

ASSESSMENT OF THE DATA OF PRE-OPERATION ULTRASOUND RESEARCH OF HAND AND ARM BLOOD VESSELS BEFORE THE FORMATION OF THE ARTERIOVENOUS LINK

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Summary

Ultrasound research of the blood vessels of hand and arm before the operation of the formation of the arteriovenous link is gradually becoming a necessity as it provides multiple useful information for the planning of the operation. Hospital of Lithuanian University of Health Sciences Kaunas clinics (LSMUL) is performing a prospective research based on the pre-operation ultrasound evaluation of hand and arm blood vessels. 182 patients with terminal deficiency of the renal function were researched; they were treated in LSMUL Department of Nephrology in 2008 to 2010. Before the formation of the primary arteriovenal link in the forearm, vena cephalica end to arteria radialis side (end-to-side anastomosis), the patients had hand and arm blood vessels ultrasound research performed. The age average of the patients was $64,62 \pm 2,31$ (18-91) years, of whom males constituted 92 (50,5%). 137 patients (75,3%) underwent the operation of the left arm. Internal diameter of a. radialis and v. cephalica were being measured together with the amount of blood flowing through a. radialis as well as the state of the blood vessels (a. radialis atherosclerosis, v. cephalica thrombosis). During the operation, blood vessels were observed directly (atherosclerosis plates and calcinosis in the arteries) as well as measured. The diameter of the blood vessels when assessing in terms of gender usually was 2.01-3.00 mm regarding the arm under operation. A. radialis and v. cephalica average diameter of the cross-

section area in dependence of the patient gender and the hand/ arm under operation ranged within 2.08 ± 0.126 to 2.58 ± 0.136 mm and 2.11 ± 0.17 to $2,49 \pm 0,33$. In different age groups, blood vessels also dominated (both a. radialis and v. cephalica) with the cross-section of 2.01 to 3.00 mm. The most frequent amount of blood flow in a. radialis was 0.01 l/min. A. radialis atherosclerosis was found in senior patients with the age average of 65.63 ± 14.648 years. V. cephalica thrombosis was encountered in 41 patients (14 males, 27 females). The gender, age and the arm under operation do not influence the results of the operation. Patients of the senior age group who have atherosclerosis more commonly necessitate pre-operation ultrasound research in order to discover a more favourable location for the arteriovenous link.

INTRODUCTION

The research performed in Lithuania demonstrates that the number of males and females with chronic deficiency of the renal function necessitating dialysis has been increasing. They are being applied a substitutional renal therapy, hemodialysis (HD), peritoneal dialysis or kidney transplantation. From the years 1999 to 2005, the number of patients having HD performed increased from 473 to 1092 (1). The arteriovenous link connecting one end of cephalica to the lateral part of arteria radialis is the gold standard for performing planned hemodialysis. In Lithuania, more than 90 per cent of the patients with the terminal stage of renal deficiency are dialysed via arteriovenal links (2). The distal third of the forearm is the most appropriate part of primary choice for the forming of a fistula; this allows the protection of proximal blood vessels in case a higher-level fistula is necessary to form. In the forearm, the typical ar-

teriovenous link is radiocephalous, i.e. using microsurgical technique the end of vena cephalica is connected to arteria radialis side (3,4). The arteriovenous fistula (AVF) is formed starting with the distal part of the forearm in the non-dominating arm. If this method of operation is unsuccessful (i.e. thrombosis occurs or stenosis develops), an AVF is repeatedly formed in the forearm more proximally (5).

Pre-operation ultrasound (US) tests are advisable before all the operations of AVF formation as it provides an opportunity of establishing the optimal location for the formation of a fistula. In Lithuania, researches related with ultrasound measurements and the assessment of the current state have not been performed or published. The advisable minimal diameter of the arteries is 0.25cm, and the minimum diameter of the vein is >0.25 cm during the pre-operation US analysis (6). If the veins and arteries are thin in the forearm, then a brachiocephal fistula is an alternative (one end of vena cephalica is connected into the lateral part of arteria brachialis in the elbow or the upper arm). If v.cephalica is of improper diameter or if thrombs are found in the upper arm, then a prosthetic appliance or a brachiobasilic fistula (when the end of vena basilica is connected into the lateral part of arteria brachialis) is selected (6, 7). Blood vessel assessment with ultrasound may help evaluate the appropriateness of the artery or vein for the formation of an arteriovenous fistula and decrease the danger of non-functioning of the link (8). LSMUL recently started the pre-operation method of ultrasound analysis of the hand/ arm blood vessels, and we were interested in the distribution of the results regarding the gender, age and the selected arm of the patients. The objective of our work was to explore the

cross-section area of blood vessels, the amount of blood flowing through a.radialis, and the relationship of a.radialis atherosclerosis or v.cephalica thrombosis with the gender, age or the arm selected for the operation of the patients.

RESEARCH MATERIALS AND METHODOLOGY

LSMUL has been performing a prospective research, in which 182 patients with terminal deficiency of the renal function were participating; they were treated in the Nephrology department of LSMUL in the years 2008 to 2010. By applying microsurgery techniques, primary arteriovenous links were formed in the forearm connecting one end of vena cephalica into the lateral part of arteria radialis. Before the operation, patients underwent ultrasound analysis in order to assess the state of the blood vessels of the arm/hand (the position of the arm/hand is horizontal, which is the same position as during the operation). During the operation, blood vessels were assessed by direct observation (single cases of calcification or circular sclerosis were observed), and the diameter was measured with a micrometer. On the basis of pre-operation ultrasound analysis and the operation protocol, the cross-section areas of the artery and the vein, the state of the arteries in terms of atherosclerosis and the state of the veins in terms of thrombosis were assessed together with the amount of blood flowing through the artery, and the dependence of these features on the gender, age and the selected arm of the patients was considered.

B- mode and Doppler (pulse waves and colour) modes of the sensors of the ultrasound scanner were applied for blood vessel analysis, and the multi-frequency sensor LT-8.05AT 8MHz was being used. The gel applied onto the sensor was warm, and during the analysis, the patient is lying on his/ her back.

The data of the research was calculated in terms of absolute values and percentages. When presenting averages of the data, standard deviations are indicated further. Statistical analysis of the data was performed by applying the program *PASW 18*. Data differences were considered significant if the level of significance was at $p < 0.05$.

RESULTS

The sample of the patients consisted of 92 males (50,5%), and 90 females (49,5%). The average age of the patients was $64,62 \pm 2,31$ with the median at 68. The young gest patient was 18, and the most senior patient was 91 years old. 39 patients had their right hand (22,2%) while the left arm was operated on 137 patients (75,3%).

The diameter of the blood vessels was established by US analysis, and during the operation it usually varied within 2.01 to 3.00mm (Table 1).

Table 1. Distribution of the diameter of a. radialis and v. cephalica in terms of gender and the operated arm

Analysis	Blood vessel	Diameter (mm)	Males, %	Females, %	Right arm, %	Left arm, %	p
PUA	A. radialis'	<1.00	n=55	n=55	n=56	n=94	p>0.05
		1.01-2.00	-	1.8	0.5	0.5	
		2.01-3.00	16.4	43.6	10.4	15.4	
		>3.01	63.6	50.9	15.4	29.7	
MDO	A. radialis'	<1.00	n=87	n=87	n=39	n=134	p>0.05
		1.01-2.00	1.1	-	-	0.7	
		2.01-3.00	24.1	34.5	46.2	24.6	
		>3.01	71.3	64.4	48.7	73.1	
PUA	V. cephalica	<1.00	n=54	n=56	n=56	n=94	p>0.05
		1.01-2.00	3.7	1.8	1.1	1.1	
		2.01-3.00	33.3	42.9	9.9	22.5	
		3.01-4.00	38.9	37.5	11.5	19.8	
MDO	V. cephalica	1.01-2.00	n=88	n=88	n=39	n=137	p>0.05
		2.01-3.00	20.5	23.9	25.6	21.2	
		>3.01	75.0	76.1	74.4	75.9	
			4.5	-	-	2.9	

PUA: pre-operation ultrasound analysis; MDO: measured during operation *- $p=0,002$; #- $p=0,024$

Table 2. Distribution of the average of diameter of a. radialis and v. cephalica in terms of gender and the operated arm

Analysis	Blood vessel	Average of diameter of a blood vessel (mm); p significance			
Pre-operation ultrasound analysis	A. radialis	Right arm (n=27)	p>0.05	Males (n=55)	p<0.001
		2.35±0.22		2.58±0.136	
		Left arm (n=83)		Females (n=55)	
		2.34±0.12		2.08±0.126	
Measured during operation	A. radialis	Right arm (n=39)	p>0.05	Males (n=87)	p=0.006
		2.11±0.17		2.38±0.128	
		Left arm (n=134)		Females (n=87)	
		2.31±0.086		2.156±0.084	
Pre-operation ultrasound analysis	V. cephalica	Right arm (n=27)	p>0.05	Males (n=54)	p>0.05
		2.49±0.33		2.54±0.248	
		Left arm (n=83)		Females (n=56)	
		2.39±0.19		2.31±0.216	
Measured during operation	V. cephalica	Right arm (n=39)	p=0.034	Males (n=88)	p=0.007
		2.26±0.15		2.42±0.11	
		Left arm (n=137)		Females (n=88)	
		2.303±0.087		2.17±0.097	

Table 3. A. radialis and v. cephalica most usual lumen diameter 2.01 - 3.00 distribution in age groups

Blood vessel	Presence of diameter of a blood vessel within 2.01 to 3.00 mm in terms of age groups (%); p significance				
A. radialis	n=63 (PUA)		n=118 (OP)		
	<=25yrs	50.0%		0.0%	
	25-45yrs	56.3%		57.7%	
	46-65yrs	62.1%	p<0.001	69.1%	p>0.05
	66-85yrs	55.7%		72.9%	
	>86yrs	50.0%	25.00%		
V. cephalica	n=133 (PUA)		n=133 (OP)		
	<=25yrs	100.0%		50.0%	
	25-45yrs	23.5%		80.8%	
	46-65yrs	34.5%	p>0.05	72.3%	p>0.05
	66-85yrs	41.7%		76.3%	
	>86yrs	50.0%	75.00%		

PUA: pre-operation ultrasound analysis; OP: operation protocol

A. radialis and v. cephalica average diameter of the diameter in dependence on the age and the operated arm of the patient varied within the limits of 2.11±0.17 to 2.42±0.11 mm (Table 2).

Different age groups also showed the dominance of blood vessels (both a. radialis and v. cephalica) with the diameter area of 2.01 to 3.00 mm (Table 3).

During the pre-operation ultrasound research, the amount of the established blood flow through a. radialis varied from 0.01l/min to 0.07 l/min. 0.01 l/min was the most frequent amount of the blood flow (Table 4).

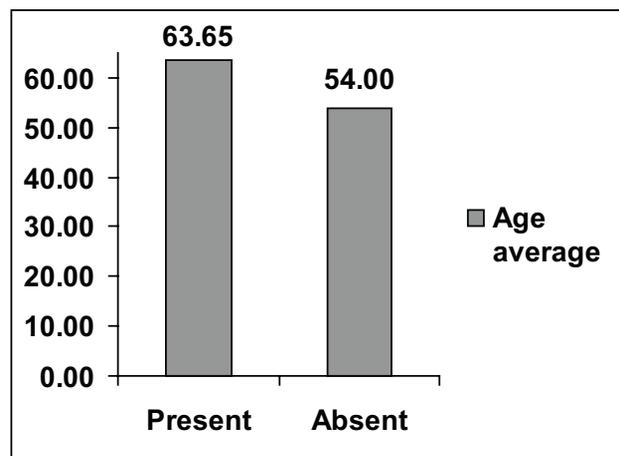
Among males and females, atherosclerosis occurred more for female (59,3%) as for male (40.7%) (p>0.05). In the right arm, it was in 33.3% cases while in the left arm it occurred in 66.7% cases (p>0.05). Atherosclerosis was more common in senior patients (Picture 1).

V. cephalica thrombosis was found in 15,22% male and 30% female in US analyses (p=0.052). In the right arm, it was in 8,3% cases while in the left arm it occurred in 61,9% cases (p<0.001). Thrombosis was found in senior patients with the age average of 64.41±5.27 years (p>0.05).

Table 4. Amount of blood flow in a. radialis in terms of gender and arm under operation

Analysis	Blood vessel	Amount of blood flow in the blood vessel (l/min.)	Males, %	Females, %	Right arm, %	Left arm, %	p
PUT	A. radialis	0.01	n=15	n=25	n=14	n=48	p>0.05
		0.02	51.7	75.8	57.1	66.7	
		0.03	24.1	12.1	21.4	16.7	
		0.04	20.7	3.0	14.3	10.4	
		0.06	0.0	6.1	0.0	4.2	
		0.07	0.0	3.0	7.1	0.0	
		0.07	3.4	0.0	0.0	2.1	

PUA: pre-operation ultrasound analysis

**1 Figure 1. Presence of A. radialis atherosclerosis in terms of age average of the patients (p>0.05)**

DISCUSSION OF RESULTS

The age of the majority of patients was >51 years (79,7%). The patients who are prepared for hemodialysis are usually of senior age as age is one of the risk factors for chronic renal deficiency (9).

The arteriovenous link is formed in the non-dominant arm as after the formation of a fistula, major physical activity of the arm/ hand is impossible (5). Since most people and consequently patients are right-handed, the left arm is most frequently selected for operations. 75,3% of the patients had the state of blood vessels assessed in their right arm during the pre-operation ultrasound analysis.

A. radialis and v. cephalica showed the most frequent diameter between 2.01 and 3.00 mm in males (p>0.05). That is why in terms of this aspect, the cross-section of a. radialis > 2.00 mm; v. cephalica > 2.5 mm however < 4.00 mm is deemed suitable for the formation of arteriovenous link and conditions a lower probability of non-functioning of the fistula (10). For example, Parmar et al. claim that 46% of fistulae resulted in early complications due to which

the arteriovenous link did not function if the diameter area was <1.5 mm while there were 0% complications with the diameter >1.5 mm (11). In the database, we found only one research similar to ours performed in 2009 by V.Persic et al., the results of the pre-operation ultrasound research are comparable with the data of the average diameter of blood vessels, the presence of atherosclerosis in a. radialis and the selection of the arm for the operation. In our research, the cross-section of a. radialis in the right hand was 2.11 ± 0.17 mm, atherosclerosis occurred in 31.00% of the cases while in the research by the Slovenian team, it was correspondingly 2.30 ± 0.40 mm and 36.00%; in the left arm 2.31 ± 0.086 mm and 28.6% correspondingly 2.30 ± 0.50 and 29.00%. The diameter of V. cephalica in our research in the right arm was 2.26 ± 0.15 mm while in the research by V.Persic et al. it was 3.7 ± 0.7 mm, in the left arm 2.303 ± 0.087 , correspondingly 3.5 ± 1.00 mm (12). The majority of the patients participating in this research, both males and females, had a sufficient and safe diameter of blood vessels both in the left and the right arms to form a radiocephalic link.

In terms of age, in a. radialis and v. cephalica, the most frequent diameter of the cross-section also was 2.01 to 3.00 mm ($p > 0.05$). Thus despite the age of the patient the probability that the diameter areas of blood vessels are sufficient for the formation of the arteriovenous link is high.

In the right and the left arms of males and females, the most frequent amount of blood flow was 0.01 l/min ($p > 0.05$). This is not a large amount of blood flowing through a. radialis; nevertheless, it is more important that the cross-section of the artery should be sufficient as the blood flow after having formed a fistula substantially increases already during the first twenty-four hours (13).

Among males and females, a. radialis atherosclerosis occurred more at females. However, in terms of age, it was found more frequently in senior patients whose age average was $65.6314.648 \pm$ years ($p > 0.05$). A. radialis atherosclerosis, with the exception of a few cases occurred in more than half of patients over 45 years of age ($p > 0.05$). Atherosclerosis is one of the risk factors of early non-functioning of the arteriovenous link, and this pathology is established during the pre-operation ultrasound analysis whose data is correlated with the findings of the operation (14). That is why all the senior patients should undergo US analyses before the operation of arteriovenous link formation, and the higher risks of early complications should be considered since not only atherosclerosis but also the senior age in itself are risk factors concerning the non-functioning of the arteriovenous fistula (15).

V. cephalica thrombosis was found in 14 male and 27

female in US analyses. These patients had the dominant arm selected for the operation as the thrombosis-featuring vein is unsuitable for the formation of the arteriovenous link (16).

CONCLUSIONS

1. Arteriovenous link may be formed in most patients due to the presence of suitable blood vessels in the lower third of the forearm independently of gender, age or the selected arm.

2. A. radialis atherosclerosis is common among patients of senior age and occurs in more than half cases of patients over 45 years. These patients necessitate pre-operation ultrasound research as alterations leading to the decrease of possibilities of functioning of the arteriovenous link are discovered.

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RANKOS KRAUJAGYSLIŲ ULTRAGARSINIO TYRIMO DUOMENŲ ANALIZĖ PRIEŠ ARTERIOVENINĖS JUNGTIOS FORMAVIMO OPERACIJĄ

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Santrauka

Raktažodžiai: ultragarsinis rankos kraujagyslių tyrimas, arterioveninė jungtis, arterioveninės jungties formavimo operacija, rankos kraujagyslių spindžiai.

Ultragarsinis rankos kraujagyslių tyrimas prieš arterioveninės jungties formavimo operaciją Lietuvoje pamažu tampa būtinybe, nes jo metu gaunama daug informacijos, naudingos operacijos planavimui. Lietuvos sveikatos mokslų universiteto ligoninėje Kauno klinikose (LSMUL) atliekamas prospektyvinis atsitiktinių imčių tyrimas, kuris remiasi priešoperaciniu ultragarsiniu rankos kraujagyslių vizualizavimu. Tirti 182 paci-

entai, sergantys terminaliniu inkstų funkcijos nepakankamumu, jie gydyti LSMUL Nefrologijos skyriuje 2008-2010 m. Prieš pirminės arterioveninės jungties formavimą dilbyje vena cephalica į arteria radialis šoną pacientams buvo atliekamas rankos kraujagyslių ultragarsinis tyrimas. Pacientų amžiaus vidurkis 64,62 ± 2,31 (18-91) metų, vyrų buvo 92 (50,5%). 137 (75,3%) pacientų operuota kairė ranka. Buvo matuojamas vidinis a. radialis ir v. cephalica spindis, pratekantis a. radialis kraujo kiekis, kraujagyslių būklė (a. radialis aterosklerozė, v. cephalica trombozė). Operacijos metu kraujagyslės vertintos tiesioginės apžiūros metu (aterosklerozės plokštelės ir kalcinozė arterijoje) ir matuojamos. Kraujagyslių spindis, vertinant pagal lytį, dažniausiai buvo 2,01-3,00 mm operuotos rankos atžvilgiu. A. radialis ir v. cephalica vidutinis spindžio diametras priklausomai nuo pacientų lyties ir operuotos rankos įvairavo atitinkamai 2,08±0,126 - 2,58±0,136 mm ir 2,11±0,17 - 2,49±0,33 ribose. Skirtingose amžiaus grupėse taip pat dominavo kraujagyslės (tiek a. radialis, tiek v. cephalica), kurių spindis yra 2,01-3,00 mm. Dažniausias pratekantis a. radialis kraujo kiekis buvo 0,01 l/min. A. radialis aterosklerozė pasitaikė vyresniems pacientams, kurių vidutinis amžius 65,63±14,648. V. cephalica trombozė pasitaikė 41 pacientui (14 vyrų, 27 moterų). Lytis, amžius ar pasirinkta operuoti ranka įtakos operacijai neturi. Vyresnio amžiaus pacientams, kuriems būdinga aterosklerozė priešoperacinis ultragarsinis tyrimas yra būtinas dėl geresnės arterioveninės jungties vietos pasirinkimo.

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