Original Article

The Effects of Local Heating on Facilitating Radial Angiography: A Randomized Controlled Trial

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Abstract

Background: Angiography through the radial artery is a novel selective approach with several advantages. Shortening the duration of each stage of the procedure leads to many benefits for patients and health personnel. This study aimed to investigate the effect of local forearm heating on facilitating radial angiography. **Materials and Methods:** This randomized clinical trial included one intervention and one control group with a post-test design. The study was conducted on 80 radial angiography candidates visiting the angiography ward, at Razi Hospital, Birjand, Iran, in 2018. The subjects were selected through convenient sampling and allocated to control and intervention groups using simple random allocation. The data were collected using a demographic form and radial angiography checklist. The intervention consisted of using an infrared emitter fixed 60 cm from the patient's forearm. Infrared radiation was applied for 10 min for each patient to warm the radial artery. Afterward, the radial angiography procedure was carried out. The collected data were analyzed using descriptive and inferential statistics in the Statistical Package for Social Science (SPSS) software (v. 16) ($p < 0.05$). **Results:** The frequency and duration of artery puncture, the necessity of injecting a radiocontrast agent, the necessity of catheter replacement, the duration of fluoroscopy, and the volume of the radiocontrast agent in the experimental group were significantly lower than those in the control group ($p < 0.05$). **Conclusions:** Local heat in radial angiography is recommended for facilitating the procedure and improving patient welfare and peace.

Keywords: *Angiography, catheterization, heating, radial artery*

Introduction

Coronary angiography is widely regarded as the most effective diagnostic method for identifying obstructive coronary artery disease.[1] Every year, over a million coronary angiograms are performed in the USA.[2] This procedure can be implemented by accessing the femoral, brachial, radial, ulnar, or axillary arteries through the skin.[3] Femoral access is the traditional angiography approach. There is evidence that radial artery access can be as efficient and practical as the femoral method.[4-6] The trans-radial method, compared to the trans-femoral method, has advantages such as less bleeding, a lower rate of mortality, fewer side effects of accessing the site, and lower costs.[4-7] The radial and ulnar arteries are both accessible through the hand so that they can be brought next to each other to build deep and surface arcs. Despite the femoral or brachial arteries, the radial artery is not the sole supplier of blood, so if the ulnar artery can supply adequate flow, radial artery blockage does not completely interrupt perfusion. In addition, the terminal surface path of the radial artery facilitates compression of the artery, meaning that after removing the angiography sheath, the patient can move in the very short term.[8,9] It is imperative to use trans-radial angiography as the primary option for coronary catheterization in all patients, as recommended by the American Heart Association (2018).[10]

One of the greatest drawbacks of both common angiography methods (femoral and radial) is the long procedure and fluoroscopy time, which increases the volume of radiation received by the health team and patient.[11] Therefore, shortening each of the stages of the procedure, including artery puncture, cannulation, and catheter placement in the coronary artery, can shorten the angiography procedure time and the amount of radiation. One of the reasons for a prolonged procedure

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time is the lack of skill of the specialist as well as the side effects during angiography.[12] The side effects are blockage, radial artery spasm, arterial fistula, bleeding, and complex regional pain.[13] These side effects can be very painful and frustrating for the patient and consequently disrupt the access of an inexperienced specialist. Different methods have been proposed to attenuate the side effects of radial angiography. For instance, to attenuate the side effects of radial angiography-induced blockage, anticoagulation, proper sheath selection, and proper post-procedure hemostasis are recommended. To control spasms and pain, spasmolytic agents, proper equipment (thinner catheter, for instance), and painkillers are some of the recommended treatments. These methods do not necessarily lead to desirable results, and the recurrence of side effects is expected.[14] It is notable that pharmaceutical methods are not free of side effects and might add to the complicacy of the patient's situation.[15] Therefore, novel drug and non-drug methods should be introduced. Heating the forearm is one of these new approaches. Over the years, nurses have been utilizing heat to establish venipuncture and venous cannulation. Different heating methods, such as immersion of the hand or arm in warm water, covering the arm with a hot towel and chemical heating sources, have been used by nurses and other healthcare providers.[16] Studies have shown that a warm environment causes vasodilation and decreases vascular resistance.[17] In addition, heat is believed to decrease muscular spasms by decreasing the irritability of the muscle spindle and extension. Several studies have been conducted on the effects of heating on peripheral veins,[18,19] while there have been few studies on artery heating. In this regard, Ünal *et al*. (2017)[20] maintained that manual heating of the radial artery with the Balbay maneuver (a technique that involves heating the radial artery site for three minutes with the palm) facilitates radial artery puncture in patients undergoing cardiac catheterization. Additionally, a study by Al-Hakim *et al*. (2019)[21] revealed that the application of an air-activated heat pack to the palm led to a significant increase in the radial artery cross-sectional area. Clearly, the ease of performing angiography lowers the volume of radiocontrast agents and, consequently, the side effects, such as injection site reactions, nausea, allergic reactions, and renal damage.[22]

To the best of our knowledge, there has been no study specifically on local heating with an infrared (IR) emitter and its effects on the radial artery to control the side effects of radial angiography and facilitate the process. It should be noted that the heating technique of the current study differs from prior techniques introduced in previous studies. Considering the paucity of studies on radial angiography and the importance of facilitating radial angiography to improve patient welfare and attenuate side effects, the present study attempted to examine the effects of local forearm heating on facilitating radial angiography.

Materials and Methods

A randomized clinical trial (code: IRCT20200606047665N1) with a post-test design was conducted with the participation of 80 candidates who underwent radial angiography at the angiography ward of Razi Hospital, Birjand, Iran, in 2018. The sample size was determined according to a similar previous study,[20] with a confidence level of 99%, a test power of 80%, and an attrition rate of 5%. In total, 40 participants were selected for each group. The participants were selected through convenient sampling and randomly allocated to the control and experimental groups [Figure 1]. The simple randomization technique was employed by assigning even numbers to the control group and odd numbers to the experimental group using a random number table. Furthermore, allocation concealment was performed using sequentially numbered, opaque, and sealed envelopes (SNOSE), which were kept by the head nurse of the angiography ward. The inclusion criteria included patients who had a history of coronary artery disease or suspected coronary artery disease, provided informed consent to participate, were aged 25–65 years, had a body mass index (BMI) of 20–30 kg/m^2,[23,24] had no history of past radial angiography, had a negative modified Allen test, and had a stable hemodynamic status. Individuals who were candidates for angioplasty or coronary artery bypass graft surgery were excluded.

After admittance to the angiography ward, receiving a brief introduction to the procedure, and signing an informed letter of consent, patients were positioned on the angiography bed. Then, a circulatory nurse prepared the patient, disinfected his/her forearm, and performed a modified Allen test. In the next step, an IR emitter (Osram Co., 1000–40000 Å) was positioned 60 cm from the forearm of the patient. The distance was measured using a fabric measurement instrument. The IR emitter was turned on for 10 min. After that, local anesthesia was ensured by injecting 2% lidocaine under sterile conditions. Then, the timer of the angiography device was turned on, and an artery puncture was performed using an artery sheath needle (Merit 6F^2) with a length of 7 cm. After the artery puncture, the timer was turned off, and the duration of the artery puncture and the number of attempts were recorded by the nurse (first author). In addition, heparin (70 U/kg) was injected intravenously, and nitroglycerine (100 mg) was injected into the radial artery. Angiography was performed using a 5F tiger radial catheter (Merit Co), a 6F artery sheath (Merit Co), a length of 7 cm, and a 0.035 cm guide wire. The volume of the radiocontrast agent was measured in cc. Again, the timer was turned on from the entrance of the catheter into the sheath until the catheter was removed from the sheath at the end of the angiography. The duration of fluoroscopy was also recorded by the device. The necessity of radial artery injection was recorded in the checklist. The radial sheath was removed by an expert physician (second author), and a closer band was used

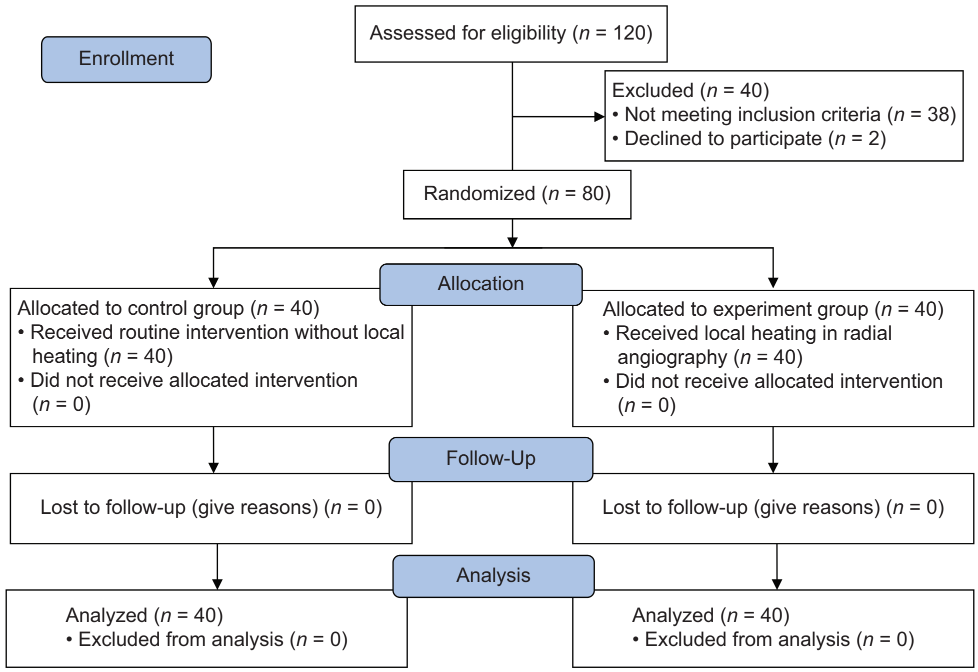

Figure 1: Consort of the study

to compress the puncture site. Notably, the control group underwent the same procedure except for the IR heating.

The demographic data, including age, sex, BMI, and risk factors for atherosclerotic disease, including smoking status, diabetes status, family history of atherosclerotic disease, high blood lipid levels, hypertension status, and heart failure status, were collected using a demographic form. The height and weight of the patients were measured by the researcher based on the standard procedure of the ward to obtain the BMI. During angiography, information such as the number and duration of artery punctures, fluoroscopy term, volume of radiocontrast agent (cc), angiography term, necessity of injection to the radial artery (yes/no), necessity of catheter replacement (yes/no), and transformation of the procedure from the radial artery to the ulnar, brachial, opposite hand, or femoral artery (yes/no) was recorded using a researcher-made checklist. Six experts, including a supervisor, a specialist counselor, and four cardiologists, approved the checklist.

The data were analyzed using SPSS software version 16 (SPSS, Inc., Chicago, IL, USA) at a significance level of 0.05. The distribution of the data was examined using the Kolmogorov–Smirnov test. Afterward, the data were analyzed using descriptive statistics (frequency, mean, and standard deviation [SD]) and inferential statistics such as the Chi-square test, Fisher's exact test, *t* test, or the nonparametric equivalent (Mann–Whitney test).

Ethical consideration

This study was approved by the Ethics Committee of Birjand University of Medical Sciences (BUMS), Birjand, Iran (code: IR.bums.REC.1397.229), and was registered in the Iranian Registry of Clinical Trials. The objectives of the study were explained to all potential candidates. The candidates who met the inclusion criteria were asked to sign and provide written consent. Participants were reminded of the confidentiality of the collected data and the participants' right to leave the study at any stage. The research team assured the patients who that compensation would be provided if they were harmed during the study and that no additional costs would be imposed on them.

Results

Among the 80 patients, 40 (50%) were in the experimental group, and 40 (50%) were in the control group. The mean ages (SD) of the patients in the experimental and control groups were 54.05 (10.05) and 57.12 (12.52), respectively. The results of the independent *t* test showed that there was no significant difference between the two groups in terms of age ($t_{78} = 1.21$, $p = 0.23$). The mean BMIs in the experimental and control groups were 25.42 (2.80) and 25.77 (2.77), respectively. According to the independent *t* test, there was no significant difference between the two groups in terms of BMI ($t_{78} = 2.16$, $P = 0.07$). The remaining demographic data are listed in Table 1; clearly, there was no significant difference between the two groups in terms of demographic information ($p > 0.05$).

The results of the Kolmogorov–Smirnov test showed that the *p* values for BMI and age were greater than 0.05, which means that the variables were normally distributed. However, other variables were not normally distributed ($p > 0.05$).

As shown in Table 2, the number of artery puncture attempts in the experimental group was significantly lower than that in the control group ($x^2 = 10.31$, $p = 0.001$).

Table 1: Frequency distribution of demographical variables in the experiment and control groups

Variable		Experiment group *n* (%)	Control group *n* (%)	Statistical value	df	*p*
Gender	Male	20 (50)	16 (40)	0.81		0.37
	Female	20 (50)	24 (60)			
Age (year)	≤50	17 (42.50)	12 (30)	1.56	2	0.45
	51–60	13 (32.50)	14 (35)			
	<60	10 (25)	14 (35)			
History of angioplasty	Positive	3 (7.50)	0 (0)			0.24*
	Negative	37 (92.50)	40 (100)			
History of smoking	Positive	0 (0)	3 (7.50)	3.11		0.08
	Negative	(100) 40	37 (92.50)			
History of diabetes	Positive	10 (25)	16 (40)	2.05		0.15
	Negative	30 (75)	24 (60)			
History in family	Positive	7 (17.50)	10 (25)	0.67		0.41
	Negative	33 (82.50)	30 (75)			
High blood lipids	Positive	2 (12.50)	7 (17.50)	0.83		0.36
	Negative	35 (87.50)	33 (82.50)			
Hypertension	Positive	19 (14.50)	24 (60)	1.26		0.26
	Negative	21 (52.50)	16 (40)			
Heart failure	Positive	0 (0)	2 (5)	2.05		0.15
	Negative	40 (100)	38 (95)			
Chronic renal diseases	Positive	0 (0)	1 (2.50)			1.00*
	Negative	40 (100)	39 (97.50)			

*Fisher's exact test

As listed in Table 3, the necessity of catheter replacement in the control group was significantly greater than that in the experimental group ($x^2 = 4.05$, $p = 0.04$). In addition, the need for the injection of radiocontrast into the radial artery was significantly greater in the control group than in the experimental group ($x^2 = 4.50$, $p = 0.03$).

The Mann–Whitney U test showed that the mean number of artery punctures and fluoroscopy procedures performed in the experimental group were significantly lower than those performed in the control group ($p < 0.05$). However, the mean duration of angiography did not significantly differ between the two groups ($z = 1.51$, $p = 0.13$). In addition, the mean number of artery puncture attempts and injections of the radiocontrast agent in the experimental group were significantly lower than those in the control group ($p < 0.05$) [Table 4].

The results also showed that there was no catheterization transfer from the radial artery to other arteries in the two groups.

Discussion

This study investigated the effect of local heating on facilitating radial angiography.

There was a significant difference between the two groups in terms of the number of artery puncture attempts and term. Therefore, the number of attempts and number of artery punctures were lower in the experimental group than in the control group. To explain these findings, the results of other studies are notable. In a previous study (2017), researchers aimed to assess the effectiveness of radial artery manual heating (Balbay maneuver) in facilitating artery puncture during angiography. The results revealed a significant decrease in the number of failed attempts at artery puncture among patients who had received the intervention.[20] According to the results of a previous study (2018), local warming with a warm heat pack increased the vein cross-sectional area.[18] Another similar study (2016) showed that a digital moist heating pad decreased pain in chemotherapy patients during venipuncture, improved vasodilation, increased vascular protrusion, and decreased the number of venipuncture attempts and the term.[19]

In addition, studies have shown that a warm environment dilates vessels and decreases vessel resistance.[17] Different mechanisms have been introduced for the effects of heating on vessels. For instance, heat decreases muscular spasms by decreasing the irritability of muscle splines and muscle extension. This is more evident in the flat muscles of vessel walls.[25] In addition, heat increases the flow of blood due to dilation of the vessels following stimulation of the beta receptors.[17] For this reason, over the years, nurses have used heat for cases such as venous lines due to vein protrusion and increased ease of vein success.[16] Studies have also shown that local heating helps facilitate venipuncture and the term, which in turn decreases the perceived hardship by patients.[19]

The results also revealed that subjects in the experimental group had significantly fewer cases of catheter replacement

Table 2: Frequency distribution of artery puncture attempts in the experiment and control groups

Attempts Groups	Once *n* (%)	Twice or more *n* (%)
Experiment	35 (87.50)	5 (12.50)
Control	22 (55)	18 (45)

p=0.001, x^2=10.31

Table 3: Relative frequency of necessity to replace catheter and injection of radiocontrast agent to the hand artery in the two groups

Variable	Group	Negative *n* (%)	Positive *n* (%)	Squared chi test
Replace catheter	Experiment	24 (60)	16 (40)	p=0.04
	Control	15 (37.50)	25 (62.50)	x^2=4.05
Injection to the hand artery	Experiment	37 (92.50)	3 (7.50)	p=0.03
	Control	30 (75)	10 (25)	x^2=4.50

Table 4: Mean term of artery puncture, angiography, and fluoroscopy in the two groups

Variable	Group	Mean (SD)	*Z*	*p*
Artery puncture term (min)	Experiment	1.14 (0.39)	2.74	0.006
	Control	1.71 (1.12)		
Angiography term (min)	Experiment	10.08 (3.90)	1.51	0.13
	Control	13.63 (9.52)		
Fluoroscopy term (min)	Experiment	2.03 (1.94)	2.58	0.01
	Control	2.96 (3.16)		
Artery puncture attempts	Experiment	1.13 (0.33)	3.26	0.001
	Control	1.55 (0.71)		
Radiocontrast agent	Experiment	18.08 (5.62)	3.12	0.002
	Control	22.95 (7.69)		

than those in the control group. One reason for catheter replacement is artery spasm.[26,27] Some studies have demonstrated that the application of heat can effectively alleviate arterial spasms.[15,28] In addition, researchers have argued that unsuccessful vascular access results in increased fear and anxiety in patients.[29] Increased fear and anxiety stimulate the sympathetic nervous system and cause vasoconstriction.[30] In the case of vasoconstriction, there might be a need to replace the catheter.[26,27] Local heating significantly increased the successful artery puncture rate in the experimental group on the first attempt. It is clear that these patients experienced less fear and anxiety and enjoyed better outcomes.

The results showed that the need for radiocontrast agent injection into the radial artery during angiography was significantly lower in the experimental group than in the control group. The reason for injecting the agent is to find the path for entering the catheter. Some reasons for injection of the agent at the time of catheter insertion are rejection of the possibility of mistakes in path selection, artery blockage, and observation of the anatomy of the artery.[31] Artery dilation is another advantage of local heating that has been supported by other studies.[20,21] Dilation increases blood flow and intensifies the artery pulse.[32] Therefore, artery puncture is facilitated, and the specialist can correctly select the path. Therefore, the need for radiocontrast agents at the initiation of angiography is decreased. Obviously, with less artery spasm following heating, the catheter can enter easily, and the need for radiocontrast agents decreases.[15,31]

The results also indicated that the mean duration of fluoroscopy and the volume of Visipaques (radiocontrast agent) in the experimental group were significantly lower than those in the control group. However, the duration of angiography did not significantly differ between the two groups. A decrease in the required volume of radiocontrast at the initiation of the artery puncture process and a decrease in the number of artery punctures and attempts lead to shorter fluoroscopy times and fewer radiocontrast agents.

The clinical trial nature of the study and the suitable sample size are some of the advantages of the present study. Nevertheless, the study is not free of limitations. For instance, sampling was limited to one health-therapeutic center. In addition, the sampling method was convenient, and the age range was limited to 25–65 years. Future studies should consider selecting participants from various healthcare centers using random sampling, with no age restrictions. It is also recommended to include a larger sample size to evaluate the effects of local heating on facilitating angiography through alternative arteries. Additionally, future research could explore the impact of local heating on other complications associated with trans-radial angiography, such as blockages, radial artery spasms, bleeding, arterial fistulas, and complex regional pain.

Conclusion

The results showed that local heating increased the ease of radial angiography by decreasing the number of artery punctures and the term, the need for injecting radiocontrast agent and its volume, and the fluoroscopy term. Therefore, local heating with an IR emitter as a safe, low-cost, and easy-to-use option can be considered to facilitate radial angiography and increase the comfort and welfare of patients, physicians, and nurses in angiography wards.

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Conflicts of interest

Nothing to declare.

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