



TRANSRADIAL VERSUS TRANSFEMORAL ARTERIAL APPROACH: A STUDY ON EFFICIENCY AND PATIENT COMFORT

USPOREDBA TRANSRADIALNOG I TRANSFEMORALNOG ARTERIJSKOG PRISTUPA: STUDIJA O EFIKASNOSTI I KOMFORU PACIJENATA

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Original Scientific Article

Received: 10/08/2024

Accepted: 26/09/2024

ABSTRACT

The aim of this research is to perform a comprehensive comparative analysis of transradial (TR) and transfemoral (TF) arterial approaches in conducting diagnostic coronary angiographies. The research involved a total of 240 participants, categorized into two cohorts. Group one included 121 participants who received coronary angiography via TR arterial approach, while group two comprised 119 participants who were administered the procedure via TF arterial approach. The MannWhitney U test was employed to assess the research objectives. Additionally, Spearman's correlation coefficient was utilized to evaluate the relationships between the variables observed in the research. This research confirms that TR approach results in longer procedures compared to TF approach. Despite the longer duration and higher radiation exposure with TR approach, there was no significant difference in the amount of contrast agent used between TR and TF approaches. There was no significant difference in hospitalization duration between patients undergoing TR and TF approaches. Patient comfort during and after the procedure was significantly better with TR approach. The average cost of materials used was higher for patients undergoing TR approach compared to TF approach, making TR approach about 15% more expensive on average. The results of this research indicate that both methods demonstrate no notable difference in the volume of contrast agent administered or in the occurrence rate of complications. However, TF arterial approach leads to reduced procedure times and lower radiation exposure, whereas TR arterial approach enhances patient comfort.

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Keywords: Coronary artery disease, diagnostic coronary angiography, coronary angiography, transradial arterial approach, transfemoral arterial approach.

SAŽETAK

Cilj istraživanja je da se učini sveobuhvatna komparativna analiza transradijalnog (TR) i transfemoralnog (TF) arterijskog pristupa pri izvođenju dijagnostičkih koronarnih angiografija. U istraživanju je sudjelovalo ukupno 240 učesnika, kategoriziranih u dvije skupine. Prva skupina je uključivala 121 učesnika kojima je dijagnostička koronarna angiografija učinjena putem TR arterijskog pristupa, dok je druga skupina uključivala 119 učesnika kojima je dijagnostička koronarna angiografija učinjena putem TF arterijskog pristupa. Za procjenu ciljeva istraživanja korišten je Mann-Whitney U test. Dodatno, Spearmanov koeficijent korelacije korišten je za procjenu odnosa između varijabli uočenih u istraživanju. Ovo istraživanje potvrđuje da TR arterijski pristup rezultira dužim vremenom trajanja procedura u odnosu na TF arterijski pristup. Uprkos dužem trajanju i većoj izloženosti jonizirajućem zračenju pri korištenju TR arterijskog pristupa, nije bilo značajne razlike u količini kontrastnog sredstva korištenog između TR i TF arterijskog pristupa. Nije bilo značajne razlike u trajanju hospitalizacije između pacijenata koji su bili podvrgnuti TR i TF arterijskim pristupima. Udobnost pacijenata tokom i nakon procedure bila je značajno bolja pri korištenju TR arterijskog pristupa. Prosječna cijena koštanja potrošnog materijala bila je veća za pacijente koji su podvrgnuti TR arterijskom pristupu u odnosu na TF arterijski pristup, čineći izvođenje dijagnostičkih koronarnih angiografija TR arterijskim pristupom u prosjeku skupljim za oko 15%. Rezultati ovog istraživanja pokazuju da oba arterijska pristupa ne pokazuju značajnu razliku u količini upotrijebljenog kontrastnog sredstva niti u učestalosti komplikacija. Međutim, TF arterijski pristup dovodi do kraćeg vremena izvođenja procedure i manje izloženosti jonizirajućem zračenju, dok TR arterijski pristup povećava udobnost pacijenta u toku i nakon procedure.

Ključne riječi: koronarna arterijska bolest, dijagnostička koronarna angiografija, koronarna angiografija, transradijalni arterijski pristup, transfemoralni arterijski pristup.

INTRODUCTION

Coronary angiography is considered the gold standard in the diagnosis of coronary artery disease. TF arterial approach remains the most commonly used method for performing coronary angiography and percutaneous coronary interventions in most centres around the world, including Bosnia and Herzegovina. Recently, TR arterial approach has been gaining more advocates among interventional cardiologists (1), who suggest that this method offers certain advantages over TF approach, especially for patients on antiplatelet and anticoagulant therapy who have a higher risk of bleeding and other complications related to the puncture site. Additionally, it is reported that TR approach is associated with shorter patient immobilization and reduced hospitalization time (2). Despite this, a significant number of interventional cardiologists still prefer the TF approach due to its safety, simplicity, and speed of execution.

The diagnosis and assessment of coronary disease involve a clinical evaluation of the patient, identification of biochemical risk factors (e.g., significant dyslipidaemia, hyperglycaemia), and specific cardiological tests such as stress testing or coronary angiography. These examinations can be useful for confirming the diagnosis of myocardial ischemia in patients suspected of having coronary disease. In practice, diagnostic and prognostic assessments are carried out simultaneously, and many of the tests used for diagnosis also provide prognostic information for the patient.

Coronary angiography is an invasive radiographic procedure where a contrast agent (usually iodine-based) is injected through catheters placed at the openings of the coronary arteries to radiographically visualize and detect stenoses or occlusions of the coronary arteries (3). It is the gold standard for detecting significant flow-limiting stenoses that can be revascularized through percutaneous or surgical interventions. However, this procedure has several limitations. The degree of stenosis is determined visually, but the assessment is limited by observer subjectivity, which can vary from 30 to 60%. The presence of diffuse disease can also lead to underestimation of the degree of stenosis because the degree is determined as a percentage of the luminal diameter at the site of stenosis, compared to the luminal diameter of a normal ("healthy") coronary segment; in diffusely diseased coronary arteries, "healthy" coronary segments do not exist. Another limitation is the visualization of only the part of the coronary artery filled with blood (and contrast agent), while the size of the plaque present in the artery wall cannot be assessed (4). Due to these limitations of coronary angiography, and to better anatomically and functionally assess coronary stenosis, other techniques such as IVUS and FFR can be used (5). Rational use of coronary angiography as a diagnostic method implies a high percentage of finding critical stenoses on the coronary arteries, which is followed by percutaneous intervention.

TF arterial approach is the first standardized approach that was used for performing coronary angiographies. It has been a traditional method due to its ease of access and familiarity among healthcare professionals. Over time, alternative approaches like TR approach have been developed and refined, offering certain advantages such as reduced complications and quicker patient recovery.

TR arterial approach for heart catheterization was first performed by Campeau in 1989. The technique was successful in most patients, but some experienced loss of radial pulse following the procedure (6). The first percutaneous transluminal coronary angioplasty using TR approach was done in 1993. Since then, both the equipment used and the procedure itself have been refined, making TR approach much more commonly used for diagnostic and therapeutic purposes.

The Cardiovascular Clinic of the University Clinical Centre Tuzla introduced the routine use of TR arterial approach for coronary angiographies in 2015, and to this day, this approach is preferred for such procedures. When recording diagnostic coronary angiographies, TR arterial approach can be technically more demanding compared to the transfemoral arterial approach, which may mean a longer duration of the procedure as well as the technical failure of the procedure itself. Consequently, this can also mean greater exposure to ionizing radiation for both the patient and the operator. In this research, we attempted to make a comprehensive comparison of the advantages and disadvantages of the two mentioned arterial approaches in

performing diagnostic coronary angiographies to make better decisions in everyday clinical practice. It is very important to know the advantages and disadvantages of TR and TF arterial approaches, especially in light of the exceptionally high incidence of coronary disease in our country and limited health resources.

MATERIAL AND METHOD

The research included participants with positive anamnestic data and a high suspicion of coronary disease (positive at least one non-invasive test for induced myocardial ischemia assessment) who underwent elective diagnostic coronary angiography. The research was conducted at the Clinic for Invasive Cardiology at University Clinical Center Tuzla Tuzla from December 2019 to January 2021. Based on the vascular approach used, participants were divided into two groups. Group A consisted of 121 patients who underwent TR arterial approach, and Group B consisted of 119 patients who underwent TF arterial approach. Data were taken directly from the catheterization laboratory on the Phillips ALLURA XPER FD20 machine. All procedures were performed by a single operator. All punctures at the access sites (a. radialis and a. femoralis communis) were done after manual palpation, without the use of ultrasound guidance. It is important to emphasize that for the standardization of the procedure and the comfort of the operator, only the right TR and TF arterial approaches were used during the procedures. All data were collected from regular work with patients, without the need for additional processing and resource expenditure. Consent was obtained from all participants when taking anamnestic data used in the questionnaires.

In the research, each participant's gender and age were identified, and the date of the procedure was recorded. During each coronary angiography, the duration of the procedure (in minutes), the amount of contrast agent applied (in millilitres), and the amount of radiation delivered during the procedure (in mGy) were measured.

The periprocedural and postprocedural comfort related to the procedure was also tracked for all participants. Periprocedural comfort was determined using a visual analogue scale (VAS) where the patient used a visual scale to determine comfort during coronary angiography, with 0 indicating no pain during the procedure and 10 indicating the greatest pain imaginable (7). Postprocedural patient comfort was determined using a purpose-designed questionnaire that graded discomfort or pain of various postprocedural aspects, including compression of the puncture site after removal of the arterial introducer, "loss of sensation" in the punctured extremity, feeling of "foreign body" presence at the puncture site, length of immobilization after the procedure, pain at the puncture site, back pain after the procedure, bleeding/hematoma at the puncture site. Each of these aspects of postprocedural patient comfort was scored on a scale of 1 to 5 based on patient statements.

The duration of hospitalization after the procedure and the cost of the procedure, i.e., the amount of material used during the procedure, were recorded for all participants.

To test the research objectives, the Mann-Whitney U test was applied, and to check the correlation between the observed variables of the research, Spearman's correlation coefficient was used. The research data were processed in the statistical package SPSS for Windows. This approach allows for non-parametric testing, suitable for data that may not follow a normal distribution, providing a robust analysis of the research objectives.

RESULTS

The duration of coronary angiography for patients undergoing TR and TF arterial approaches is presented using descriptive statistics in Table 1. Based on the results it can be seen that the duration of coronary angiography is longer for subjects undergoing TR arterial approach (12.10 ± 3.71 minutes) compared to TF arterial approach (10.39 ± 4.54 minutes). The results of the Kolmogorov-Smirnov test (KS) and the Shapiro-Wilk test (SW) shown in Table 1 indicate that the data distribution is not normally distributed. Therefore, the Mann-Whitney U test will be applied to determine significant differences between the arterial approaches used. Based on the results of the Mann-Whitney U test shown in Table 2, it can be concluded that at the statistical significance level of 0.01, the duration of coronary angiography is greater for patients undergoing TR arterial approach.

Table 1. Results of descriptive statistics

Variables	Arterial approach	N	AS	SD	SG	KS	SW
Duration of coronary angiography	Transradial	121	12.10	3.71	.33	.000	.000
	Transfemoral	119	10.39	4.54	.41		
Amount of applied contrast agent	Transradial	121	79.91	22.71	2.06	.000	.000
	Transfemoral	119	79.11	25.04	2.29		
Amount of radiation	Transradial	121	250.60	81.84	7.44	.000	.000
	Transfemoral	119	182.97	70.86	6.49		
Duration of hospitalization	Transradial	121	1.04	.20	.01	.000	.000
	Transfemoral	119	1.09	.39	.03		
Periprocedural and postprocedural comfort	Transradial	121	13.14	4.76	.43	.000	.000
	Transfemoral	119	15.72	4.99	.45		
The price of the used material	Transradial	121	449.50	115.42	10.49	.000	.000
	Transfemoral	119	387.76	109.83	10.06		

Table 1 presents the descriptive statistics regarding the amount of contrast agent used in patients undergoing TR and TF arterial approaches. The results shown in Table 1 indicate that the average amount of contrast agent used for subjects undergoing TR arterial approach is $79,91 \pm 22,71$ ml, while for patients undergoing TF arterial approach, it is $79,11 \pm 25,05$ ml. The Kolmogorov-Smirnov test and the Shapiro-Wilk test results, as shown in Table 1, demonstrate that the data distribution is not normally distributed. Therefore, the Mann-Whitney U test will be applied to determine significant differences between the arterial approaches used. Based on the Mann-Whitney U test results shown in Table 2, it can be concluded that there is no statistically significant difference in the amount of contrast agent used between patients undergoing TR and TF arterial approaches.

Table 2. Results of the Mann-Whitney U test (M-W)

Variables	Arterial approach	Average rank	Sum of ranks	M-W	Z	p
Duration of coronary angiography	Transradial	139.62	16894.50	4885.50	-4.30	.000
	Transfemoral	101.05	12025.50			
Amount of applied contrast agent	Transradial	122.35	14804.50	6975.50	-.42	.673
	Transfemoral	118.62	14115.50			
Amount of radiation	Transradial	149.98	18148.00	3632.00	-6.63	.000
	Transfemoral	90.52	10772.00			
Duration of hospitalization	Transradial	116.92	13913.00	6773.00	.90	.363
	Transfemoral	120.11	14053.00			
Periprocedural and postprocedural comfort	Transradial	101.37	12266.00	4885.00	-4.31	.000
	Transfemoral	139.95	16654.00			
The price of the used material	Transradial	143.22	17330.00	4450.00	-5.11	.000
	Transfemoral	97.39	11590.00			

The results presented in Table 1 for the descriptive statistics regarding the amount of ionizing radiation delivered during coronary angiography show that patients undergoing TR arterial approach received an average of 250.60 ± 81.44 mGy, while those undergoing TF arterial approach received 182.97 ± 70.86 mGy. The Kolmogorov-Smirnov and Shapiro-Wilk tests indicate that the data distribution is not normal, so the Mann-Whitney U test will be used to determine statistically significant differences between the arterial approaches. According to the Mann-Whitney U test results in Table 2, there is a statistically significant difference at the 0.01 level, with TR arterial approach resulting in a higher amount of radiation delivered during coronary angiography.

Additionally, Table 1 shows the descriptive statistics related to the duration of hospitalization after coronary angiography for patients undergoing TR and TF arterial approaches. The results indicate that the average hospitalization duration after coronary angiography for patients undergoing the TR approach is 1.04 ± 0.20 days, compared to 1.09 ± 0.39 days for those undergoing the TF approach. The Kolmogorov-Smirnov and Shapiro-Wilk tests confirm that the data distribution is not normal. Therefore, the Mann-Whitney U test was applied to determine statistically significant differences between the arterial approaches. The Mann-Whitney U test results in Table 2 show that there is no statistically significant difference in the duration of hospitalization after coronary angiography between patients undergoing TR and TF arterial approaches.

The results in Table 1, showing measures of central tendency and dispersion for periprocedural and postprocedural comfort during coronary angiography, indicate that the average values for patients undergoing TR approach are 13.14 ± 4.76 , while for TF approach, they are 15.75 ± 4.99 . Since a lower score indicates better comfort, it can be concluded that both periprocedural and postprocedural comfort are better for patients undergoing TR arterial approach. The Kolmogorov-Smirnov and Shapiro-Wilk tests confirm that the data is not normally distributed, so the Mann-Whitney U test will be used to determine statistically significant differences between the arterial approaches. The Mann-Whitney U test results, shown in Table 2, conclude that at a statistical significance level of 0.01, the periprocedural and postprocedural comfort is better for patients undergoing TR arterial approach.

Regarding the cost of materials used during the procedure, Table 1 shows that the average cost for patients undergoing TR approach is 449.50 ± 115.42 KM, while for TF approach, it is 387.76 ± 109.83 KM. The Kolmogorov-Smirnov and Shapiro-Wilk tests indicate that the data distribution is not normal. Therefore, the Mann-Whitney U test will be applied to determine statistically significant differences between the arterial approaches. Based on the Mann-Whitney U test results shown in Table 2, it can be concluded that at a statistical significance level of 0.01, the cost of materials used during the procedure is higher for patients undergoing TR arterial approach.

Table 3. Results of correlation analysis

Variables	A	B	C	D	E	F	G	H
A	1,000	,120	,097	,073	,083	,045	.136*	,051
B	,120	1,000	.761**	.761**	.574**	.567**	.315**	.613**
C	,097	.761**	1,000	.671**	.660**	.687**	.285**	.564**
D	,073	.761**	.671**	1,000	.442**	.413**	.331**	.629**
E	,083	.574**	.660**	.442**	1,000	.869**	.315**	.491**
F	,045	.567**	.687**	.413**	.869**	1,000	.320**	.458**
G	.136*	.315**	.285**	.331**	.315**	.320**	1,000	.318**
H	,051	.613**	.564**	.629**	.491**	.458**	.318**	1,000

Legend: *significance 0.05; **significance 0.01; A - Chronological age; B - Total duration of the procedure; C - Amount of applied contrast agent; D - Amount of delivered radiation; E - Visual analogue scale; F - Periprocedural and postprocedural comfort; G - Total duration of hospitalization and H - Cost of materials used during the procedure.

The application of Spearman's correlation coefficient in the research aimed to establish the relationship between the variables used. The findings, as shown in Table 3, suggest that at a statistical significance level of 0.01, as the total duration of the procedure increases, so does the amount of contrast agent applied and the radiation delivered, leading to increased pain and decreased comfort for the patient. Additionally, the duration of hospitalization and the cost of the procedure also increase. Furthermore, Table 3 indicates that at a significance level of 0.05, although the correlation is weak, the total duration of the procedure increases with the age of the patient. An increase in the amount of contrast agent applied is associated with increased pain, reduced comfort, longer hospitalization, and higher procedure costs at a significance

level of 0.01. This comprehensive analysis underscores the importance of considering these factors when planning and conducting coronary angiography procedures.

DISCUSSION

In recent years, TR arterial approach has been increasingly adopted in standardized practice by centres worldwide, including Bosnia and Herzegovina, with a growing number of interventional cardiologists preferring it as the first choice for their patients. Several studies have compared these two arterial approaches in clinical practice, examining various aspects of each. Similar studies have not been conducted in Bosnia and Herzegovina until now. Given the country's unique socio-economic situation, a comprehensive comparative analysis of the TR and TF arterial approaches in performing coronary angiographies for the diagnosis of coronary disease has been conducted.

As previously mentioned, the aim of this research was to perform a comprehensive comparative analysis of the TR and TF arterial approaches in conducting diagnostic coronary angiographies. We compared seven aspects of the procedure: the duration of the procedure, the amount of contrast agent used during the procedure, the amount of ionizing radiation delivered during the procedure, the frequency of periprocedural and postprocedural complications, the duration of hospitalization after the procedure, the periprocedural and postprocedural comfort of the patient, and the cost of the procedure or the amount of material used during the procedure. This analysis is crucial for making informed decisions in daily clinical practice, especially considering the high incidence of coronary disease in our country and the limited healthcare resources.

TR arterial approach for coronary angiography is technically more demanding and has a steeper learning curve than TF approach. Previous studies have shown that procedures using the TR approach tend to last longer. This research confirms that TR approach results in longer procedures, averaging 12.10 minutes compared to 10.39 minutes for TF approach. The longer duration is partly due to the need to switch from TR to TF access during some procedures. Despite the longer duration and higher radiation exposure with TR approach, there was no significant difference in the amount of contrast agent used between TR and TF approaches (79.91 ml vs. 79.11 ml). This suggests that the longer procedure time and increased radiation are related to the technical complexity of TR approach rather than the use of more contrast agent. Interventional cardiologists should aim to use the least amount of contrast agent necessary to complete the diagnostic examination successfully, especially considering the specific patient groups at risk for contrast-induced nephropathy, iodine allergy, or thyroid dysfunction. These findings are consistent with previous research (8,9) and have implications for planning daily work in angiography suites, particularly in settings like Bosnia and Herzegovina, where resources and personnel may be limited.

The research highlights the importance of minimizing ionizing radiation during invasive radiographic procedures, including coronary angiographies. It was found that TR approach resulted in higher radiation exposure (250.6 mGy) compared to TF approach (182.9 mGy). This confirms previous studies (10), including a large meta-analysis, which indicated a slight but significant increase in radiation exposure with TR approach. However, the gap is narrowing over the years, likely due to more frequent use of TR approach and technological

advancements. Some studies (8,9) contradict these findings, showing no difference in fluoroscopy time and radiation exposure. Research involving high-volume centres using TR approach (11) suggests that proper radiation protection techniques can lead to less exposure for the patient.

Considering the limited healthcare resources in Bosnia and Herzegovina, the research also compared the economic aspects of performing coronary angiographies using TR and TF approaches to better plan resource utilization. The cost calculation focused only on the periprocedural aspect, i.e., the amount and type of materials used, without considering hospitalization time in the cost of the procedure. The evidence suggests that while current radiation exposure is higher with TR approach, it can be significantly reduced with wider acceptance, technical improvements, and protective measures, potentially favouring TR approach.

The research underscores the need for efficient use of healthcare resources by optimizing and reducing hospitalization time after invasive procedures, which also helps prevent potential hospital-acquired infections. Although recent practices allow same-day discharge after diagnostic coronary angiographies via TR approach, during the research period, the clinic's practice was to keep all patients, regardless of the approach used, for 24 hours post-procedure. Consequently, there was no significant difference in hospitalization duration between patients undergoing TR and TF approaches, diverging from other studies (12,13) where patients undergone TR approach had significantly shorter hospital stays.

Patient comfort during and after the procedure was significantly better with TR approach, supported by a visual analogue pain scale and a specially designed questionnaire. TR approach is particularly beneficial for patients with back and hip pain or urinary retention due to quicker mobilization after the procedure. These findings align with previous research (14,15) indicating better patient comfort, including shorter hospital stays, with TR approach.

The average cost of materials was higher for patients undergoing TR approach (449.50 ± 115.42 KM) compared to TF approach (387.76 ± 109.83 KM), making TR approach about 15% more expensive on average. These results are somewhat consistent with previous studies showing comparable or slightly higher costs for TR approach. However, these studies (13) also highlighted lower postprocedural hospitalization costs for TR approach patients, justified by shorter average hospital stays and fewer bleeding complications in high-risk patients. Since the clinic's practice was to hospitalize all patients for at least 24 hours, there was no significant difference in hospitalization duration between TR and TF approaches, thus not significantly affecting the total procedure cost. Also, as bleeding complications are rare in diagnostic coronary angiographies and the research's design did not include high-risk bleeding patients, this aspect did not significantly impact the total procedure cost. For these reasons, the research's cost comparison was limited to the cost of materials used during the procedure. Recently, the clinic and worldwide practices have been discharging more patients on the same day after diagnostic coronary angiographies via TR approach, shortening hospital stays and reducing the overall cost of medical services.

REFERENCES

1. Kolkailah AA, Alreshq RS, Muhammad AM, Zahran ME, Anas El-Wegoud M, Nabhan AF (2018) Radial artery versus femoral artery approach for performing coronary angiography. *Cochrane* 10 1002/14651858.
2. Anjum I, Khan MA, Aadil M, Faraz A, Farooqui M, Hashmi A (2017) Transradial vs. Transfemoral Approach in Cardiac Catheterization: A Literature Review. *Cureus* 9(6):1309
3. Scanlon PJ, Faxon DP, Audet AM, Blase Carabello B, Dehmer GJ, Eagle KA, Legako RD, Leon DF, Murray JA, Nissen SE, Pepine CJ, Watson RM, Ritchie JL, Gibbons RJ, Cheitlin MD, Gardner TJ, Garson Jr A, O Russell Jr R, Ryan TJ, Smith Jr. SC (1999) A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Coronary Angiography) developed in collaboration with the Society for Cardiac Angiography and Interventions. *ACC/AHA guidelines for coronary angiography* 99:2345–2357.
4. Anderson RD and Pepine CJ (2013) Coronary Angiography, Is it Time to Reassess? *Circulation* 127(17):1760-1762.
5. Groves EM, Seto AH, Kern MJ (2014) Invasive testing for coronary artery disease: FFR, IVUS, OCT, NIRS. *Cardiol Clin* 32(3):405-417.
6. Campeau L (1989) Percutaneous radial artery approach for coronary angiography. *Cathet Cardiovasc Diagn* 16(1):3-7.
7. McCormack HM, Horne DJ, Sheather S. Clinical applications of visual analogue scales: a critical review. *Psychol Med.* 1988 Nov;18(4):1007-19. doi:10.1017/s0033291700009934. PMID: 3078045.
8. Becher T, Behnes M, Ünsal M, Baumann S, El-Battrawy I, Fastner C, Kuschyk J, Papavassiliu T, Hoffmann U, Mashayekhi K, Borggrete M, Akin I (2016) Radiation exposure and contrast agent use related to radial versus femoral arterial access during percutaneous coronary intervention (PCI)-Results of the FERARI study. *Cardiovasc Revasc Med* 17(8):505-509.
9. Iwachow P, Miechowicz I, Kałmucki P, Dziki B, Szyszka A, Baszko A, Siminiak T (2017) Evaluation of radiological risk during coronary angioplasty procedures: comparison of transradial and transfemoral approaches, *Int J Cardiovasc Imaging* 33(9):1297-1303.
10. Plourde G, Pancholy SB, Nolan J, Jolly S, Rao SV, Amhed I, Bangalore S, Patel T, Dahm JB, Bertrand OF (2015) Radiation exposure in relation to the arterial access site used for diagnostic coronary angiography and percutaneous coronary intervention: a systematic review and meta-analysis. *Lancet* 386(10009):2129–2203.
11. Georges JL, Belle L, Meunier L, Dechery T, Khalifé K, Pecheux M, Elhaddad S, Amabile N, Pansieri M, Ballout J, Marchand X, Rouault G, Leddet P, Nogue O, Lucke N, Cattan S, RAY'ACT Investigators (2017) Radial versus femoral access for coronary angiography and intervention is associated with lower patient radiation exposure in high-radial-volume centres: Insights from the RAY'ACT-1 study. *Arch Cardiovasc Dis* 110(3):179-187.
12. Cooper CJ, El-Shiekh RA, Cohen DJ, Blaessing L, Burket MW, Basu A, Moore JA (1999) Effect of transradial access on quality of life and cost of cardiac catheterization: A randomized comparison. *Am Heart J* 138(3):430-436.

13. Safely MD, Amin PA, House AJ, Baklanov D, Mills R, Giersiefen H, Bremer A, Marso PS (2013) Comparison of costs between transradial and transfemoral percutaneous coronary intervention: a cohort analysis from the Premier research database. *Am Heart J* 165(3):303-309.
14. Amit PA, House AJ, Safley MD, Chhatrwalla KA, Giersiefen H, Bremer A, Hamon M, Baklanov VD, Aluko A, Wohns D, Mathias WD, Applegate AR, Cohen JD, Marso PS (2013) Costs of Transradial Percutaneous Coronary Intervention; *JACC: Cardiovascular Intervention* 6 (8): 827-834
15. Rutka KJ, Bryniarski K, Tokarek T, Dębski G, Krawczyk A, Żabówka A, Siudak Z, Dudek D (2016) Comparative Study, Comparison of patient comfort after coronary angiography by standard arterial access approaches. *Kardiologia Polska* 74(1):68-74.