

How Access Site affects the Radiation Dose and the Amount of Contrast Agent Used during Diagnostic Coronary Angiography - A Single Center Study

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Abstract

Background: To evaluate the differences in radiation dose and contrast volume between the femoral approach (FA) and the left (LRA) and right (RRA) radial accesses separately during coronary angiography (CA).

Background: CA is crucial in the diagnosis of coronary artery disease (CAD). Two access sites are usually used for angiography - femoral and radial.

Methods: We retrospectively analyzed 8978 patients who underwent coronary angiography in our hospital between January 1, 2014 and December 31, 2016. Patients with prior coronary artery bypass grafting were excluded from the analysis.

Results: A total of 7302 patients were included in the statistical analysis. The smallest amount of contrast agent was used in cases of RRA (103.3 ml; SD 42.5); larger in cases of LRA (112.6 ml; SD 54.6) and FA (119.2 ml; SD 55.8). The differences were statistically significant between each of the groups ($p < 0.001$). The lowest radiation dose was used in cases of RRA (365.1 mGy; SD 262.4); larger in cases of LRA (390.1 mGy; SD 282.9) and FA (382.6 mGy; SD 317.5). The differences between LRA and FA ($P = 0.007$) as well as RRA and LRA ($P = 0.001$) were responsible for the statistical validity ($p = 0.001$). No statistically significant difference in radiation dose was seen between RRA and FA. A comparative analysis was also applied to femoral access versus both radial access groups together. Statistically significant differences in the amount of contrast agent used was observed ($p < 0.05$), but no for radiation dose ($p = 0.45$).

Conclusion: RRA was associated with a significantly reduced amount of contrast agent and radiation dose. Our results indicate RRA and LRA access groups should not be considered interchangeable. RAA is responsible for the advantage of both radial accesses, in relation to the classic femoral access.

Keywords: Coronary angiography; Contrast; Access site; Radiation

Introduction

Left heart catheterization is performed for both diagnostic and treatment purposes. Despite the procedure being minimally invasive, there still exists the possibility of complications [1]. An advantage of the common femoral access technique (FA) is that it enables a more rapid access to the target site. Moreover, the diameter of the vessel, as well as the shape and profile of the catheters primarily designed for FA procedures enable their easy placement. The radial access technique (RA) requires more time for many operators to become proficient [2]. The most common problem associated with the RA technique is radial artery spasm [3]. Despite the use of various preventative methods, it is sometimes necessary to abort the procedure and switch to contralateral RA or FA, which lengthens the procedure and may also increase the overall amount of contrast agent and radiation dose used. The profile and shape of catheters primarily designed for FA facilitate an easier procedure and would consequently decrease the amount of contrast agent and radiation dose.

A considerable reduction in RA-related hemorrhagic complications has been demonstrated with the increased procedure duration, radiation dose and amount of contrast agent used [4]. Its advantage is that it has a reduced risk of major hemorrhagic complications when compared to the FA procedure [5]. The choice of access type can have a major influence on the length of hospitalization, treatment costs, and mortality [4,6,7]. Post-procedural patient comfort is also not without significance. On the other hand, RA procedures often fail, requiring conversion to FA. Despite the many advantages, a number of questions remain. It is unclear if the longer RA procedure time, and the more frequent difficulties with the passage of catheters, may be associated with increased radiation dose and amount of contrast agent used.

Our study aimed to investigate the differences between various types of vascular access such as femoral, right radial, and left radial during diagnostic coronary catheterization.

Materials and Methods

Study population

Our retrospective analysis included successive patients who had undergone diagnostic coronary catheterization and/or post-CABG angiography using one of the three types of vascular access femoral access (FA), right radial access (RRA), and left radial access (LRA) between Jan. 1, 2016 and Dec. 31, 2016. Before the study started, the project was submitted for approval to the Ethical Committee and received a positive opinion. Due to the retrospective nature of the study, no informed consent was obtained from patients.

Eligibility for undergoing a diagnostic procedure was determined by the presence of coronary or valvular disease. Patients with valvular disease were evaluated for surgery and were evaluated for surgery according to current European Society of Cardiology (ESC) recommendations [8,9].

Procedure technical aspects

The most common valvular disease subjected to coronary diagnostics was aortic stenosis. Most procedures (approximately 80%) used 6F vascular catheters; the remaining procedures used 5F, with no significant differences between access type. The choice of vascular access type depended mostly on the operator's preferences. The calculated radiation dose (in mGy) used during the procedure was taken from the angiography lamp indications. The volume of contrast agent used was measured in milliliters and was obtained from the procedure records. Patients' age was obtained from each patient's individual identification number (PESEL) and body mass was obtained from anthropometric data found in the documentation.

Statistical Analysis

Because the variable distribution differed from the normal distribution, non-parametric ANOVA Rang Kruskal-Wallis tests were used for the statistical analysis. The same tests were used in post-hoc examinations to confirm which group was responsible for the differences. Patient's mass, age, amount of contrast and radiation dose used, and the non-normal distribution were expressed as mean values, with $p < 0.05$ being deemed statistically significant.

Results

Patient population

The study group consisted of 8978 patients; however, because of incomplete data or simultaneous post-CABG angiography, 7302 patients were included in the statistical analysis. The majority (69.5%) were patients who had undergone invasive coronary diagnostics in the course of stable coronary artery disease (SCAD). Other indications included acute coronary syndromes (ACS) and the presence of valvular disease before planned surgical procedures (Table 1). The mean age of patients was 66.4 years (SD 10.9); the mean body mass, regardless of sex, was 79.4 kg (SD 15.3). During the diagnostic procedure, the mean volume of contrast agent used was 112 ml (SD 51.7); the mean radiation dose was 377.2 mGy (SD 292.6). A detailed analysis was made on each vascular access site. A total of 3007 patients (41.2%) had either left or right femoral access. The RRA group included 2591 patients (35.5%), and the LRA group included 1704 patients (23.4%). A significantly higher percentage of smokers ($p = 0.001$) was observed in

the FA group. It was also observed that this same group had a significantly higher percentage of patients with a prior history of cerebral stroke ($p < 0.001$) and prior coronary angioplasty ($p = 0.013$). Previous myocardial infarction was also more frequent in this group; however, this did not reach a level of statistical significance ($p = 0.338$) (Table 2).

Variables	LRA	RRA	FA	All
Stable coronary artery disease	1164 (68.1%)	1792 (69.2%)	2117 (70.4%)	5073 (69.5%)
Unstable coronary artery disease	158 (9.3%)	322 (12.4%)	314 (10.4%)	794 (10.9%)
Valvular defects	257 (15.1%)	232 (9.0%)	252 (8.38%)	741 (10.2%)
STEMI	9 (0.5%)	32 (1.2%)	61 (2.0%)	102 (1.4%)
NSTEMI	97 (5.7%)	180 (7.0%)	202 (6.7%)	479 (6.6%)
Other	17 (1.0%)	31 (1.2%)	49 (1.6%)	97 (1.3%)
Cardiac arrest	2 (0.1%)	2 (0.1%)	12 (0.4%)	16 (0.2%)
All	1704 (23.4%)	2591 (35.5%)	3007 (41.2%)	7302 (100.0%)

Table 1: Distribution of coronary diagnostic indications.

LRA was chosen more often in the case of valvular disease diagnostics; FA was chosen more often in the case of STEMI; while RRA was chosen more often in the case of unstable angina (Table 2). The mean body mass of patients who underwent FA was 77.9 kg (SD 14.7); for LRA patients, the mean body mass was 80.5 kg (SD 15.7); and for RRA patients, the mean body mass was 80.4 kg (SD 15.7). Statistical analysis showed a significant difference between the groups in terms of average body weight ($p < 0.001$) (Figure 1).

Variables	LRA	RRA	FA	p value
Hypertension	1167 (68.5%)	1803 (69.6%)	2080 (69.2%)	$p = NS$
Diabetes	343 (20.1%)	438 (16.9%)	540 (18.0%)	$p < 0.05$
Renal failure	63 (3.7%)	82 (3.2%)	124 (4.1%)	$p = NS$
Smoking	222 (13.0%)	313 (12.1%)	461 (15.3%)	$p < 0.05$
Prior PCI	211 (12.4%)	365 (14.1%)	466 (15.5%)	$p < 0.05$
Prior cerebral stroke	32 (1.9%)	33 (1.27%)	242 (8.1%)	$p < 0.05$
Prior myocardial infarction	162 (9.5%)	260 (10.0%)	325 (10.8%)	$p = NS$
COPD	17 (1.5%)	26 (1.5%)	26 (1.4%)	$p = NS$

Table 2: Distribution of risk factors in various vascular access groups.

Post-hoc tests confirmed a significant difference between the RRA and FA groups ($p < 0.001$) as well as between FA and LRA groups ($p < 0.001$); there was no significant difference between the RA groups

($p=1.00$). The mean age in the FA group was 66.8 years (SD 11.2), whereas it was 65.9 years in the RRA group (SD 10.7) and 66.2 years in the LRA group (SD 10.6) (Figure 2). These slight differences were statistically significant ($p=0.002$).

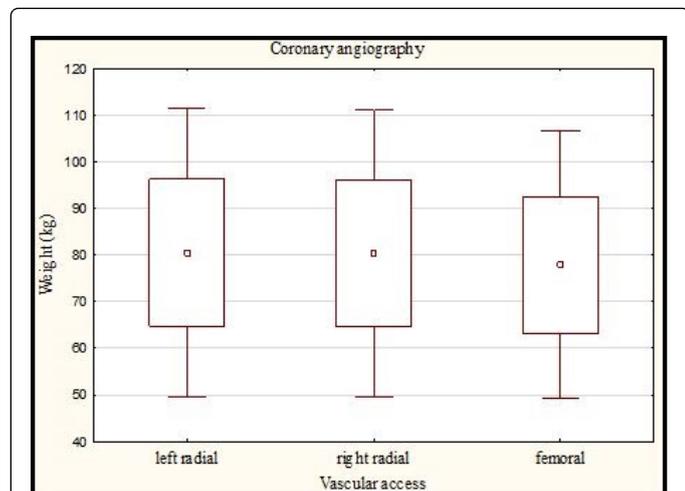


Figure 1: Mean body mass in patients from various radial access groups ($p<0.001$).

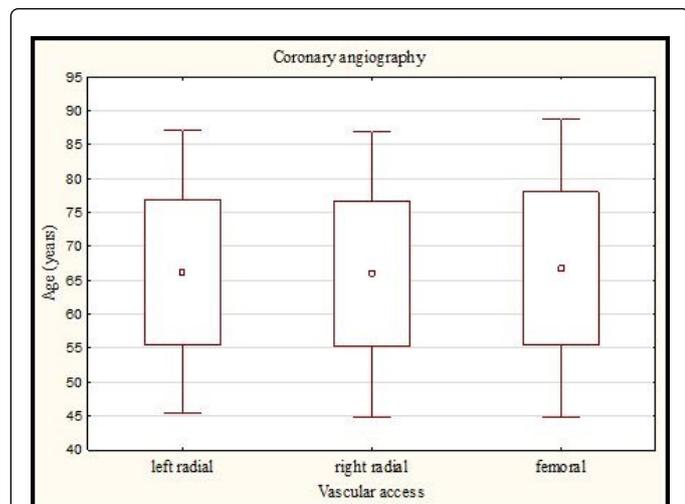


Figure 2: Mean age of patients from various radial access groups ($p=0.002$).

The smallest amount of contrast agent was used in cases of RRA (103.3 ml; SD 42.5); while larger amounts were used in cases of LRA (112.6 ml; SD 54.6) and FA (119.2 ml; SD 55.8). The differences between each of the groups were statistically significant ($p<0.001$, Figure 3). The lowest radiation dose was used in cases of RRA (365.1 mGy; SD 262.4); larger radiation doses were used in cases of LRA (390.1 mGy; SD 282.9) and FA (382.6 mGy; SD 317.5). The differences between LRA and FA ($p=0.007$), as well as RRA and LRA ($P=0.001$), were responsible for the statistical validity ($p=0.001$). No statistically significant difference was noted between RRA and FA groups in terms of the radiation dose used (Figure 4).

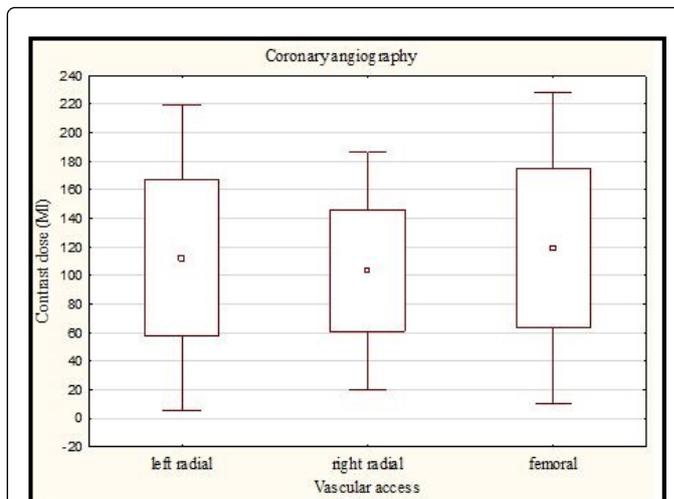


Figure 3: Mean volume of contrast agent used in patients from various radial access groups ($p<0.001$).

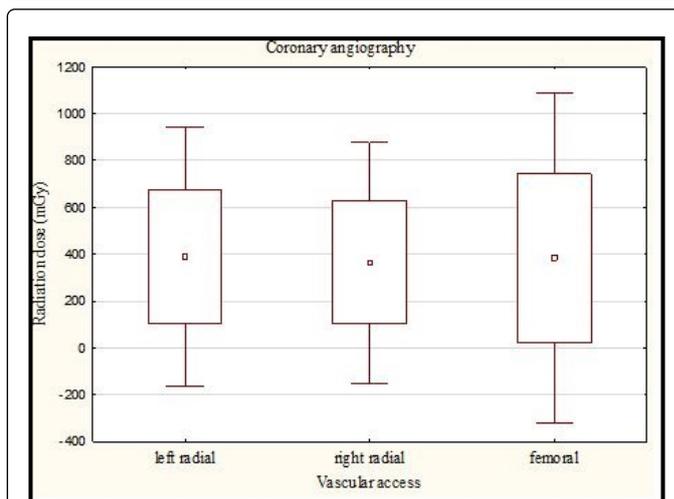


Figure 4: Mean radiation dose used in patients from various radial access groups ($p=0.001$).

The femoral access vs both radial access groups was also comparatively analyzed. In the case of age, body mass, and volume of contrast agent used, statistically significant differences were observed ($p<0.05$). The mean patient age was higher in the FA group. The mean body mass was higher in both RA groups; however, the mean volume of contrast agent and radiation doses were lower in the RA group. No statistically significant difference was observed in the radiation dose ($p=0.45$).

Discussion

Several previous studies have demonstrated that radial access is associated with a higher radiation dose [10]. In the radial vs. femoral access for coronary intervention (RIVAL) trial, radial access was associated with an increased radiation dose and fluoroscopy time. However, these studies involved institutions with a smaller number of procedures and operators [4,7]. Subsequent trials have not shown any

difference in the duration of fluoroscopy; however, smaller volumes of contrast agent were used in cases of radial access [7]. Furthermore, a study which analyzed intracoronary angioplasty, in addition to angiography, demonstrated that radial access is associated with a higher radiation dose [6,10]. A randomized study, including 1540 patients, comparing left and right radial access, showed shorter fluoroscopy duration in cases of left radial access [11]. Similar results were obtained in another single-center study involving a smaller group (1032 patients) [12].

The amount of contrast agent and radiation dose

Our study is a single-center, large patient group, all-comers analysis, covering a period of time that utilized a wider implementation of radial access (43.4% FA). Differences in radiation dose and amount of contrast agent have been shown in cases of diagnostic coronary catheterization procedures between the types of radial access. The lowest radiation doses were used in cases of right radial access, while the highest doses were used in cases of left radial access. Statistically significant differences were observed between femoral and left radial access as well as between right and left radial access. Differences in radiation dose were not confirmed between the femoral and right radial access sites. Only left radial access was associated with a significantly larger radiation dose.

The mean amount of contrast agent used was significantly lower in cases of RRA and highest in cases of FA. In the analyzed group, right radial access was associated with a significantly reduced amount of contrast agent and radiation dose. It should be noted that in the group of FA patients there were significantly more risk factors such as hypertension, smoking, prior cerebral stroke, and/or intracoronary interventions which may have created a more complex and advanced morphology of coronary lesions. These factors may have influenced the amount of radiation and contrast agent used in this group due to the necessity of rendering additional images. The comparison of femoral access with both radial access groups did not show a statistically significant difference in radiation dose. Our results indicate that right and left radial access groups should not be considered as a single group in terms of radiation dose and volume of contrast agent used.

Age and body weight

There have been reports of more frequent hemorrhagic complications in patients undergoing FA (3.71%) and RA (0.58%) [6]. This could be related to different methods of obtaining hemostasis, as well as a patient's age, sex, and body weight [13]. In the analyzed group, it was confirmed that patients who underwent FA were slightly older than those in the RA groups. The increased probability of lower extremity arteriosclerosis occurring in this group makes RA a better choice. On the other hand, older patients often have more arterial tortuosities, especially of the subclavian arteries. In this case, RA might actually complicate the procedure, extend its duration, and increase the radiation dose and volume of contrast agent used, which could lead to contrast-induced nephropathy [3,14,15]. The above factors most likely influenced the final choice of access type. A higher patient body mass meant that right ($p<0.001$) and left radial access ($p<0.001$) were used more frequently than femoral access. The choice of RA in this patient group, despite the increasing availability of vessel closing instruments, is related to a significantly easier way of obtaining hemostasis.

Limitations

Our study has several limitations. First, it is a retrospective and one-center study, involving operators/clinicians at various stages of their medical training. Some of the procedures initiated as radial access were, for various reasons, converted to femoral access (5.82%) or contralateral radial access (4.82%). The statistical analysis included a group of 8504 procedures and results are similar to previously published data (4.0-5.8%) [16,17]. Some of the patients (10.1%) underwent invasive coronary diagnostics for valvular disease, with the most common being aortic stenosis. Occasionally, an additional aortography was performed (the exact percentage is unknown) which may have affected the final radiation dose and volume of contrast agent used.

Conclusion

Our analysis involved a patient group which underwent diagnostic coronary catheterization in a large, single-center study. Right radial access was associated with the smallest mean dose of radiation and volume of contrast agent used. This advantage over femoral access disappeared when the left and right radial accesses were analyzed as one group. This may indicate that it is only the right radial access that is responsible for the advantage of radial accesses described so far, in relations to the classic femoral access. The key factor which predisposed an operator to choose radial access was the patient's body mass, not age. Our study indicates that for patients with higher body weight, right radial access should be the first choice for reducing radiation dose. The advantages of right radial access over other locations require further research and randomized studies, especially in patients undergoing PCI and diagnostic bypassography.

Data Availability

All the data used in the analysis is presented within the manuscript.

Conflict of Interests

The authors declare no conflicts of interest.

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