



EFFECTIVENESS OF USING COLD ESALINE COMPRESS IN REDUCING THE AREA OF HEMATOMA AFTER CORONARY INTERVENTION PERCUTANEOUS FEMORAL ACCESS

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ABSTRACT

Percutaneous Coronary Intervention (PCI) with a transfemoral approach is an invasive procedure commonly used in the management of coronary artery disease. This study aims to evaluate the effectiveness of esaline cold compress application in reducing hematoma size at the femoral access site in patients undergoing PCI. This study employed a Randomized Controlled Trial (RCT) design with a consecutive sampling technique. The sample consisted of 80 respondents who underwent transfemoral PCI, including 40 respondents in the intervention group and 40 respondents in the control group. Participants were recruited consecutively based on predetermined inclusion and exclusion criteria and were randomly allocated into intervention and control groups. The intervention group received esaline cold compresses applied to the femoral access area after sheath removal, while the control group received standard care. Data were collected through observation of hematoma size, pain scale, and patient comfort for 24 hours post-procedure. Data analysis was conducted using the Mann-Whitney U test with a significance level of 0.05. The results showed that the characteristics of respondents in both groups were relatively homogeneous. There was a statistically significant difference in hematoma size between the intervention group and the control group ($p = 0.001 < 0.05$). Specifically, the group receiving esaline cold compresses demonstrated a mean rank of 30.41 with a total rank of 1216.50. The application of esaline cold compresses was proven to be statistically and clinically effective in preventing and minimizing the extent of hematoma following femoral access PCI.

Keywords: cold therapy; esaline cold compress; hematoma; nursing care; transfemoral PCI

How to cite (in APA style)

Sihombing, D., Rumahorbo, H., Supriadi, D., Kosasih, C. E., & Santoso, M. B. (2026). Effectiveness of Using Cold Esaline Compress in Reducing the Area of Hematoma after Coronary Intervention Percutaneous Femoral Access. *Indonesian Journal of Global Health Research*, 8(4), 1335–1352. <https://doi.org/10.37287/ijghr.v8i4.1568>.

INTRODUCTION

Exclusive The development of global modernization has influenced people's behavior and lifestyles. People now tend to choose modern lifestyles such as consuming low-fiber, high-fat foods, lack of physical activity, smoking, and consuming alcohol (Banatvala et al., 2023). This lifestyle contributes to an increase in serious health problems, including high rates of cardiovascular disease in various countries (Hyder et al., 2023). Coronary artery disease (CAD) is a common cause of coronary heart disease. Artery Coronary artery disease (CAD) is currently one of the world's major health problems, contributing to rising mortality rates and disrupting economic stability. Globally, the death toll from CAD reached 17.9 million in 2019, equivalent to 32% of the world's total deaths (WHO, 2021). This disease not only impacts individuals but also burdens health systems in many countries. The high prevalence of risk factors such as hypertension, diabetes, and unhealthy lifestyles contribute to the worsening of CAD. Prevention and early treatment are crucial to reduce the impact of this disease (British Heart Foundation, 2024).

Basic Health Research Data shows that the prevalence of coronary heart disease (CHD) increases with age. This disease is not only limited to urban communities, but is also commonly found among rural communities, the less educated, and the unemployed. This indicates that CHD is a serious health problem that impacts all levels of society in Indonesia. In 2023, the prevalence of CHD sufferers in Indonesia was recorded at 1.5%, and this condition requires special attention because of the burden it causes to families, communities, and the state (Ministry of Health of the Republic of Indonesia, 2023) . Furthermore, it is stated that West Java is the 4th largest province with a prevalence of heart disease (1.2%) after DKI Jakarta Province (1.6%), Central Papua (1.65%), and the highest ranking is in the Yogyakarta Special Region (DIY) Province (1.67%). Based on data from the Adventist Hospital medical record, heart and blood vessel disease is the most common disease in both outpatient and inpatient care.

Coronary Artery Disease (CAD) occurs when coronary arteries undergo arteriosclerotic and atherosclerotic changes in the coronary arteries, causing inadequate blood and oxygen supply to the myocardium. This condition causes a decrease in oxygen supply to the myocardium, thus triggering anaerobic metabolism. As a result, there is an increase in lactic acid production that spreads to the muscles and nerves, causing the patient to experience pain and physical weakness (Bansal & Hiwale, 2023) . Changes in blood vessels can begin at an early age. The incidence of CAD in men occurs 10 to 15 years earlier than in women, and increases in women after menopause (Abubakar et al., 2023) . Treatment for patients with CAD involves revascularization procedures, such as CAD. Artery Bypass Graft (CABG) or Percutaneous Coronary Intervention (PCI). PCI is a non-surgical intervention used to reopen coronary arteries by inserting a balloon or stent through a catheter into the blood vessel. This procedure aims to increase blood flow to the coronary arteries, improve myocardial ischemia, and address the clinical symptoms of CAD (Hartley & Nijjer, 2022).

Percutaneous Coronary Intervention (PCI), the primary intervention for treating coronary artery disease, has been shown to have several side effects. Several studies have shown post-PCI complications and severity. Commonly reported complications include hematoma, infection, and the risk of re-narrowing of the coronary artery (restenosis) (Hanna et al., 2023) . Patients are also at risk of developing blood vessel damage or blood clot formation around the stent. (in- stent thrombosis). Post-procedure monitoring is crucial to prevent and manage these complications early (Doll et al., 2020) . PCI insertion is most often performed through the femoral artery. Although effective in treating CAD, this procedure still carries risks and complications (Visseren et al., 2021) . Some complications that can occur include cardiac tamponade, dysrhythmias, pneumothorax, hypovolemia, cardiac arrest, and arterial embolism (Arnett et al., 2019) . Vascular complications of PCI include hematoma, aneurysm, and thrombosis. microvascular, active bleeding, edema, pain at the insertion site, ecchymosis, embolism, arterial occlusion, arterial spasm, fistula arteriovenous, and hematoma retroperitoneal. These complications can increase the risk of death, morbidity, treatment costs, and length of hospital stay. Hematoma and pain are the most common complications experienced by patients after PCI (NICE Guideline, 2023) .

Hematoma is a frequently reported vascular complication after PCI and can cause serious complications, usually accompanied by swelling and pain. Hematoma occurs due to incomplete closure of the femoral artery access, which results in blood accumulation in the surrounding tissue (Galli et al., 2022) . A study in the United States reported that of more than 3 million PCI procedures, 12.1% experienced hematoma complications, some even resulting in death (Pinxterhuis et al., 2023) . A study at the RSHS reported that the incidence of hematoma after PCI reached 17% (Azizah, 2017). The Bandung Adventist Hospital Cathlab in 2023 reported that there were 7.3% of hematoma complications occurring within 24 hours after PCI with hematoma areas varying between 5-30 mm², and there have been reports of hematomas requiring further action, namely hematoma evacuation through surgical procedures.

The resulting hematoma causes pain, an unpleasant sensory and emotional experience associated with actual or potential tissue damage. If pain is not managed properly, it can trigger a vasovagal response and vascular complications (Henein et al., 2022). The sensory and emotional experience of this actual tissue damage causes discomfort for the patient. Pain also stimulates the sympathetic nervous system, resulting in the release of epinephrine. This in turn increases blood pressure, cardiac output, and peripheral vascular resistance (Reynolds & Minic, 2023). Nurses play a crucial role in post-PCI management. Their role involves improving the quality of healthcare and patient satisfaction through education and active patient involvement in the care process. Nursing interventions encompass three main domains: reducing the risk of complications, enhancing psychological well-being, and improving quality of life (Sugiharto et al., 2024). Nurses are also responsible for closely monitoring vital signs and early detection of complications. With a holistic approach, nurses can provide comprehensive support both physically and emotionally to accelerate patient recovery (Zhang & Qi, 2021).

Until now, nursing actions in the cathlab still use standard manual compression care and pressure dressings. bandage) in the procedure aff sheath. Currently, there are many innovations in the medical world to treat hematomas. post-affairs Femoral access sheath with various types of VCD. Vascular device Closure (VCD) is still frequently used in patients undergoing percutaneous coronary intervention (PCI) and has been shown to reduce access complications. site bleeding (ASB) in patients undergoing primary femoral access IKP (Timothy et al., 2015). The challenge in using VCDs is the high cost. Research on nursing interventions applied to prevent vascular complications, based on scientific evidence and validity, is still very limited. Nevertheless, the importance of developing further research to strengthen evidence-based interventions cannot be overstated (Chen et al., 2022). Increasing the number of comprehensive studies will help nurses design more effective interventions, thereby reducing complication rates and improving the overall quality of patient care (Sobh et al., 2021). Cold compresses are one of the effective nursing interventions in preventing pain and hematomas. The use of cold compresses is often chosen because of its physiological effects, such as vasoconstriction of blood vessels, slowing tissue metabolism, increasing blood viscosity, and acting as a local anesthetic (Handayani et al., 2024). Cold compresses can also help reduce swelling and inflammation in the traumatized area. Implementing this intervention has been proven safe and easy, so it is often recommended in nursing practice to accelerate the recovery process (Nuraeni et al., 2023).

Cold compresses can reduce blood flow and capillary permeability through vasoconstriction in arterioles, thereby minimizing bleeding. Cold compresses also slow blood flow and increase viscosity and the coagulation process (Widodo et al., 2023). Based on the author's studies and experience, the method of using cold compresses has not been implemented in cath labs in Indonesia as an effort to prevent hematoma complications after sheath removal. femoral access in patients undergoing Percutaneous Coronary Intervention (PCI) procedures. Based on this, this study aims to apply cold compresses to reduce the area of hematoma at the femoral access site in patients undergoing Percutaneous Coronary Intervention. The cold compress used was 100 cc of Normal Saline (NS 0.9%) solution frozen into ice at -5 °C so that it can remain frozen at room temperature for up to 40 minutes.

METHOD

This study uses a randomized design. Controlled Trial (RCT) with pretest – posttest approach control group to evaluate the effectiveness of saline cold compresses on reducing the size of hematoma after Percutaneous Coronary Intervention (PCI) with femoral access (Creswell & Creswell, 2021). This design was chosen because it is the gold standard in clinical experimental research to assess the causal relationship between intervention and outcome (Sugiyono, 2018). The independent variable in this study was the administration of saline cold compresses, while the dependent variable was the hematoma area measured in mm² using vascular Doppler

ultrasonography. The study population consisted of elective femoral access PCI patients aged 30–70 years undergoing procedures in the cardiac catheterization laboratory at Bandung Adventist Hospital. Subjects were recruited using a consecutive sampling technique based on predetermined inclusion and exclusion criteria, in which all eligible patients were enrolled sequentially until the required sample size was achieved. After recruitment, participants were randomly allocated into intervention and control groups to ensure comparability between groups and minimize selection bias. Exclusion criteria included a body mass index $>27 \text{ kg/m}^2$, a smoking history of >20 years, multiple puncture femoral artery disease, chronic kidney disease requiring hemodialysis, active cancer, and coagulation disorders. The sample size was calculated using Cohen's d approach with a medium effect size (0.5), significance level (α) of 0.05, and statistical power of 80%, resulting in 40 respondents per group (total of 80 respondents).

Randomization was performed using a closed lottery technique after the IKP procedure was completed and before sheath removal. femoral, to avoid selection bias and ensure equal opportunity for each subject to enter the intervention and control groups. The intervention group received a cold compress made from 100 cc of 0.9% Normal Saline solution, frozen at -5°C to 0°C , wrapped in sterile gauze, and applied immediately after the sheath was removed with a gradual pressure technique for 15–20 minutes. The control group received standard care in the form of manual compression and pressure dressing according to hospital standard operating procedures. Hematoma area measurements were performed twice, immediately after the pressure was completed (pretest) and 24 hours after the operation. sheath (posttest). Hematoma identification was performed using Doppler ultrasound with a linear probe (L-12), then the area is measured using the trace feature in two-dimensional mode and confirmed with color Doppler to ensure there is no active blood flow. In addition to the main output of the hematoma area, the pain scale is also recorded using Numeric Rating Scale (NRS) and patient comfort level through structured observation sheets.

Data were analyzed using statistical software through editing, coding, and tabulation. Univariate analysis was used to describe the characteristics of respondents and the distribution of research variables. Bivariate analysis was performed to compare the mean hematoma area between the intervention and control groups using the Independent Sample T- Test if the assumptions of normality (Kolmogorov - Smirnov test) and homogeneity of variance (Levene's test) were met. If the data were not normally distributed, a non- parametric test was used. Mann –Whitney U. The level of statistical significance was set at $p < 0.05$. This research was conducted in accordance with the ethical principles of biomedical research, including respect for subject autonomy through informed consent. written consent, the principle of beneficence and non- maleficence with close monitoring of the possibility of local hypothermia or perfusion disorders, the principle of fairness in the randomization process, and protection of the confidentiality of respondent data. With a controlled experimental approach and objective measurements based on ultrasound, this study is expected to produce valid scientific evidence regarding the effectiveness of esaline cold compresses as a nursing intervention in reducing the area of hematoma after femoral access PCI.

RESULT

Analysis of respondent characteristics was conducted to describe the demographic and clinical profiles of research subjects and to ensure equivalence (baseline) comparability) between the intervention group and the control group before treatment is given. Equivalence of initial characteristics is an important component in a randomized design. Controlled A randomized trial (RCT) was used, as it minimizes potential bias and increases the internal validity of the study. The characteristics analyzed included age, body mass index (BMI), gender, education level, and smoking history. Data distribution is presented as mean, standard deviation, minimum and maximum values for numeric variables, and frequency and percentage for categorical variables.

Table 1 of Research Respondents

Respondent Characteristics	Intervention Group		Control Group	
Age				
Mean	55.7		60.7	
Standard Deviation	7.9		8.8	
Minimum	42		36	
Maximum	70		70	
BMI				
Mean	24.3		24.8	
Standard Deviation	2.1		2.1	
Minimum	19		19	
Maximum	27		27	
Respondent Characteristics	f	%	f	%
Gender				
Man	30	75	31	77.5
Woman	10	25	9	22.5
Education				
Elementary School	1	2.5	9	22.5
Junior High School	4	10	2	5
Senior High School	19	47.5	16	40
3-year diploma	3	7.5	1	2.5
Bachelor degree	10	25	10	25
Strata 2	3	7.5	2	5
Smoking History				
Smoker	26	65	29	72.5
Non-smoker	14	35	11	27.5

The characteristics of respondents in the study of the effectiveness of using saline cold compresses in preventing hematoma after femoral access PCI showed a relatively comparable picture between the intervention group and the control group. In terms of age, the average age of respondents in the intervention group was 55.7 years with a standard deviation of 7.9 years, the youngest age was 42 years and the oldest was 70 years. Overall, the characteristics of respondents in the intervention and control groups were relatively similar. Most respondents were in the adult to elderly age range, which is associated with a high risk of coronary heart disease. The average BMI in both groups fell within the normal to overweight category with a similar range, indicating relatively homogeneous nutritional status. The majority of respondents in both groups were male, had secondary to higher education levels, and had a history of smoking. These comparable characteristics suggest that both groups were well balanced, thereby minimizing potential bias and supporting the validity of the study results.

Hematoma Area between Intervention and Control Groups

To analyze the difference in hematoma area before (pretest) and after (posttest) the intervention was given to each group, a paired statistical test was carried out. Sample T- Test. This test was selected based on the results of the normality test, which showed that the pretest and posttest data in both the intervention and control groups were normally distributed. This analysis aims to determine significant changes in hematoma area in each group after treatment, as follows.

Table 2
Normality Test of Data for Intervention and Control Groups

Variables	Shapiro-Wilk		
	Statistics	df	p
Intervention Group Pretest	0.947	40	0.060
Intervention Group Posttest	0.969	40	0.333
P retest Control Group	0.949	40	0.070
Control Group Posttest	0.953	40	0.093
Second Hematoma Size Group	0.969	40	0.015

Data from the intervention and control groups, both before and after treatment, showed a relatively reasonable and consistent distribution pattern. This indicates that the values obtained in both groups did not deviate significantly and still reflected the general condition of the respondents. In the intervention group, the pre- and post-treatment data showed stable conditions, allowing for reasonably well-observed changes. Similarly, in the control group, the pre- and post-treatment data also showed a similar distribution and showed no significant anomalies. When the hematoma extents from both groups were combined, greater variation was observed. This indicates that the differences in conditions between the intervention and control groups were quite pronounced, so the combined data no longer showed a uniform distribution. Overall, these results indicate that the data for each group individually were in good condition and could be analyzed, while differences in characteristics between the two groups caused greater variation in the combined data. These findings support that the treatment provided contributed to the differences in outcomes between the groups.

Table 3
Difference in Hematoma Size in the Intervention and Control Groups

Variables	Mean	SD	t	p
Pretest-Posttest Intervention Group	0.7650	0.6848	7,065	0.001
Pretest-Posttest Control Group	0.0100	0.0496	1,275	0.210

In the intervention group, the mean values before and after treatment showed significant changes. The very small significance value (0.001) indicates that the changes were truly due to the treatment. This indicates that without the administration of saline cold compresses, there was no significant change in hematoma size. Treatment in the intervention group had a significant effect on the measured outcomes. In the control group, the difference between before and after conditions was barely visible. The mean change was very small, and the significance value of 0.210 indicates that there was no significant change. This means that without any special treatment, the condition in the control group tended to remain the same. Overall, these results indicate that the treatment given to the intervention group was effective, while in the control group there was no significant change. These findings strengthen the evidence that the administration of saline cold compresses plays an effective role in preventing and reducing hematoma size in patients after femoral access PCI.

Esaline Cold Compress in Preventing Hematoma in Femoral Access IKP Patients

A homogeneity test is performed before hypothesis testing to determine the appropriate type of statistical test. If the variance between groups is homogeneous, the analysis can proceed using parametric tests.

Table 4
Homogeneity Test

		Levene's Test		t- test	
		F	Sig.	t	Sig. (2-tailed)
Hematoma Size	Equal variances assumed	6,498	0.013	-4,580	0,000
	Equal variances not assumed			-4,580	0,000

Results of homogeneity test using Levene's The test showed a significance value of 0.013 ($p < 0.05$), which indicates that the variance of hematoma area data between the intervention and control groups is not homogeneous. Therefore, the use of the Mann -Whitney U Test as a non-parametric alternative is methodologically appropriate in this study. To determine the effectiveness of the use of Esaline cold compresses in preventing hematoma in patients after femoral access percutaneous coronary intervention (PCI), an analysis of the difference in hematoma area between the intervention and control groups was conducted. Based on the results of the previous normality test, the hematoma area data were not normally distributed, so the analysis of differences between groups was carried out using a non- parametric test. Mann –Whitney U. The results of the analysis are presented in Table 4.5, which describes the comparison of the hematoma area between patients who received Esaline cold compresses and patients who did not receive this intervention.

Table 5 Compress in Preventing Hematoma

Hematoma Size	Mean Rank	Z	p
Intervention Group	30.41	-3,895	0.001
Control Group	50.59		

Hematoma area between the intervention and control groups. The intervention group had a lower mean ranking score than the control group. This indicates that the hematoma area in the intervention group tended to be smaller compared to the control group. A significance value of 0.001 indicates that the difference in hematoma area between the two groups was truly significant. The difference found can be attributed to the treatment given to the intervention group. Overall, these results indicate that the intervention was effective in reducing the hematoma area compared to the control group. These findings support that the intervention has benefits in preventing or reducing the occurrence of hematomas.

DISCUSSION

Age

The results of the study showed that respondents were predominantly in the late adult to elderly age range, which is known as a high-risk group for PCI intervention. This indicates that the majority of respondents are in a high-risk group for coronary heart disease and PCI procedures because the prevalence of atherosclerosis and cardiovascular risk factors is higher at this age. Age over 50 years is one of the main risk factors for post-intervention vascular complications, including hematoma, because blood vessel elasticity decreases and hemostasis ability tends to decrease with age. This is in line with the findings of epidemiological studies that show a high incidence of vascular complications in PCI patients in the middle to elderly age group, where the relative risk can increase up to 2-3 times compared to the younger age group (Pristya et al., 2025).

The use of cold compresses works through a local vasoconstriction mechanism, namely narrowing of blood vessels which results in reduced blood flow to the incision area, decreased capillary permeability, and increased blood viscosity. All of this helps speed up the hemostasis process and reduces the risk of further bleeding or hematoma formation. (Pristya et al., 2025). Furthermore, cold temperatures also inhibit sensory nerve conduction by increasing the pain threshold and reducing pain perception at the application site, a message consistent with improved patient comfort after PCI (Seweid et al., 2021). According to the researchers, from a biological perspective and empirical research, this finding that elderly patients in late adulthood are potentially more susceptible to vascular complications after PCI supports the need for additional interventions such as cold compresses. This is because the vasoconstriction mechanism of cold in reducing blood flow and assisting local clotting, in accordance with the physiological theory of thermoregulation. Scientific studies support the use of cold compresses as a non-pharmacological strategy to prevent hematomas and pain efficiency after invasive procedures. Older age is correlated with a higher risk of vascular complications, making preventive interventions such as cold compresses even more important. Cold compresses can work as a simple, safe, and cost-effective clinical strategy compared to other pharmacological or invasive interventions. The effectiveness of cold compresses may also be influenced by the duration and timing of application; administration within 15–20 minutes post-procedure has been shown to be optimal in many studies.

Body Mass Index (BMI)

The results of this study placed the majority of study participants in the normal weight to mildly overweight category, reflecting a nutritional status that was at the upper limit of normal to slightly excessive. According to the WHO definition, a BMI of 18.5–24.9 kg/m² is categorized as normal and ≥ 25 kg/m² as overweight, while >30 kg/m² is considered obese. BMI is used as a simple indicator of weight status related to the risk of metabolic and cardiovascular disease (Park et al., 2021). Studies assessing post-PCI outcomes in large CAD populations have shown a U-shaped relationship between BMI and long-term mortality, with the overweight group (BMI 25–29.9

kg/m²) experiencing a lower risk of mortality than the normal or underweight categories ; this also indicates that a normal or low BMI does not always provide the best prognosis after PCI (Ndrepepa et al., 2025) . In another analysis, overweight / obese was associated with lower rates of complications including bleeding or vascular complications compared to low BMI groups, although results varied between studies (Kwak et al., 2025) .

In another context, researchers found no significant association between BMI categories and acute complications, including procedural success or post-PCI complications, suggesting that BMI alone is not a strong predictor of acute infarction outcomes or events directly related to the procedure (Aziz et al., 2025) . According to the researchers, BMI within the normal range of mild overweight may not have a dominant clinical impact on the occurrence of post-PCI hematoma, especially when compared with other risk factors such as age, anticoagulant use, and procedural technique. Patients with normal or slightly overweight BMI may have sufficient nutritional reserves and a more moderate metabolic risk, so its impact on post-procedure hemostasis is less pronounced than other clinical factors such as individual hemostatic response or vascular weakness. BMI measurement as a single parameter may be less sensitive for predicting local vascular complications such as hematoma than other measures such as body mass index (BMI). composition visceral fat index or distribution is more directly related to inflammation and vascular risk.

Gender

The results showed that the majority of participants in both groups were male. This composition is consistent with the trend of a high prevalence of coronary heart disease commonly found in men. This finding is consistent with epidemiological patterns showing that coronary heart disease (CHD) and the need for interventions such as PCI have historically been more common in men, particularly in middle and older adulthood. Data from European and global studies indicate that men tend to have higher rates of coronary heart disease and undergo clinical procedures such as angiography or PCI more frequently than women, particularly before menopause. Men are also more likely to have traditional risk factors such as smoking, hypertension, and dyslipidemia, which contribute to the development of atherosclerosis. (Kim, 2024) . Clinical studies also report that more men than women experience acute events such as STEMI and prior to receiving invasive cardiovascular interventions, with male figures often reaching 70–80% of all patients in many PCI registries (Lutfiah & Mustika, 2025) . The researchers' assumption that male dominance reflects the clinical reality of high CHD risk in the male group. Due to biological factors and lifestyle behaviors, men are more likely to experience CHD and undergo PCI, so the gender predominance in the study is representative. Gender distribution was not a major confounder affecting the main outcome of the study. Because both the intervention and control groups had almost equal distributions of men, gender variables are unlikely to influence the observed effect of saline cold compresses on hematoma incidence.

Education

The results showed that both study groups had relatively balanced educational profiles. Given the small number of respondents with primary education, it can be concluded that the majority of participants were at secondary or higher education levels. Balance This educational profile is important in the research context because education level can influence patient understanding of care instructions and adherence to clinical procedures (Beda et al., 2024) . Individuals with secondary or higher education are generally better able to understand medical instructions and post-invasive care such as PCI, thus minimizing potential bias due to differences in understanding between the two groups. This homogenous condition increases the internal validity of the study because the baseline characteristics of respondents did not differ significantly between the intervention and control groups (Arifin, 2022) . Related research often confirms that educational status is a determinant of health behavior that can influence the outcome of therapy or intervention. Better education is often associated with patient adherence to post- invasive instructions, such as

wound management, use of compresses, and monitoring for signs of complications (Andreiani et al., 2025) . Thus, the balanced educational characteristics between the groups minimize confounding variables and strengthen the conclusion that changes in hematoma incidence are more likely due to the effectiveness of Esaline cold compresses than differences in educational level.

Smoking History

The results showed that the majority of respondents in both study groups were smokers. Although the control group had a slightly higher number of smokers than the intervention group, the overall smoking profiles in both groups tended to be similar. This finding suggests that smoking is a significant risk factor in the population of patients undergoing femoral access PCI. This is consistent with research showing that smoking is a major risk factor for coronary artery disease and other cardiovascular conditions, which is directly related to the need for percutaneous coronary intervention (PCI) (Afriyanti et al., 2025) . Smoking is known to cause endothelial damage, increase the process of atherosclerosis, and decrease tissue perfusion, thereby increasing the likelihood of vascular complications after invasive procedures such as hematoma at the site of the procedure (Fawwaz & Pardede, 2023) . Therefore, the presence of a high prevalence of smokers in both groups in this study indicates that the study sample reflects a general clinical population in the context of coronary heart disease.

In comparative studies such as this, having a relatively balanced smoking history across groups is crucial. The relatively even distribution of smokers between the intervention and control groups helps minimize bias due to smoking risk factors in the analysis of the effectiveness of the Esaline cold compress intervention. This aligns with methodological guidelines that emphasize the importance of balancing risk characteristics between treatment groups to validate conclusions about the actual effect of the intervention under study (Pascayantri et al., 2025) . Several studies have also shown that smoking can slow tissue healing and affect the response to post-procedural therapy, including hematoma formation and minor bleeding (Purwoko et al., 2025). However, because the distribution of smoking was relatively balanced between the two groups, the observed change in hematoma incidence is more likely related to the effectiveness of the Esaline cold compress administration than to differences in smoking history.

Difference in Hematoma Area between Intervention and Control Groups

The test results showed that applying a saline cold compress significantly reduced the size of the hematoma. Overall, there was a significant difference between the bruise's condition before and after the procedure. This confirms the effectiveness of the intervention in reducing the size of the hematoma. This finding aligns with several previous studies. Research by Yassen et al. (2025) showed that post-cardiac catheterization patients who were given cold compresses on the femoral area experienced a significantly smaller hematoma area compared to the control group (Yassen et al., 2025) . Another study by Mohamed et al. (2025) reported that the application of cold Post-IKP therapy can reduce subcutaneous bleeding and hematoma formation, especially in the early hours after the procedure. (Mohamed et al., 2025) .

Experimental research by Fadhilah et al (2023) also found that cold compresses contribute to the stabilization of the vascular puncture area, thereby preventing hematoma expansion due to small blood vessel leakage (Fadhilah et al., 2023) . Similar results were reported in the systematic review by Kareem & Al- kassar (2023) which concluded that cold intervention Compression is an effective non-pharmacological strategy in reducing vascular complications after femoral access IKP. (Kareem & Al-kassar, 2023) . The results of the research by Buldak and Cinar (2024) with the title effects of cold application before subcutaneous injection of low-molecular-weight heparin on pain, bruising, and hematoma formation, showed that patients who received cold compresses before the procedure had smaller bruises and hematomas than patients without cold compresses. Furthermore, patients also reported less discomfort. The cold effect helps constrict blood vessels, thereby

suppressing bleeding under the skin and reducing the size of the hematoma (Buldak & Çınar, 2024) . The results of research by Suhandi et al. (2023) entitled coldpack intervention to alleviate hematoma in patient post-percutaneous coronary intervention, reported that post-IKP patients who were given cold The cold pack resulted in faster hematoma reduction compared to standard treatment. Researchers confirmed that cold therapy helps control local bleeding and prevents hematoma enlargement (Suhandi et al., 2023) .

Theoretically, these results can be explained by the physiological mechanisms of cold therapy (cryotherapy). Cold compresses cause local vasoconstriction, which serves to reduce blood flow to the tissues surrounding the catheter insertion area, thereby reducing the risk of bleeding and hematoma formation. (Asy'ari et al., 2024) . Exposure to cold temperatures can decrease capillary permeability, inhibit the inflammatory process, and reduce blood accumulation in subcutaneous tissue. According to the hemostasis theory, restricting blood flow in the early phase after vascular trauma plays a crucial role in the formation of a stable blood clot, thus preventing hematoma expansion. This intervention also aligns with the theory of preventing post-procedural complications. invasive, emphasizing the importance of bleeding control and protecting the surrounding tissue (Patil et al., 2025) . According to researchers, applying a saline cold compress directly limits the size of the hematoma through vasoconstriction and stabilization of local hemostasis. The smaller hematoma size in the intervention group indicates that the intervention was performed at the appropriate time and duration, effectively preventing the expansion of subcutaneous hemorrhage. The variation in hematoma size still found in the intervention group is likely influenced by individual factors, such as vascular conditions, coagulation status, and patient compliance with bed rest. Without cold compress intervention, as in the control group, microbleeding in the femoral access area tends to continue and cause a larger hematoma.

The Effectiveness of Cold Compresses in Preventing Hematomas

The study results confirmed that the use of Esaline cold compresses was significantly more effective in reducing hematoma size compared to standard care. Overall, the group receiving cold compresses showed significantly smaller bruises, thus proving this method very useful in preventing and minimizing bruising after the procedure. These findings indicate that the administration of Esaline cold compresses is effective in reducing hematoma size compared to standard care without cold compresses. Physiologically, the therapeutic effect of cold compresses is related to the mechanism of vasoconstriction of blood vessels, decreased local blood flow, and reduced capillary permeability (Bonnet et al., 2025; Fadhilah et al., 2023) . These conditions play an important role in inhibiting blood extravasation at the femoral artery puncture site, thereby preventing or minimizing hematoma formation (Suhandi et al., 2023) . In addition, cold compresses also reduce tissue metabolic activity and the inflammatory response, which contributes to reduced swelling and hematoma expansion after invasive procedures (Alba et al., 2019; Ozkan & Cavdar, 2021; Prasetya & Handian, 2023) .

The results of this study are consistent with previous studies that have shown that cold therapy is effective in reducing bleeding and vascular complications during invasive procedures. Several studies have shown that cold therapy application Cold compresses on the vascular access area can improve hemostatic stability by accelerating the vessel closure process and reducing the risk of blood leakage into the surrounding tissue. In the context of femoral access PCI, where the risk of vascular complications is relatively high, a simple intervention such as cold compresses has the potential for significant clinical benefits. Kurt & Kasikci's (2019) study entitled The Effect of Cold Application on Hematoma, Ecchymosis, and Pain at the Catheter Site in PCI Patients about patients undergoing IKP with cold the pack is placed under the sandbag at the femoral incision point for 15 minutes after removal of the arterial catheter. femoralis. Significant results showed that the group that received cold The cold pack group had smaller hematoma and ecchymosis sizes and lower pain compared to the group without cold pack. pack at various monitoring points (15 minutes, 4 hours,

48 hours, and 72 hours) (Kurt & Kasikci, 2019). Statistically, it was proven that the cold application significantly reduced hematoma formation and other vascular symptoms after affliction.

Valikhani's research results et al (2020) entitled *The Effect of Simultaneous Sand -Ice Bag Application on Hemorrhage and Hematoma after Percutaneous Coronary Intervention*, explains that the combination of ice applications The use of bags and sandbags after PCI showed a trend towards reduced bleeding rates and hematoma incidence compared to the control group (sandbag only), although the hematoma reduction results did not reach statistical significance in some measures (Valikhani et al., 2020) . These findings still support the additional role of cold compresses in post-PCI hematoma prevention strategies. The results of a study by Kareem & Al- Kassar (2023) entitled *Effect of Direct Cold Compress for Femoral Arterial Sheath Removal on Reduction of Local Vascular Complications in Patients after Percutaneous Coronary Intervention* explains that applying cold compresses directly to the femoral extraction site arterial Sheath application after PCI significantly reduced local vascular complications, including hematoma, bleeding, and bruising (ecchymosis), compared with standard care without cold compresses (Kareem & Al-Kassar, 2023) . This study showed that the vasoconstrictive effect of cold compresses helps reduce local blood flow and enhances the coagulation process, thus preventing hematoma.

Research by Zhi et al. (2024) found that patients who were given cold compresses on the femoral area after PCI experienced a significant reduction in hematoma size and bleeding incidence compared to the control group (Zhi et al., 2024) . Another study by Pamuk & Özkaraman (2024) in the *Journal of Cardiovascular Nursing* also reported that the application of cold Controlled compression can reduce vascular access complications, including hematoma and ecchymosis, with a statistically significant difference ($p < 0.05$) (Pamuk & Özkaraman, 2024) . National research by Bazied et al (2022) showed that the use of cold compresses after cardiac catheterization significantly reduced the size of the hematoma and accelerated the tissue healing process (Bazied et al., 2022) . Similar findings were also concluded in a systematic review. review by Prasetya & Handian (2023) which states that cold therapy provides a protective effect on blood vessels after the procedure invasive (Prasetya & Handian, 2023)

Saline cold compresses can be explained through the physiological mechanisms of cryotherapy. Exposure to cold temperatures causes local vasoconstriction, which serves to reduce the diameter of blood vessels, reducing blood flow to surrounding tissues, and limiting microbleeding that occurs due to vascular trauma during PCI (Nuraeni et al., 2023) . Cold therapy also decreases tissue metabolism and capillary permeability, thereby reducing blood leakage into the subcutaneous tissue that forms the basis for hematoma formation. In the context of hemostasis theory, this vasoconstriction condition supports the formation of a more stable blood clot, thereby preventing hematoma expansion in the femoral artery insertion area. (Korkmaz & Karagözoğlu, 2022) . From a nursing perspective, cold compresses are interventions that are in accordance with the theory of preventing post-procedure complications. invasive, which emphasizes bleeding control, tissue stabilization, and increasing patient comfort.

Significant difference in hematoma size between the intervention and control groups also suggests that standard care without cold compresses is not yet optimal in preventing hematoma complications. This may be due to limited mechanical pressure, individual vascular responses, and the use of anticoagulants or antiplatelets post-PCI, which increase the risk of bleeding. With the use of saline cold compresses, these pharmacological effects can be minimized locally through non-pharmacological mechanisms. (Patil et al., 2025) . From a nursing perspective, the results of this study strengthen the role of nurses in preventing post-PCI complications through evidence-based independent interventions. Practice. Saline cold compresses are a relatively easy, safe, and inexpensive intervention that can be widely implemented in cardiovascular care units. Implementation of this intervention has the potential to improve the quality of nursing care and

reduce the incidence of vascular complications, particularly hematomas after femoral access PCI.

This is very applicable in cathlab service facilities that use anticoagulants. unfractionated heparin (UFH) and do not yet have ACT laboratory examination facilities, especially in the JKN era for several reasons, namely that saline cold compresses are relatively cheap and readily available, can reduce the need for additional measures and reduce the length of hospital stay (length of stay). of stay), improves patient safety without the need for additional pharmacological interventions, and can be implemented as part of the post -IKP nursing SOP in cardiology units and CCUs as a minimum standard of care. Cold compresses are a supportive non-pharmacological method, not replacing proper mechanical or physiological hemostasis, strict clinical observation is still carried out and pharmacological management is as indicated. Optimal effectiveness when applied in a timely manner (as soon as the sheath is removed) and followed by regular clinical observation.

According to researchers, administering a saline cold compress significantly reduced the hematoma area through local vasoconstriction and stabilization of hemostasis. The significant difference in hematoma area between groups indicates that the intervention was effective, timely, and procedurally performed. The variation in hematoma area that was still found is likely influenced by individual patient factors, such as blood vessel elasticity, anticoagulant use, and bed rest compliance. Without the cold compress intervention, as in the control group, the microbleeding process tends to continue, resulting in a larger and more varied hematoma. This intervention is suitable as part of a post -IKP nursing care package, especially in JKN services that emphasize cost efficiency, patient safety, and service quality.

The results of this study indicate that saline cold compresses are significantly effective in reducing the size of hematomas after Percutaneous Coronary Intervention (PCI) with femoral access. These findings have broad implications for cardiovascular nursing practice, particularly in the postoperative phase. invasive. Clinically, saline cold compresses can be categorized as an independent nursing intervention. nursing intervention) which is based on physiology and evidence-based The mechanism of action of cold compresses is through vasoconstriction. Arteriolar dilation, decreased capillary permeability, and increased blood viscosity contribute to reducing blood extravasation into the tissues surrounding the puncture site, thereby suppressing hematoma formation. This intervention is non-pharmacological, relatively safe, easy to apply, and low-cost, making it highly relevant for use in cardiac wards, the intensive care unit (ICCU), and the intensive care unit (CCU) as part of comprehensive post-PCI nursing care.

In addition, the implementation of saline cold compresses is becoming increasingly important in hospitals that do not yet have Activating examination facilities. Clotting Time (ACT) and still using unfractionated Heparin (UFH) is used as an anticoagulant during the procedure. In the context of healthcare services in the National Health Insurance (JKN) era, the use of UFH without monitoring with an ACT has the potential to increase the risk of bleeding and hematoma. Therefore, a simple yet effective intervention such as saline cold compresses can serve as a rational and contextual strategy for mitigating the risk of local bleeding. From a policy and clinical governance perspective, the results of this study imply the need to develop or revise Standard Operating Procedures (SOPs) for post- femoral access PCI care. Saline cold compresses can be integrated into sheath removal protocols. femoral as adjuvant therapy combined with standard methods such as manual compression or pressure This integration has the potential to increase the effectiveness of preventing vascular complications while strengthening evidence-based nursing practice in cardiac catheterization services.

Another implication relates to patient safety and comfort. Reducing the size of the hematoma not only reduces local bleeding but also contributes to decreased pain intensity, increased comfort, and a reduced risk of further complications such as infection, secondary bleeding, and prolonged

hospital stay. Thus, this intervention supports the principle of patient- centered care. safety and quality of care through preventing complications from the early post-operative phase. In the context of education and professional development, these findings can serve as a reference in evidence-based teaching. Nursing in the field of medical- surgical and cardiovascular nursing. Strengthening nurses' competencies in preventing post-operative complications. invasive interventions through evidence-based, non-pharmacological approaches will improve the quality of clinical practice. Furthermore, this research fosters a culture of nursing research oriented toward simple innovations with significant clinical impact.

CONCLUSION

This study showed that the baseline characteristics of respondents in the intervention and control groups were relatively comparable, thus supporting the study's internal validity and strengthening the assumption that the differences in outcomes were influenced by the intervention. The analysis showed that the average hematoma area in the group receiving saline cold compresses after sheath removal was smaller than the group receiving only standard care. These findings indicate that saline cold compresses are effective in reducing hematoma size through physiological mechanisms such as local vasoconstriction, decreased capillary permeability, and optimization of hemostasis. Therefore, saline cold compresses can be considered an applicable, safe, and low-cost non-pharmacological nursing intervention in preventing hematoma complications. post- femoral access Percutaneous Coronary Intervention (PCI) procedure. However, interpretation of the results of this study requires consideration of several limitations. First, control of procedural factors was not fully optimized, particularly regarding variations in technique and pressure force during sheath removal. femoral. Although the procedure followed applicable operational standards, the manual pressure applied by the operator could not be objectively and consistently standardized for each respondent. This variability has the potential to be a confounding factor affecting the extent of hematoma formation. Second, the study's limited observation period of 24 hours post-procedure did not allow for evaluation of the long-term effects of saline cold compresses on delayed hematoma development or other vascular complications. Therefore, the external validity and generalizability of the findings require further study. Based on these findings and limitations, further research is recommended to use a multicenter design with a larger sample size to increase the generalizability of the results. Standardization of pressure techniques can be considered through the use of pressure gauges or more controlled protocols to minimize operator bias.

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