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The Impact of Flow-Mediated Dilation on the Success Rate of Distal Radial Artery Puncture

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Abstract: Flow-mediated dilation (FMD) has shown benefits in cardiovascular interventions, but its impact on distal radial artery punctures needs exploration. This study investigated FMD's efficacy in improving cannulation success and reducing complications. In a controlled trial, 200 patients were randomized into FMD treatment and waiting-observation groups. The FMD group had a higher success rate (94% vs. 84%), fewer attempts (1.4 vs. 2.3), and a lower pulse disappearance rate (4% vs. 12%). FMD's effectiveness was more pronounced in younger patients, males, and those without hypertension and diabetes. FMD pre-treatment enhances radial artery cannulation success, reduces attempts, and minimizes complications. The findings support integrating FMD in clinical settings to improve vascular access outcomes, especially in specific patient demographics.

1. Introduction

Advancements in medical technology have enhanced the success and safety of percutaneous coronary intervention (PCI), making distal radial artery puncture, which offers fewer complications and quicker recovery, increasingly favored over traditional femoral artery puncture[1,2]. However, the smaller diameter and higher failure rate of distal radial artery punctures pose greater demands on medical personnel, especially in patients with smaller or diseased vessels[3-5]. Flow-mediated dilation (FMD) is a non-invasive method to assess endothelial function. Studies suggest that FMD not only assesses cardiovascular disease risk but also enhances the success rate of punctures and cannulation by promoting vasodilation[6,7].

Recent studies have examined the use of FMD in cardiovascular interventions, especially its ability to increase puncture success rates. However, the effectiveness and role of FMD in distal radial artery punctures still need more research[8]Recent studies have examined the use of FMD in cardiovascular interventions, especially its ability to increase puncture success rates. However, the effectiveness and role of FMD in distal radial artery punctures still need more research.

2. Methods

2.1 Study Design

This study assesses how flow-mediated dilation (FMD) improves distal radial artery punctures, following ethical guidelines and including adult patients from Jiangxi Provincial People's Hospital, excluding specific cases.

2.2 Experimental Methods

Patients were randomized into two groups at a 1:1 ratio: the FMD group and the waiting-observation group. The FMD group experienced arterial flow occlusion via a blood pressure cuff for 10 minutes to induce vasodilation and enhance puncture success, while the waiting-observation group had the cuff applied without pressure for comparison.

2.3 Data Collection and Analysis

Data on puncture outcomes and demographics were analyzed using SPSS 22. Variables were presented as means ± SD, medians, or counts. T-tests, Kruskal-Wallis H tests, and $\chi 2$ tests were used, with significance at $p < 0.05$.

3. Results

3.1 Baseline Characteristics Comparison

Both groups were comparable at the start of the experiment in terms of age, gender, hypertension, diabetes, body mass index, and distal radial artery diameter.

3.2 This table offers a statistical analysis of the effects of variables such as FMD pre-treatment, age, gender, hypertension, and diabetes on clinical outcomes including success rates, average punctures, and pulse disappearance rates, detailing coefficients and P-values to evaluate their significance. See Table 1

Table 1: Comparison of Radial Artery Cannulation Efficacy between FMD and Waiting-Observation Groups

Characteristics	FMD Group	Wait-and-see Group	P-value
Number of Patients	100	100	-
Age (years)	55 ± 10	56 ± 11	0.65
Gender (Male/Female)	60/40	58/42	0.78
Hypertension (Yes/No)	40/60	38/62	0.82
Diabetes (Yes/No)	30/70	32/68	0.75
Body Mass Index (average)	25.3 ± 3.2	25.1 ± 3.4	0.83
Distal Radial Artery Diameter (mm)	2.5 ± 0.5	2.5 ± 0.5	0.97

In the meantime, the FMD group showed a significantly higher success rate (94%) compared to the waiting-observation group (84%); the average number of puncture attempts was also lower in the FMD group (1.4 vs. 2.3), as well as a lower pulse disappearance rate (4% *vs*. 12%). See Table 2.

Table 2: Comparative Analysis of Catheterization Outcomes between FMD Treatment and Wait-and-See Approaches

Group	Number of Cases	Success Rate of Catheterization (%)	Average Number of Punctures	Pulse Disappearance Rate (%)
FMD	100	94	1.4	4
Wait-and-see	100	84	2.3	12

3.3 Comparison between FMD and Waiting-Observation Groups across Different Baseline Feature Subgroups

Subgroup analyses were performed based on age, gender, hypertension, and diabetes to assess their impact on success rates, puncture attempts, and pulse disappearance rates. See Table 3.

Table 3: Impact of Age, Gender, and Health Conditions on Catheterization Outcomes: FMD vs. Wait-and-See Approaches

Baseline Characteristics	Group	Success Rate of Catheterization (%)	Average Number of Punctures	Pulse Disappearance Rate (%)
< 65 years old	FMD	96	1.3	3
< 65 years old	Wait-and-see	88	2.5	11
≥ 65 years old	FMD	92	1.5	5
≥ 65 years old	Wait-and-see	82	2.8	13
Male	FMD	95	1.4	4
Male	Wait-and-see	85	2.6	12
Female	FMD	93	1.5	5
Female	Wait-and-see	87	2.4	11
Hypertension	FMD	92	1.6	6
Hypertension	Wait-and-see	83	2.7	14
No Hypertension	FMD	96	1.2	2
No Hypertension	Wait-and-see	89	2.2	9
Diabetes	FMD	91	1.7	7
Diabetes	Wait-and-see	84	2.9	15
No Diabetes	FMD	95	1.3	3
No Diabetes	Wait-and-see	87	2.3	10

The study shows that baseline characteristics like age, gender, and health conditions significantly affect the effectiveness of Flow-Mediated Dilation (FMD) treatment. Patients under 65 and those without hypertension or diabetes had better outcomes post-FMD, indicating age and health status influence treatment response. Additionally, male patients showed improved puncture success compared to females, highlighting gender differences in FMD outcomes.

3.4 Impact of FMD Pre-treatment on Radial Artery Cannulation Success Rate and the Influence of Patient Characteristics on Treatment Efficacy.

The study highlights that FMD pre-treatment significantly enhances the success rate of radial artery cannulation, reduces the number of attempts, and decreases complications. Further analysis revealed that age, gender, hypertension, and diabetes influence the effectiveness of FMD. Younger patients (<65 years) and those without hypertension or diabetes showed higher success rates and

lower pulse disappearance rates after FMD pre-treatment, suggesting better vascular responsiveness. Males showed a more significant improvement in success rates, indicating potential gender differences in response to FMD treatment. See Table 4.

Table 4: Effects of Demographic and Health Variables on Clinical Procedure Outcomes: Statistical Analysis of Success Rates, Number of Punctures, and Pulse Disappearance

Variable	Success Rate Coefficient (β)	Success Rate P-value	Average Number of Punctures Coefficient (β)	Average Number of Punctures P-value	Pulse Disappearance Rate Coefficient (β)	Pulse Disappearance Rate P-value
FMD Pre-treatment	0.10	0.02	-0.70	0.01	-0.08	0.04
Age	0.001	0.31	0.002	0.28	0.0005	0.62
Gender	-0.03	0.09	0.10	0.12	0.02	0.33
Hypertension	-0.02	0.14	0.20	0.07	0.05	0.11
Diabetes	-0.04	0.05	0.30	0.03	0.07	0.02

3.5 Statistical Analysis of the Impact of FMD Pre-treatment on Radial Artery Cannulation Efficacy

To further quantify the effects of Flow-Mediated Dilation (FMD) pre-treatment and other baseline characteristics on the efficacy of radial artery cannulation, we developed a series of statistical models and produced corresponding charts. Charts one to three respectively display the influence of various variables on puncture success rate, average number of puncture attempts, and pulse disappearance rate, as indicated by their β coefficients (See Figure 1, 2, 3).

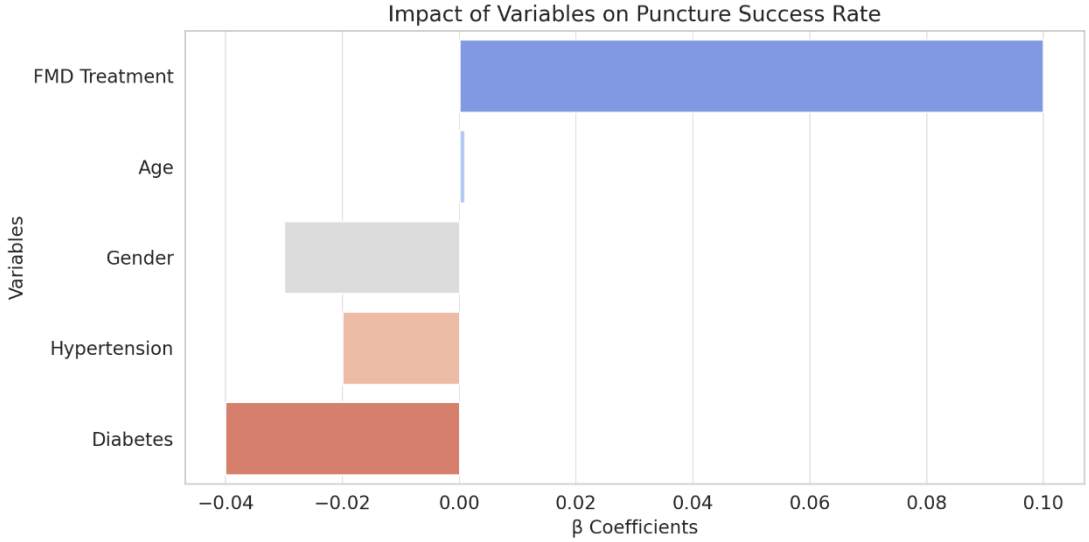

Figure 1: Impact of FMD Pre-treatment on Puncture Success Rate: Multivariable Regression Analysis

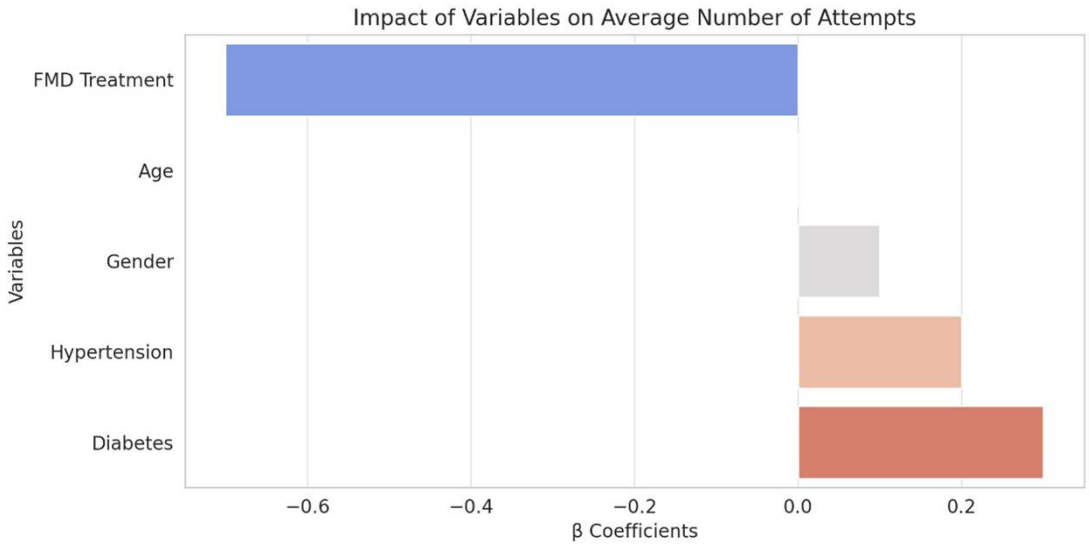

Figure 2: Factors Affecting Average Number of Puncture Attempts: The Role of FMD Pre-treatment

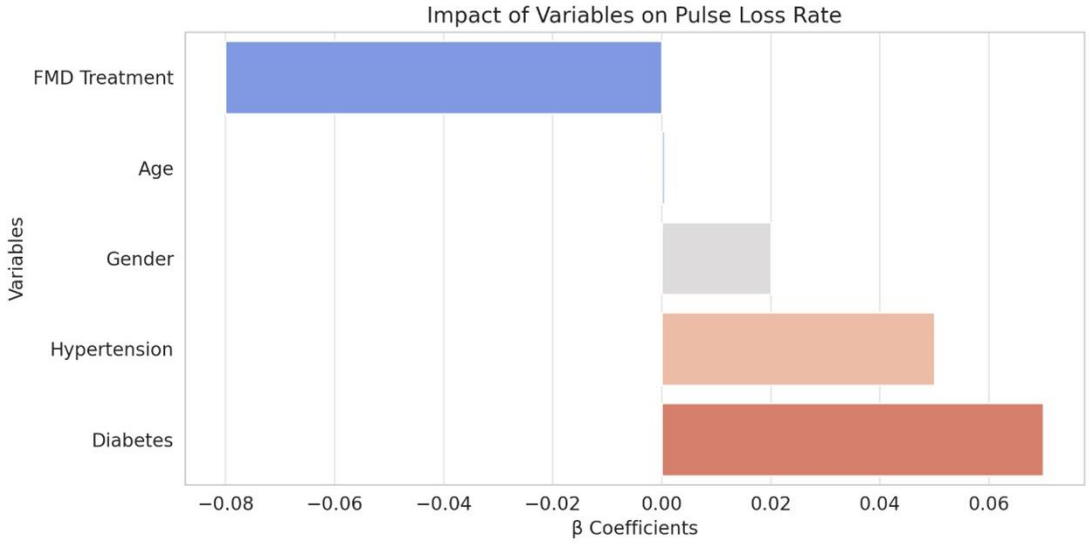

Figure 3: Impact of FMD Pre-treatment on Pulse Disappearance Rate: Multivariable Analysis

Charts illustrate FMD pre-treatment and baseline characteristics' effects on radial artery cannulation. FMD increases puncture success rates, reduces attempt numbers, enhances efficiency, shortens surgery times, alleviates discomfort, and decreases pulse disappearance risk post-puncture, minimizing complications.

4. Discussion

FMD pre-treatment improves distal radial artery puncture success and safety, with varying effects across patient subgroups. Regression analysis, controlling for confounders, confirms FMD's benefits in increasing success rates and reducing attempts and complications. Baseline comparisons verify the study's integrity by ensuring group consistency.

FMD pre-treatment significantly enhances the success and safety of radial artery cannulation compared to a waiting-observation strategy, with a higher success rate in the FMD group (94% vs. 84%), confirming its effectiveness in improving puncture outcomes [9,10]. This improvement is likely due to the vasodilation and increased blood flow facilitated by FMD, which makes the puncture

process easier and more precise[11,12] . FMD significantly lowered the average puncture attempts (1.4 *vs.* 2.3), enhancing efficiency and patient comfort. This is crucial for reducing procedure time, vascular damage, and complications [13].

The rate of pulse disappearance post-puncture was significantly lower in the FMD group compared to the waiting-observation group (4% *vs.* 12%), further supporting the role of FMD in reducing procedural complications [14]. FMD pre-treatment may reduce the risks of vascular spasm and thrombosis by improving vascular function and facilitating blood flow recovery.

Subgroup analysis revealed that age significantly influences the effectiveness of FMD pre-treatment. Younger patients (< 65 years old) in the FMD group exhibited higher success rates and lower rates of pulse disappearance compared to older patients (≥ 65 years old), suggesting that FMD may be more effective in younger populations, possibly due to better vascular elasticity and responsiveness to flow-mediated dilation[15,16]. Although FMD was effective in both male and female patients, the improvement in puncture success rates was more pronounced in males. This finding suggests that gender may affect the response to FMD pre-treatment, although further research is needed to explore the underlying mechanisms[17] , which previous studies have suggested may relate to differences in vascular structure, endothelial function, and hormonal levels[18]. Despite unresolved mechanisms, the states of hypertension and diabetes significantly impact the effectiveness of FMD pre-treatment. Patients without hypertension or diabetes showed more pronounced improvements in both success rates and pulse disappearance rates following FMD treatment. This suggests that patients with better vascular function respond more favorably to FMD, while hypertension and diabetes, which may impair vascular function, could diminish the effectiveness of FMD pre-treatment[19,20].

Multivariable regression, adjusting for confounders, highlighted FMD's independent positive effect on puncture success and negative impact on attempt numbers and pulse disappearance, validating its clinical use [21], FMD shows promise in clinical procedures, particularly for specific patients, providing new insights into improving puncture success and safety.

Some studies, such as Coppola et al., suggest that other pharmacological pre-treatments, like nitroglycerin and sodium nitroprusside, may be as effective as FMD in preventing radial artery spasm.[21] . Additionally, a study by Pancholy et al. compared the effects of two different hemostatic devices on radial artery outcomes post-transradial catheterization, indicating that device selection might be more critical than pre-treatment strategy[22].

FMD pre-treatment improves radial artery can nulation efficacy and safety. Future research should evaluate pre-treatment methods and personalized strategies to optimize outcomes.

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