Journal of Neurointervention and Stroke

Journal of Neurointervention and Stroke 2026;2(1):1-8
doi: 10.63937/jnevis-2026.21.28 | e-ISSN: 3123-6227

Original Article

Manual Compression Variations (Fingers vs. Fingers Assisted by Fist) and Hematoma Incidence Following Cerebral Angiography

Fritz Sumantri Usman[1], Andrianor Rahman[1]✉, Alfi Rizky Medikanto[1], Engki Irawan[1], Agus Budi Bowo Leksono[1], Merlin Prisilia Kastilong[1], Leny Kurnia[1]

[1] Neuro Center, PELNI Hospital, Jakarta, Indonesia

Corresponding Author:
Andrianor Rahman
Neuro Center, PELNI Hospital, Jakarta, Indonesia
Email: andrianrahmann@gmail.com

Received: March 16, 2026
Revised: May 13, 2026
Accepted: May 26, 2026
Published: May 30, 2026

Introduction: Complications at the femoral access site remain a significant clinical challenge following cerebral angiography. The most common complication is an access-site hematoma resulting from inadequate hemostasis after sheath removal. Evaluating different manual compression techniques is essential to optimize bleeding control and improve patient safety. **Objective:** This study compared the effectiveness of standard finger compression (FC) versus the fingers-assisted-by-fist (FAbF) technique on post-procedural hematoma incidence. **Method:** In this single-center randomized controlled trial, 150 adult patients at PELNI Hospital, Jakarta, were allocated into two equal groups: FC (control, n=75) or FAbF (intervention, n=75). Hematoma occurrence was evaluated after sheath removal. Data were analyzed using Chi-square/Fisher's exact tests and multivariate binary logistic regression. **Result:** Puncture-site hematomas occurred in 17 cases overall, with a significantly higher incidence in the FC group than the FAbF group (13 vs. 4 patients; $p = 0.02$; OR = 3.72; 95% CI: 1.15–12.01). Bivariate analysis also showed an association between pre-procedural antiplatelet therapy and an increased risk of hematoma ($p = 0.043$). Multivariate logistic regression confirmed that the compression technique was the sole independent predictor of hematoma formation; patients undergoing conventional FC were significantly more likely to develop a hematoma than those receiving FAbF ($p = 0.014$; aOR = 4.62; 95% CI: 1.36–15.75). **Conclusion:** The FAbF technique is significantly more effective than the conventional FC technique at reducing hematoma incidence following cerebral angiography with femoral access.

Keywords: Cerebral angiography, Femoral access, Hematoma, Manual compression.

Highlights

- The FAbF technique reduced the incidence of puncture-site hematoma.
- FAbF is an independent protective factor against hematoma.

Introduction

Cerebral angiography produces clear and accurate images of blood vessels without the need for surgery. This procedure is performed by inserting a thin catheter into a femoral or radial artery and then injecting a contrast material. Images are captured using X-rays and processed to digitally subtract the bones of the skull so that the blood vessels appear more clearly. This technique is commonly used in the diagnosis and management of cerebrovascular diseases.[1,2]

Although radial access is growing in popularity for cerebral angiography, femoral access remains the most widely used traditional approach. The femoral artery is

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

easy to palpate, and its position is relatively consistent above the head of the femur; thus, the success rate of the initial puncture is exceptionally high, especially for experienced operators. The location of this artery just above the femur also allows for effective manual compression after the procedure. In this prospective study, femoral access was carried out in a standard manner using a closure device followed by manual compression for 5 minutes, after which the patient lay flat for 2 hours. The results showed that the diagnostic goal of the angiograms was achieved in 152 out of 154 patients (99%), confirming the reliability of femoral access as a primary method with a high success rate and good bleeding control, although minor complications such as local pain or closure device failure may still occur.[3,4]

Complications after femoral access procedures should not be underestimated, as their incidence can reach up to 6% of patients. A hematoma is the most common complication, typically appearing within minutes to hours after sheath removal. It is characterized by pain, a local mass, hypotension, or decreased hematocrit, which is later confirmed through noninvasive examinations such as ultrasound or computed tomography scan. Although a hematoma is often considered mild, its clinical impact is significant, as it can progress to more serious conditions such as pseudoaneurysms, arteriovenous fistulas, thrombosis, local nerve compression, and even potentially fatal retroperitoneal hemorrhage. In clinical practice, femoral pseudoaneurysms alone have an incidence of 0.05–2% in diagnostic procedures, which increases to 2–6% in therapeutic interventions, carrying a higher risk when using a closure device compared to manual compression. Small pseudoaneurysms can be monitored with serial imaging, while large or symptomatic ones require interventions such as thrombin injections or open surgery. In line with the findings of vascular studies, a large hematoma (>5 cm) is associated with longer hospitalization and higher morbidity. Therefore, femoral access complications not only impact patient safety but also increase the healthcare cost burden.[5-7]

Access-site hematomas may increase both clinical and economic burdens through prolonged monitoring, additional imaging, blood transfusions, secondary interventions, and extended hospital stays. In a large U.S. cohort of 17,672 patients undergoing large-bore percutaneous procedures, bleeding complications occurred in 17.7% of cases and were associated with higher in-hospital mortality, longer hospitalizations, and higher median total healthcare costs compared to non-bleeding cases ($48,663 vs. $29,968). In a percutaneous coronary intervention (PCI) cost-effectiveness study from Belgium involving 8,292 patients, vascular complications occurred in 2.7% of cases; the use of vascular closure devices (VCDs) was associated with lower vascular complication rates (1.5% vs. 3.0%), a shorter post-PCI length of stay (mean 1.5 vs. 2.8 days), and approximately €498 lower direct medical costs per patient. These data reinforce that femoral access complications, including clinically significant hematomas, negatively affect both patient safety and healthcare resource utilization.[8,9]

Regarding closure strategies, evidence from systematic reviews and meta-analyses suggests that VCDs generally reduce the time to hemostasis and ambulation compared with manual compression, but their effect on major vascular complications remains variable across studies. A meta-analysis of 44 randomized controlled trials including 18,802 patients reported that manual compression was associated with a longer time to hemostasis, a longer time to ambulation, and a higher risk of large hematomas (>5 cm) compared with vascular hemostasis devices. However, no clear differences were found regarding major bleeding, pseudoaneurysms, infection, arteriovenous fistulas, limb ischemia, or the need for surgery. Another systematic review and meta-analysis similarly noted that comparisons between VCDs and manual compression remain controversial, particularly regarding safety outcomes beyond earlier mobilization and hemostasis. Consequently, although VCDs may improve procedural efficiency, manual compression remains clinically relevant, especially in settings where cost, device availability, and operator skill are primary considerations.[10,11]

Therefore, effective hemostasis techniques after femoral sheath removal are crucial. The two primary methods commonly used are manual compression and VCDs. Numerous studies have shown that while VCDs offer advantages such as faster hemostasis, evidence demonstrating that they significantly reduce access-site complications (including hematomas) compared to manual compression remains limited and inconsistent.[12]

In many low- and middle-income countries (LMICs), including several neurointerventional centers in Indonesia, manual compression remains widely used after femoral artery access because of its low cost, simplicity, and the limited availability of VCDs. Although VCDs may shorten the times to hemostasis and ambulation, their routine use can be restricted in resource-limited settings due to device costs, supply limitations, and the need for additional operator training. Consequently, manual compression continues to be an important and practical hemostasis strategy in many healthcare systems worldwide.[13,14]

However, manual compression is highly operator-dependent. Variations in hand positioning, compression force, duration, operator fatigue, and procedural experience may affect hemostatic effectiveness and complication rates, including hematoma formation.

These limitations can become more pronounced in high-volume centers and settings with limited staffing resources. Despite the widespread use of manual compression in LMICs, evidence regarding the comparative effectiveness of specific manual compression techniques remains limited. Therefore, evaluating simple technical modifications, such as the Fingers Assisted by Fist (FAbF) technique, may provide clinically relevant, low-cost strategies to improve vascular access outcomes, particularly in resource-constrained settings.[15,16]

Manual compression techniques are basic skills that heavily dictate the success of hemostasis and patient comfort following femoral access procedures. These skills are generally acquired through hands-on practice in the field using a "see, do, teach" approach, making variations in technique between healthcare workers inevitable. Compression protocols also vary across institutions, which can directly affect complication rates. At PELNI Hospital in Jakarta, manual compression is performed using two distinct techniques: conventional fingers compression and fist-assisted compression.[17]

This operational variance is where the research question arose: which of the two techniques is more effective? The theoretical rationale is that by using the proximal phalanges of the index and middle fingers of the non-dominant hand as the primary compression element, supported by the dominant hand's fist, the operator can apply more stable, focused, and ergonomic pressure. Hypothetically, this can accelerate hemostasis and reduce hematoma incidence. The existence of these knowledge gaps and their clinical implications for reducing vascular access morbidity makes this study highly relevant. The ultimate goal is to provide scientific evidence to standardize operating procedures for manual compression after femoral sheath removal at PELNI Hospital Jakarta. This standardization is expected to reduce hematoma incidence, improve the quality of patient care, and lower treatment costs, demonstrating the high urgency of this study within neurointervention and vascular access management.

Objective

This study aims to compare the effectiveness of conventional finger compression (FC) versus the FAbF technique on hematoma incidence in patients undergoing femoral access cerebral angiography at PELNI Hospital, Jakarta.

Method

This study was a single-center, unblinded, parallel-group randomized controlled trial (RCT) conducted at PELNI Hospital in Jakarta, Indonesia. The trial took place between December 2025 and March 2026, or until the targeted sample size was met.

Patients were consecutively screened and enrolled based on predefined eligibility criteria. The inclusion criteria required participants to be older than 18 years, undergoing cerebral angiography via femoral artery access, and willing to provide written informed consent, obtained either directly from the patient or via an authorized legal proxy if neurological deficits precluded self-signature. Conversely, patients were excluded if the procedure was performed under emergency or acute trauma conditions, or if they experienced a technical failure during the initial femoral artery puncture. Further exclusion criteria included severe pre-existing coagulation disorders, defined as an International Normalized Ratio greater than 3 or a platelet count less than 120,000 per microliter, non-standard arterial puncture sites such as those above the inguinal ligament or below the femoral bifurcation, cases requiring more than two puncture attempts at the same location, and severe uncontrolled hypertension with a systolic blood pressure greater than 200 mmHg and/or a diastolic blood pressure greater than 110 mmHg.

The required sample size was calculated using the difference-of-two-proportions formula for parallel clinical studies.[18] Historical baseline data from PELNI Hospital indicated a 37.4% incidence rate of access-site hematomas following digital subtraction angiography using conventional FC technique, which established our control proportion. Assuming the FAbF technique could achieve an absolute reduction of approximately 20.4 percentage points, lowering the incidence to 17.0%, a minimum sample size of 74 subjects per group was determined necessary to achieve 80% statistical power with a two-tailed significance level of 0.05. To account for potential data loss or dropouts, the cohort size was rounded to 75 subjects per group, yielding a total sample size of 150 participants. Eligible patients were enrolled via consecutive sampling and randomly allocated in a 1-to-1 ratio into either the control group, which received the conventional FC technique, or the intervention group, which received the FAbF technique.

The research framework evaluated several distinct clinical variables. The independent variable was the type of manual compression technique applied for hemostasis, categorized as either conventional FC or the FAbF technique. The primary dependent variable was the occurrence of a puncture-site hematoma, measured dichotomously as a yes or no outcome. To ensure a robust analysis, several baseline demographic, clinical, and procedural characteristics were tracked as potential confounding variables, including age, gender, body mass index, history of hypertension, diabetes mellitus, dyslipidemia, heart disease, active antiplatelet use, active anticoagulant use, sheath size, overall procedure

duration, manual compression duration, and the type of procedure performed, which was classified as either diagnostic or interventional. Furthermore, specific continuous variables were dichotomized for the final analysis: age was categorized into 55 years or less versus greater than 55 years, procedure duration into 30 minutes or less versus greater than 30 minutes, and manual compression duration into 10 minutes or less versus greater than 10 minutes.

All statistical operations were performed using SPSS version 29.0. Continuous variables were presented as means with standard deviations or medians with ranges, while categorical variables were expressed as frequencies and percentages. Bivariate analysis was first executed to evaluate differences in baseline characteristics and hematoma incidence between the groups. Categorical data were analyzed using the Chi-square test or Fisher's exact test. To control for potential confounding variables and identify independent predictors of hematoma formation, a multivariate analysis was performed. All clinical and procedural variables demonstrating a p-value less than 0.250 in the baseline bivariate analysis were entered into a multivariate binary logistic regression model. The model was optimized using the Backward Likelihood Ratio elimination method. For all final statistical tests, a p-value less than 0.05 was considered statistically significant.

Ethical approval for this clinical trial was granted by the Ethics Committee of the Faculty of Medicine, Al-Azhar Islamic University, under registration number 210/EC-04/FK-06/UNIZAR/XII/2025. The study was executed in strict accordance with the Declaration of Helsinki and local clinical practice guidelines, ensuring participant data confidentiality and safety throughout data collection and analysis.

Result

Baseline characteristics

A total of 150 procedures were evaluated in this study, with 75 patients allocated to the conventional FC group and 75 to the FAbF group. The overall study population had a mean age of 54.33 ± 13.40 years, and the majority of the participants were male (58.67%).

Hematoma Occurrence

Puncture-site hematomas occurred in 17 patients overall, including 13 from the FC group and 4 from the FAbF group. This difference between the two techniques was statistically significant, indicating a higher risk of hematoma with conventional compression ($p = 0.02$; OR = 3.72; 95% CI: 1.15–12.01). Among the other baseline and clinical factors evaluated, prior use of antiplatelet therapy was also significantly associated with an increased incidence of hematoma ($p = 0.043$). None of the other baseline or procedural variables reached statistical significance in the bivariate analysis. A comprehensive breakdown of the bivariate analysis cross-tabulating hematoma occurrence with all evaluated research variables is presented in Table 1.

Multivariate Analysis

Multivariate binary logistic regression was performed on variables with p-values < 0.250 in the baseline bivariate analysis. The final model revealed that the type of manual compression technique was the sole independent predictor for the occurrence of a puncture-site hematoma. Specifically, patients who underwent conventional FC were significantly more likely to develop a hematoma compared to those who received the FAbF technique ($p = 0.014$; aOR = 4.62; 95% CI: 1.36–15.75).

Table 1. Bivariate analysis of baseline and procedural characteristics associated with hematoma occurrence.

Research Variables	Hematoma Occurrence		p-value
	Yes (n=17), n(%)	No (n=133), n(%)	
Gender			
Male	11 (64.71)	77 (57.89)	0.591[a]
Female	6 (35.29)	56 (42.11)	
Age			
Mean±SD	56.94±9.81	54.00±13.78	0.396[b]
≤55 years	9 (52.94)	66 (49.62)	0.797[a]
>55 years	8 (47.06)	67 (50.38)	
Comorbidities			
Hypertension	14 (82.35)	94 (70.68)	0.241[c]
Diabetes mellitus	1 (5.88)	23 (17.29)	0.201[c]
Dislipidemia	9 (52.94)	42 (31.58)	0.080[a]
BMI>25	5 (29.41)	64 (48.12)	0.145[a]
Heart disease	4 (23.53)	13 (9.78)	0.106[c]
Antiplatelet use	17 (100.00)	109 (81.95)	0.043[c]*
Anticoagulant use	0 (0.00)	7 (5.26)	0.423[c]
Sheath size			
5 French	13 (76.47)	116 (87.22)	0.305[c]
6 French	4 (23.53)	14 (10.53)	
8 French	0 (0.00)	3 (2.26)	

Table 1 continued. Bivariate analysis of baseline and procedural characteristics associated with hematoma occurrence.

Research Variables	Hematoma Occurrence		p-value
	Yes (n=17), n(%)	No (n=133), n(%)	
Procedure duration			
≤30 minutes	12 (70.59)	91 (68.42)	0.856[a]
>30 minutes	5 (29.41)	42 (31.58)	
Procedure type			
Diagnostic	14 (82.35)	120 (90.22)	0.264[c]
Intervention	3 (17.65)	13 (9.78)	
Compression time			
≤10 minutes	7 (41.18)	81 (60.90)	0.120[a]
>10 minutes	10 (58.82)	52 (39.10)	
Compression type			
FC	13 (76.47)	62 (46.62)	0.020[a]
FAbF	4 (23.53)	71 (53.38)	

[a]Using Chi-square test, [b]Independent t-test, [c]Fisher-Exact test; *p<0.05.
FAbF: Finger Assisted by Fist, FC: Finger Compression.

Discussion

Finger Assisted by Fist: A More Effective Manual Compression Technique

The findings of this study demonstrate a statistically significant difference in hematoma incidence between conventional fingers compression and the fingers assisted by fist (FAbF) technique, with the FAbF approach proving distinctly superior in minimizing hematoma risk. Furthermore, our multivariate analysis confirmed that the choice of manual compression technique was the sole independent predictor determining hematoma development following cerebral angiography.

Our results align with the findings of Fateen, who noted that manual compression remains the clinical gold standard for arterial access sites smaller than 7 Fr, boasting a success rate exceeding 95% due to its low cost and lack of hardware requirements, despite the inherent risk of operator fatigue during prolonged procedures or when treating high-risk patients.[19] Similarly, a meta-analysis by Rolf P. Kreutz and colleagues comparing manual compression to VCDs after femoral artery access found that while VCDs accelerated hemostasis and patient mobilization, they failed to significantly lower complication rates, such as hematoma incidence, when compared to traditional manual techniques.[16]

Evaluating alternative hemostatic modalities, Fathy et al. compared manual compression, mechanical compression using the Combat Ready Clamp (CRoC), and VCDs after femoral artery puncture. Their results indicated that manual compression effectively achieved hemostasis within a relatively short window (approximately 5 to 10 minutes) and yielded fewer hematoma complications than competing mechanical methods. In contrast, while mechanical devices offered more consistent pressure and a hands-free advantage, they were associated with prolonged hemostasis and ambulation times, alongside higher patient pain scores.[20]

The logistical and institutional impacts of these vascular closure strategies represent another critical dimension of post-procedural care. A retrospective study by Julia Walter et al. evaluated the impact of manual compression versus VCDs on catheterization laboratory workflows and expenditures, finding that VCD utilization optimized procedural efficiency and reduced overall procedural costs by up to €373 compared to manual methods due to shortened room turnaround times.[21] This highlights the nuanced debate in healthcare systems regarding upfront device costs versus long-term institutional resource utilization.

In our study, the FAbF technique emerged as the most effective manual compression variation for reducing access-site complications. Conversely, patients who underwent the conventional FC technique exhibited a substantially higher vulnerability to hematoma formation, whereas the FAbF technique provided a strong protective effect that markedly reduced the odds of this complication occurring.

Biomechanically, the modified FAbF technique utilizes the operator's non-dominant hand to apply direct digital pressure over the arteriotomy site, while the dominant hand is clenched into a fist and positioned beneath the non-dominant wrist to offer structural reinforcement. This configuration provides superior rotational stability and ensures an even distribution of downward force across the proximal phalanges and metacarpals, allowing for dynamic pressure modulation based on pedal pulsation feedback to prevent absolute arterial occlusion.[22,23]

As described by Liang, this advantage occurs because the combination of the proximal phalanges and metacarpals forms a flat, broad compression field that uniformly seals the arteriotomy, thereby eliminating lateral tract leaks and subsequent rebleeding. The supporting fist prevents unintended wrist rotation, allowing the operator to maintain a stable position for over 15 minutes, while redistributing the physical workload to the larger forearm flexor muscles to delay the onset of operator fatigue by 30% to 40%. Notably, Liang reported a 100% hemostasis success rate using this supportive positioning in complex bleeding cases, with patients achieving complete vascular stability after one hour of compression.[24]

In comparison, the conventional FC technique relies on applying downward pressure over the artery using two to three fingers of the dominant hand, typically placed 2 to 3 cm proximal to the skin puncture site. While the applied pressure must be sufficient to halt active bleeding, it must avoid completely obliterating the distal

pedal pulse. This standard approach requires sustained application for 15 to 20 minutes, followed by a 5-minute observation period to confirm stable hemostasis. Although effective in most routine diagnostic cases with baseline complication rates under 5%, this conventional method remains highly dependent on operator endurance and experience to avoid the dual pitfalls of excessive pressure, which induces localized ischemia, or inadequate pressure, which inevitably culminates in hematoma formation.[19]

Antiplatelet Use Has a Significant Influence on Hematoma Incidence

The present study demonstrated a statistically significant association between regular antiplatelet use and the incidence of femoral access hematoma following cerebral angiography in bivariate analysis ($p = 0.043$). This finding suggests that patients receiving antiplatelet therapy may have a greater tendency to develop bleeding-related vascular access complications after femoral artery catheterization. Physiologically, antiplatelet agents inhibit platelet aggregation and impair primary hemostasis, thereby prolonging the time required for thrombus stabilization at the puncture site after sheath removal. Because femoral artery puncture involves a high-pressure vascular system, inadequate platelet plug formation may predispose patients to subcutaneous blood extravasation and hematoma formation, particularly when post-procedural compression is insufficient or tissue integrity is compromised.[25]

The findings of this study are consistent with previous neurointerventional literature demonstrating that antiplatelet therapy contributes to access-site bleeding complications. A study by Kota Kurisu et al. found that antiplatelet therapy was an independent predictor of femoral access-site hematoma during neuro-interventional procedures using femoral artery access. The authors reported that patients receiving antiplatelet medication had a significantly greater likelihood of post-procedural hematoma compared with non-users, even when ultrasound-guided femoral puncture techniques were utilized. These findings reinforce the notion that pharmacological inhibition of platelet function remains an important determinant of vascular closure success after femoral catheterization.[25]

One plausible explanation for the increased incidence of hematomas among antiplatelet users is impaired hemostatic efficiency after sheath removal. Hemostasis following femoral puncture relies heavily on platelet activation, fibrin formation, and effective external compression. Antiplatelet medications such as aspirin and P2Y12 inhibitors interfere with platelet adhesion and aggregation, thereby delaying clot formation at the puncture tract. Even minor leakage from the arterial wall may progressively accumulate into a clinically detectable hematoma, especially during the immediate post-compression period when arterial pressure remains high. This mechanism becomes particularly relevant in cerebral angiography because femoral access commonly involves prolonged manual compression and temporary immobilization after catheter withdrawal.[26]

Furthermore, evidence from neuroendovascular studies suggests that more intensive platelet inhibition may increase the risk of puncture-site bleeding. A case-control study evaluating hemorrhagic complications after neuroendovascular treatment reported that patients receiving multiple antiplatelet regimens experienced a significantly higher incidence of puncture-site bleeding compared with those receiving less intensive therapy. Although the current study grouped all antiplatelet users together rather than distinguishing among individual agents or dual-therapy regimens, the statistically significant association identified in the bivariate analysis may reflect the cumulative pharmacological effect of platelet suppression on vascular access hemostasis.[27]

The significance of antiplatelet therapy observed in this study also aligns with broader angiographic evidence beyond neurovascular procedures. Previous vascular and interventional radiology investigations have demonstrated that bleeding complications following femoral artery puncture are influenced by medications affecting coagulation and platelet activity. Although some studies emphasize anticoagulation intensity and thrombocytopenia as dominant predictors, antiplatelet exposure remains clinically relevant because platelet dysfunction can contribute to persistent oozing and delayed vascular sealing after catheter removal. Therefore, the current finding supports the growing body of evidence that emphasizes medication history as an essential preprocedural consideration for femoral access procedures.[28]

Study Limitations

Several limitations of this study must be acknowledged, including a relatively small sample size, a short data collection period, a restricted selection of evaluated clinical variables, and its single-center design. These factors may limit the external generalizability of our findings to broader or more diverse patient populations. Consequently, future robust, multi-center trials involving larger patient cohorts and a wider spectrum of clinical and procedural variables are warranted to validate these results and support widespread standardization.

Conclusion

This study demonstrates that the FAbF compression technique is significantly more effective than the conventional FC technique in reducing puncture-site hematoma formation following cerebral angiography via femoral access. Beyond the choice of compression modality itself, patient-specific clinical factors—such as pre-procedural antiplatelet therapy—play a critical role in hematoma development. Ultimately,

these findings underscore the clinical importance of implementing an optimized manual hemostasis method while carefully evaluating individual patient risk variables to maximize safety and improve post-angiographic outcomes.

Acknowledgement

Our deepest gratitude to PELNI's Interventional Neurology Fellow and PELNI's Cath Lab Team.

Conflict of Interest

The two authors of this manuscript are members of the editorial team of the Journal of Neurointervention and Stroke. However, they were completely blinded to the peer-review process and had no role or influence in the submission, evaluation, or decision-making for this manuscript. This article was managed entirely by an independent editor and underwent the journal's standard double-blind peer-review process.

Ethic consideration

Ethical Clearance number 210/EC-04/FK-06/UNIZAR/XII/2025 of the Faculty of Medicine, Al-Azhar Islamic University. Dated 19th December 2025.

Funding

None

Author contribution

Fritz Sumantri Usman: Conceptualization, Data Curation, Formal Analysis. **Andrianor Rahman:** Investigation, Methodology, Project Administration. **Alfi Rizky Medikanto:** Resources, Software. **Engki Irawan:** Validation. **Agus Budi Bowo Leksono:** Visualization. **Merlin Prisilia Kastilong:** Writing—Original Draft. **Leny Kurnia:** Writing—Review and Editing.

References

1. Federau C, Wintermark M. CT, CT-Angiography, and Perfusion-CT Evaluation of Stroke. In: Primer on Cerebrovascular Diseases. Academic Press; 2017. DOI: 10.1016/B978-0-12-803058-5.00131-4
2. Moini J, Gutierrez A, Avgeropoulos N. Clinical Neuroepidemiology of Acute and Chronic Disorders. Elsevier; 2023. [Book]
3. Kansal A, Jones WS, Sethi SS, Rymer JA. Vascular access and management of complications. Interv Cardiol Clin. 2025;14(2):149–59. DOI:10.1016/j.iccl.2024.11.003
4. Sani AF, Putri SA, Usman FS. Konsensus Nasional Neurointervensi. Airlangga University Press; 2020.
5. Smeds MR, Soult MC. Access-related complications of percutaneous access for diagnostic or interventional procedures - UpToDate. 2026. [Web Page]
6. Hans SS. femoral artery pseudoaneurysm secondary to femoral artery intervention and penetrating trauma. In: Contemporary Management of Lower Extremity Aneurysmal Disease. Cham: Springer Nature Switzerland; 2025. DOI: 10.1007/978-3-032-00159-7_7
7. Khan Z, Nattanamai P, Keerthivaas P, Newey CR. An Evaluation of complications in femoral arterial sheaths maintained post-neuroangiographic procedures. Cureus. 2018;10(2):e2230. DOI: 10.7759/cureus.2230
8. Redfors B, Watson BM, McAndrew T, Palisaitis E, Francese DP, Razavi M, et al. Mortality, length of stay, and cost implications of procedural bleeding after percutaneous interventions using large-bore catheters. JAMA Cardiol. 2017;2(7):798–802. DOI: 10.1001/jamacardio.2017.0265
9. Kerré S, Kustermans L, Vandendriessche T, Bosmans J, Haine SE, Miljoen H, et al. Cost-effectiveness of contemporary vascular closure devices for the prevention of vascular complications after percutaneous coronary interventions in an all-comers PCI population. EuroIntervention. 2014;10(2):191–7. DOI: 10.4244/EIJV10I2A32
10. Dahal K, Rijal J, Shahukhal R, Sharma S, Watti H, Azrin M, et al. Comparison of manual compression and vascular hemostasis devices after coronary angiography or percutaneous coronary intervention through femoral artery access: A meta-analysis of randomized controlled trials. Cardiovasc Revasc Med. 2018;19(2):151–62. DOI: 10.1016/j.carrev.2017.08. 009
11. Pang N, Gao J, Zhang B, Guo M, Zhang N, Sun M, et al. Vascular closure devices versus manual compression in cardiac interventional procedures: Systematic review and meta-analysis. Cardiovasc Ther. 2022 ;2022:8569188. DOI: 10.1155/2022/8569188
12. Robertson L, Andras A, Colgan F, Jackson R. Vascular closure devices for femoral arterial puncture site haemostasis. Cochrane Database Syst Rev. 2016;3(3):CD009541.DOI: 10.1002/14651858.CD009541.pub2
13. Noori VJ, Eldrup-Jørgensen J. A systematic review of vascular closure devices for femoral artery puncture sites. J Vasc Surg. 2018;68(3):887–99. DOI: 10.1016/j.jvs.2018.05.019
14. Spiliopoulos S, Prountzos S, Grigoriadis S, Diamantopoulos A, Paraskevopoulos I. ESR Essentials: arterial vascular access and closure devices—practice recommendations by the Cardiovascular and Interventional Radiological Society of Europe. Eur Radiol. 2025;35(4):1858–67. DOI: 10.1007/s00330-024-11053-3
15. Schulz-Schüpke S, Helde S, Gewalt S, Ibrahim T, Linhardt M, Haas K, et al. Comparison of vascular closure devices vs manual compression after femoral artery puncture: The ISAR-CLOSURE

randomized clinical trial. JAMA. 2014;312(19): 1981–7. DOI: 10.1001/jama.2014.15305

16. Kreutz RP, Phookan S, Bahrami H, Sinha AK, Breall JA, Revtyak GE, et al. Femoral artery closure devices vs manual compression during cardiac catheterization and percutaneous coronary intervention. J Soc Cardiovasc Angiogr Interv. 2022;1(5):100370. DOI:10.1016/j.jscai.2022.100370
17. Allen DW, Kaul P. Step-by-step guide to femoral vascular access closure: Devices and technical considerations. In: Coronary Interventions Handbook. 2020. [Book]
18. Usman FS, Kastilong MP, Kurniawan B, Soleh M, Keneddy E, Alaztha H, et al. Incidence and predictors of groin complication after cerebral neurointervention procedure: Single centre study. Int J Res Med Sci. 2022;10(2):316–21. DOI: 10.18203/ 2320-6012.ijrms20220274
19. Rashed MF, Majeed MN, Ahmad H, Bashir Q. A single-center experience with manual compression following femoral artery puncture for digital subtraction angiogram of the brain and spine at punjab institute of neurosciences lahore. Open Access J Neurol Neurosurg. 2025;19(3):556015. DOI: 10.19080/OAJNN.2024.19.556015
20. Fathy FM, Kamel SS, Rahman AARA. Manual versus mechanical compression for femoral artery hemostasis after coronary catheterization. IOSR J Nursing Health Sci (IOSR-JNHS). 2019;8(4):77-93. DOI:10.9790/1959-0804037793
21. Walter J, Vogl M, Holderried M, Becker C, Brandes A, Sinner MF, et al. Manual compression versus vascular closing device for closing access puncture site in femoral left-heart catheterization and percutaneous coronary interventions: A retrospective cross-sectional comparison of costs and effects in inpatient care. Value Health. 2017;20(6):769–76. DOI: 10.1016/j.jval.2016.05.004.
22. Kamatani K, Yoshida S, Hashiguchi Y, Takigawa K, Yasaka M, Aikawa H, et al. Usefulness of local manual compression with cerebral angiography for bleeding from the origin of the ICA with upper airway stenosis after carotid artery stenting. Clin Case Rep Int. 2023;7(1). [Journal]
23. Faraj DAH. Comparison of vascular closure devices versus manual compression in terms of postoperative complications among patients undergoing cerebral angiography: A hospital-based observational study. 2022. [Thesis]
24. Liang H, Ye R, Song N, Zhu C, Xu M, Ye Q, et al. Early ambulation protocol after diagnostic transfemoral cerebral angiography: An evidence-based practice project. BMC Neurol. 2024;24(1):104. DOI: 10.1186/s12883-024-03595-2
25. Kurisu K, Osanai T, Kazumata K, Nakayama N, Abumiya T, Shichinohe H, et al. Ultrasound-guided femoral artery access for minimally invasive neuro-intervention and risk factors for access site hematoma. Neurol Med Chir (Tokyo). 2016;56(12):745–52. DOI: 10.2176/nmc.oa.2016-0 026
26. Darcy MD, Kanterman RY, Kleinhoffer MA, Vesely TM, Picus D, Hicks ME, et al. Evaluation of coagulation tests as predictors of angiographic bleeding complications. Radiology. 1996;198(3):741–4. DOI: 10.1148/radiology.198 .3.8628863
27. Andersen K, Bregendahl M, Kaestel H, Skriver M, Ravkilde J. Haematoma after coronary angiography and percutaneous coronary intervention via the femoral artery frequency and Risk Factors. Eur J Cardiovasc Nurs. 2005;4(2):123–7. DOI: 10.1016/j.ejcnurse.2005.02.003
28. Tamari Y, Izumi T, Nishihori M, Imai T, Ito M, Tsukada T, et al. Case-control study of postprocedural arterial puncture site hemorrhage after neuroendovascular treatment. Nagoya J Med Sci. 2021;83(1):125–33. DOI: 10.18999/nagjms.83.1.125