing a cardiovascular pathology is higher than in those of mesomorphic and brahimorphic types, as well as in female subjects compared to those of the male gender.

GENERAL CONCLUSIONS

1. The axillary and brachial arteries are subject to variations more frequently in the male gender, of mesomorphic type, on the right upper limb.
2. In both arteries, the unilateral presence of the anatomical variants prevails numerically over the bilateral ones, and the unique variants have a higher incidence than the multiple ones.
3. The axillary artery is variable in 39,6%, and among them presence of common trunks and numerical variations prevailed, and the brachial artery – in 26,4%, more numerous being the variants of origin and branching.
4. Most commonly, the common trunks consisted of 2 and 3 arteries, and among the branches that participated in their formation were found most of the collateral branches of the axillary and brachial arteries.
5. Among the branches of the axillary artery, the highest degree of variability was determined for the posterior circumflex humeral and lateral thoracic arteries, and among the branches of the brachial artery – for the deep brachial and for superior ulnar collateral arteries.
6. Based on the mathematical modeling of the hemodynamics of the axillary and brachial arteries, it was found that the risk of developing a cardiovascular pathology is higher in female gender and dolichomorphic subjects.

RECOMMENDATIONS

1. The information on the variability of the axilla and arm arteries is proposed as teaching material to students, internists, surgeons and imagers to update knowledge in this field.
2. In humeral surgical neck fractures it is necessary to take into account the possible presence of a common trunk formed by the posterior circumflex humeral and subscapular arteries to prevent serious vascular injury.
3. During the collection of cutaneous-muscular flaps in the lateral region of the arm, the surgeon must consider the possible atypical origin of the deep brachial artery, in order to avoid the complications that may occur due to this.
4. In order to avoid lesions of the brachial plexus fascicles and nerves, in puncture and catheterization of the axillary artery, it is recommended to use the bone anatomical landmark represented by the lower edge of the glenoid cavity.
5. If the subscapular and thoracodorsal arteries are used as grafts in the coronary bypass, it is necessary to take into account their origin and type of branching.
6. The inclusion of the geometric indices of the axillary and brachial arteries in the software of the medical imaging technique will provide relevant data about the structure and functionality of the circulatory system as a whole.

REFERENCES

1. Wysiadecki G, Polguj M, Haładaj R, Topol M. Low origin of the radial artery: a case study including a review of literature and proposal of an embryological explanation. *Anatomical Science International*. 2017; 92(2): 293-298. Available on https://www.ncbi.nlm.nih.gov/pubmed/. [accessed at 07.11.2018].
2. Гаджиева Ф. Г., Околокулак Е. С. Частота вариаций подмышечной артерии человека. В: *Весенние анатомические чтения:* с*б. ст. науч.-практ. конф., посвящ. памяти доцента М. А. Колесова, 27 мая 2016, Гродно, Беларусь.* ГрГМУ; 2016. с. 37-43.
3. **Zorina Z.** Variabilitatea individuala a bifurcarii arterei brahiale. *Moldovan Journal of Health Sciences (Revista de Stiinte ale Sanatatii din Moldova)*. 2019; 21(4): 29-36.
4. Zeltser DW, Strauch RJ. Vascular anatomy relevant to distal biceps tendon repair. *J Shoulder Elbow Surg.*2016; 25(2): 283-288. Available on https://www.ncbi.nlm.nih.gov/pubmed/. [accessed at 09.09.2019].
5. Ковалевич К. М., Янушко Д. И., Мурадян А. С. Анатомия артерий верхней конечности у плодов и новорожденных с недифференцированными множественными пороками развития. *Журнал ГрГМУ.* 2009; 4: 64-69.
6. Nkomozepi P, Xhakaza N, Swanepoel E. Superficial brachial artery: a possible cause for idiopathic median nerve entrapment neuropathy. *Folia Morphologica*. 2017; 76(3): 527-531. Available on https://journals.viamedica.pl/. [accessed at 01.08.2020].
7. Haladaj R, Wysiadecki G, Dudkiewicz Z, Polguj M, Topol M. The High Origin of the Radial Artery (Brachioradial Artery): Its Anatomical Variations, Clinical Significance, and Contribution to the Blood Supply of the Hand. *Biomed Res Int*. 2018;4(2): 58-65. Available on https://www.hindawi.com/journals/bmri/. [accessed at 15.01.2019].
8. Al Fayez M, Kaimkhani Z, Zafar M. Multiple arterial variations in the right upper limb of a Caucasian male cadaver. *Int J Morphol.* 2010; 28: 659-665.
9. Babuci A, Certan G, Hacina T, **Zorina Z.** Variante de vascularizatie ale membrului superior. In: *Anale Stiintifice ale USMF „Nicolae Testemitanu". Conferinta stiintifica anuala a colaboratorilor si studentilor, USMF „Nicolae Testemitanu", 23-25 octombrie 2007, Chisinau, Republica Moldova.* USMF; 2007. 1: 35-39.
10. Jawed AM, Shamir R, Binod K, Vinod K. A rare variation in the branching pattern of axillary artery. *Saudi Journal for Health Sciences.* 2016; 5(1): 39-41.
11. Piagkou M, Totlis T, Panagiotopoulos NA, Natsis K. An arterial island pattern of the axillary and brachial arteries: a case report with clinical implications. *Surg Radiol Anat.* 2016; 4(5): 123-128.
12. Banerjee A, Kumari C, Jhajhria SK. Variation in the Branching Pattern of Third Part of Axillary Artery – A Case Report. *J Clin Diagn Res.* 2017; 11(2): 3-4. Available on https://www.ncbi.nlm.nih.gov/pubmed/. [accessed at 07.10.2020].
13. Narayanan S, Murugan S. Bifurcation of brachial artery into a common radial-interosseous trunk and superficial ulnar artery: a rare variation. *Anat Sci Int.* 2018; 93(3): 400-403. Available on https://www.ncbi.nlm.nih.gov/pubmed/. [accessed at 09.09.2019].

LIST OF SCIENTIFIC PUBLICATIONS AND EVENTS
IN WHICH THE RESULTS OF THE RESEARCH WERE PRESENTED

SCIENTIFIC WORKS

- **Articles in scientific journals abroad:**
  - ✓ **articles in foreign magazines reviewed**

1. **Зорина З. А.,** Катеренюк И. М., Киселевский Ю. М. Индивидуальная изменчивость архитектоники подмышечной артерии. Журнал Гродненского государственного медицинского университета. 2019, 17(2): 192-198.ISSN 2221-8785. doi: 10.25298/2221-8785-2019-17-2-192-198.

- **Articles in accredited national scientific journals:**
  - ✓ **articles in category B scientific journals**

2. **Zorina Z,** Catereniuc I, Babuci A, Botnati T, Certan G. Variants of branching of the upper limb arteries. *The Moldovan Medical Journal.* 2017; 60(4): 10-13. ISSN 2537-6373 (Print), ISSN 2537-6381 (Online).
3. Croitoru D, **Zorina Z,** Certan G, Galescu M, Cerevan E. The anatomical variation of the posterior circumflex humeral artery. *The Moldovan Medical Journal.* 2019; 62(3): 3-6. ISSN 2537-6373 (Print), ISSN 2537-6381 (Online).
4. **Zorina Z.** Variabilitatea individuala a bifurcarii arterei brahiale. *Moldovan Journal of Health Sciences* (Revista de Stiinte ale Sanatatii din Moldova). 2019; 21(4): 29-36. ISSN 2345-1467.

- **Articles in the proceedings of scientific conferences:**
  - ✓ **international conducted abroad**

5. **Зорина З. А.,** Катеренюк И. М. Вариантная анатомия плечевой артерии в клиническом аспекте. *Актуальные проблемы медицины. Материалы ежегодной итоговой научно-практической конференции, 25-26 января 2018, Гродно, Беларусь;* 2018, с. 316-320.
6. Мансуров В. А., Трушель Н. А., Катеренюк И. М., **Зорина З. А.** Моделирование кровотока в глубокой артерии плеча. *Современная морфология: проблемы и перспективы развития: сб. трудов научно-практической конференции с международным участием посв. 90-летию со дня рождения профессора П. И. Лобко, 3-4.10.2019, часть 1, Минск, Беларусь;* 2019, с. 151-155.
7. **Зорина З. А.,** Катеренюк И. М. Индивидуальные морфологические особенности артерий верхних конечностей. *Современная морфология: проблемы и перспективы развития: сб. трудов научно-практической конференции с международным участием посв. 90-летию со дня рождения профессора П. И. Лобко, 3-4.10.2019. часть 1, Минск, Беларусь;* 2019, с. 101-105.
8. **Зорина З. А.** Точки доступа при пункции и катетеризации подмышечной артерии. *Одонараловские морфологические чтения: материалы Всероссийской научной конференции с международным участием, 25 декабря 2020 г, Воронеж, Россия;* 2021, с. 62-65.

- ✓ **international conducted in the Republic of Moldova**

9. **Zorina Z,** Catereniuc I, Babuci A, Botnaru D. Aspectul variational al arterelor axilei. *Probleme actuale ale morfologiei: materialele Conferintei stiintifice internationale dedicata aniversarii a 75 de ani de la fondarea Universitatii de Stat de Medicina si Farmacie „Nicolae Testemitanu" din Republica Moldova. 30-31 octombrie 2020, Chisinau;* 2020, p. 109-113.

- **Summaries/abstracts/theses in the works of national and international scientific conferences**

10. **Zorina Z.** Morphological and imaging evaluation of the upper limb arteries variability. *MedEspera 2018: abstr. booke the 7th Intern. Medical Congr. for Students and Young Doctors. Chisinau;* 2018. p. 193.
11. **Zorina Zinovia,** Ilia Catereniuc, Botnari Tatiana. Individual morphological specific features of the brachial artery. *Abstract Book the 19th Congress of the Romanian Society of Anatom. Cluj-Napoca, Romania;* 2018. p. 101-102.
12. **Зорина З. А.,** Катеренюк И. М. Индивидуальная изменчивость и морфологические особенности артерий плеча. *Матеріали науково-практичної конференції з міжнародною участю «Індивідуальна анатомічна мінливість органів та структур організму в онтогенезі», присвячена 60-річчю від дня народження професора Ю. Т. Ахтемійчука. Чернівці;* 2018. с. 22-25.
13. **Zorina Z,** Catereniuc I. The incidence of anatomical variants of the brachial artery. *10th International Symposium of Clinical and Applied Anatomy. Moscow-Russia;* 2018. Морфология, приложение 3, с. 112.
14. **Зорина З. А.,** Катеренюк И. М. Вариантная анатомия артерий верхних конечностей и ее визуализация современными методами исследования. *Материалы республиканской с международным участием научно-практ. конференции, посв. 60-летию ГрГМУ. Гродно, Беларусь;* 2018. с. 14-16.
15. **Зорина З. А.,** Катеренюк И. М., Мансуров В. А., Трушель Н. А. Особенности кровотока в области ответвления глубокой артерии плеча от плечевой артерии при стенозе основного сосуда. *Сборник научных статей Международной научной конференции „Фундаментальные и прикладные науки – медицине". Минск, Беларусь;* 2018. 18(1): 36-37.
16. **Zorina Zinovia.** Variabilitatea morfologica a arterelor membrului superior. *Culegerea de rezumate a Conferintei stiintifice anuale a colaboratorilor si studentilor. USMF „Nicolae Testemitanu", Chisinau;* 2018. p. 7.
17. Трушель Н. А., Мансуров В. А., **Зорина З. А.,** Катеренюк И. М., Супиченко М. С. Математическое моделирование кровотока в области ответвления глубокой артерии плеча от плечевой артерии. *Сборник научных статей Республиканской научно-практической конференции с международным участием „Мультидисциплинарный подход к диагностике и лечению коморбидной патологии". Гомель, Беларусь;* 2018. с. 479-482.

18. **Зорина З. А.,** Катеренюк И. М. Topographic and anatomical features of the arteries of the upper extremities. *Материалы VIII съезда НМОАГЭ. Воронеж, Россия;* 2019. Морфология, приложение 2, с. 124.
19. **Zorina Zinovia,** Ilia Catereniuc, Angela Babuci, Tatiana Botnati, Galina Certan. Anatomical variations of the brachial artery bifurcation. *Abstract Book the XXIV National Congress of the Bulgarian Anatomical Society. Stara-Zagora, Bulgaria;* 2019. p. 43.
20. **Зорина З. А.,** Катеренюк И. М. Анатомо-типологические особенности плечевой артерии. *Актуальні проблеми морфології в теоретичній та практичній медицині: сб. трудов приурочена 75-річчю з дня заснування Вищого державного навчального закладу України «Буковинський державний медичний університет». Чернівці*; 2019. с. 143-145.
21. **Zorina Zinovia.** Incidenta trunchiurilor comune a arterelor membrului superior. *Culegere de rezumate a Conferintei stiintifice anuale a colaboratorilor si studentilor. USMF „Nicolae Testemitanu". Chisinau;* 2019. p. 10.
22. **Zorina Z,** Catereniuc I. The Anatomical Variation of the Origin of the Deep Brachial Artery. *Research and clinical madicine. The European Jurnal of Inovative, Integrative and Translational Medicine, vol III, suplement I, 2019, Timisoara Anatomical Days. First Edition With International Participation, december 6-7. Timisoara, Romania,* 2019. p. 87.
23. **Zinovia Zorina.** Some anatomical variants of the arteries of the upper limb. *MedEspera 2020: abstr. booke the 8th Intern. Medical Congr. for Students and Young Doctors. Chisinau;* 2020. p. 231.
24. **Zorina Z,** Catereniuc I. Aspectul variational al arterei subscapulare. *Culegere de rezumate a Congresului consacrat aniversării a 75-a de la fondarea USMF „Nicolae Testemitanu". Chisinau;* 2020. p. 19.

- **Invention patents, patents, registration certificates, materials at invention salons**
  1. **Zorina Z.,** Catereniuc I. Punct de reper in cateterizarea arterei axilare. Certificate of innovator no. 26, 07.12.2020.
  2. **Zorina Z.,** Catereniuc I., Трушель Н. А., Мансуров В. А. Modelarea matematica a hemodinamicii arterelor axilara si brahiala in functie de gen si tip constitutional. Certificate of innovator no. 27, 07.12.2020.

- **Participation with communications at scientific forums:**
  - ✓ **international**
  1. **Zorina Zinovia,** Ilia Catereniuc. Anatomical variations of the brachial artery bifurcation. *The XXIV National Congress of the Bulgarian Anatomical Society.* Stara-Zagora, Bulgaria, 31mai-02 june 2019.
  2. **Зорина З. А.,** Катеренюк И. М. Анатомо-типологические особенности плечевой артерии. *Науково-практичної конференції з міжнародною участю: Актуальні проблеми морфології в теоретичній та практичній медицині приурочена 75-річчю з дня заснування Вищого державного навчального закладу України «Буковинський державний медичний університет»,* Чернівці, 24-25 жовтня 2019.

3. **Zorina Zinovia.** Anatomical landmarks in cateterization of the axillary artery. *XI the International Symposium on Clinical Anatomy.* Varna, Bulgaria, 2-4 october 2020.
4. **Зорина З. А.** Точки доступа при пункции и катетеризации подмышечной артерии. *Всероссийская научная конференция с международным участием.* Воронеж, Россия, 25 декабря 2020 г.

✓ **national**

5. **Zorina Zinovia.** Variabilitatea morfologica a arterelor membrului superior. *Conferinta stiintifica anuala a colaboratorilor si studentilor. USMF „Nicolae Testemitanu”.* Chisinau, 15-19 octombrie 2018.
6. **Zorina Zinovia.** Aspectul variational al arterei subscapulare. *Congresul consacrat aniversarii a 75-a de la fondarea USMF „Nicolae Testemitanu”.* Chisinau, 21-23 octombrie 2020.

- **Participation with posters in scientific forums:**

✓ **international**

7. **Zorina Zinovia.** Morphological and imaging evaluation of the upper limb arteries variability. *MedEspera 2018: 7th Intern. Medical Congr. for Students and Young Doctors.* Chisinau, 3-5 may 2018.
8. **Zorina Zinovia,** Ilia Catereniuc. Individual morphological specific features of the brachial artery. *19th Congress of the Romanian Society of Anatom.* Cluj-Napoca, Romania, 17-19 may 2018.
9. **Zorina Zinovia,** Ilia Catereniuc. The incidence of anatomical variants of the brachial artery. *10th International Symposium of Clinical and Applied Anatomy.* Moscow-Russia, 13-16 september 2018.
10. **Зорина З. А.,** Катеренюк И. М. Индивидуальные морфологические особенности артерий верхних конечностей. *Научно-практическая конференция с международным участием посв. 90-летию со дня рождения профессора П. И. Лобко, «Современная морфология: проблемы и перспективы развития».* Минск, Беларусь, 3-4 октября 2019.
11. **Zorina Zinovia,** Ilia Catereniuc. The Anatomical Variation of the Origin of the Deep Brachial Artery. *Timisoara Anatomical Days. First Edition With International Participation.* Timisoara, Romania, 6-7 december 2019.
12. **Zorina Zinovia.** Some anatomical variants of the arteries of the upper limb. *MedEspera 2020: 8th Intern. Medical Congr. for Students and Young Doctors.* Chisinau, 24-26 september 2020.

✓ **national**

13. **Zorina Zinovia.** Modalitate de ramificare a arterei axilare. *Conferinta stiintifica anuala a colaboratorilor si studentilor. USMF „Nicolae Testemitanu”.* Chisinau, 18-20 octombrie 2017.
14. **Zorina Zinovia.** Incidenta trunchiurilor comune a arterelor membrului superior *Conferinta stiintifica anuala a colaboratorilor si studentilor. USMF „Nicolae Testemitanu”.* Chisinau, 15-18 octombrie 2019.