



CRYOTHERAPY INTERVENTION TO REDUCE CANNULATION PAIN IN HEMODIALYSIS PATIENTS

Giri Susanto*, Wati Jumaiyah, Siti Latipah, Fitriani Rayasari

Faculty of Nursing, Universitas Muhammadiyah Jakarta, Jl. Cemp. Putih Tengah No.27, Cemp. Putih Timur, Cemp. Putih, Jakarta Pusat, Jakarta 10510, Indonesia

*riusansuke@gmail.com

ABSTRACT

End-stage chronic kidney disease requires hemodialysis with vascular access via an arteriovenous fistula (AVF). AVF cannulation is often painful. Cryotherapy, a cold therapy that can reduce pain through gate control theory, is used. Objective to assess the effectiveness of cryotherapy in reducing pain during arteriovenous fistula (AVF) puncture in hemodialysis patients. This study applied an Evidence-Based Nursing Practice approach, including a literature search through PubMed and ProQuest databases. The primary reference used was a systematic review and meta-analysis entitled "The Effect of Cryotherapy on Pain Associated with Arteriovenous Fistula Puncture in Hemodialysis Patients." This study used a single-group pre-test and post-test design. The population consisted of hemodialysis patients with AVFs who met the inclusion criteria, patients undergoing regular hemodialysis, using AVF access, and who had been using AVF access for more than three months. Exclusion criteria included patients who had taken pain medication within three hours before hemodialysis. A total of 19 participants were included. The intervention involved applying ice gel compresses to the cannulation area for 10 minutes before the procedure. Pain levels were measured using a Visual Analogue Scale before and after the intervention. Data were analyzed using paired t-tests and Chi-square tests. Cryotherapy significantly reduced AVF cannulation pain, with a p-value of 0.001. There was a difference in pain levels before and after the cryotherapy intervention.

Keywords: cryotherapy; hemodialysis; pain

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INTRODUCTION

Chronic Kidney Disease (CKD) is a progressive and irreversible decline in kidney function, where the body fails to maintain metabolic, fluid, and electrolyte balance (Kallenbach, 2020). The suffering of CKD is increasing globally, with the number of diagnosed cases doubling approximately every seven years (Rangaswami et al., 2019). It is estimated that more than 500 million people worldwide suffer from CKD and are at risk of progressing to end-stage kidney disease if early diagnosis and intervention are not provided (Malekmakan et al., 2018). According to the International Kidney Federation, in 2021, the global prevalence of chronic kidney failure reached over 10% of the world's population, amounting to approximately 800 million cases (Kovesdy, 2022).

In Indonesia, data from the 2023 Indonesian Health Survey shows that 0.18% of the population is affected by CKD, with the highest prevalence found in Lampung Province at 0.30%. Based on medical diagnoses, the percentage of the population undergoing dialysis increased from 19.3% in 2018 to 21.1% in 2023 (Indonesian Health Survey, 2023). Hemodialysis (HD) is the most commonly used renal replacement therapy, with an arteriovenous fistula (AVF) being the standard vascular access due to its durability and long-term viability. One of the most distressing experiences for patients undergoing hemodialysis is the pain at the needle insertion site during AVF cannulation. Therefore, effectively reducing this pain and discomfort is a crucial aspect of patient care (Sasani et al., 2024).

Pain associated with arteriovenous fistula puncture is a long-standing clinical issue that remains controversial in terms of management across various clinical settings. This pain, if left unaddressed, can negatively affect patients' acceptance of dialysis therapy (Gonella et al., 2022; Kortobi et al., 2020). Repeated AVF punctures may lead to several adverse effects, including anxiety, fear, and severe pain (Aghajanloo et al., 2016). On average, patients experience approximately 300 AVF punctures per year, which can lead to psychological distress, chronic pain, depression, decreased quality of life, and reduced compliance with dialysis intervention (Neamah & Abd Ali, 2023).

Therefore, pain management during dialysis procedures is of utmost importance and should be a clinical priority to maintain patient comfort and minimize hemodialysis-related complications (Jafari-Koulae et al., 2020). Pharmacological interventions like lidocaine (in the form of topical creams, sprays, or 2% intradermal injections) are often used to manage pain. However, these interventions can be expensive and are not ideal for long-term use due to the potential for adverse side effects on the skin (Kortobi et al., 2020; Back & Lee, 2020).

Cryotherapy is a non-pharmacological technique that uses cold temperatures to reduce inflammation and pain by inhibiting the activity of pain-conducting nerve fibers (Attia & Hasan, 2017). In hemodialysis patients undergoing AVF cannulation, cryotherapy also works through the gate control theory, which posits that stimulating non-pain nerve fibers can block pain signals, thereby reducing perceived pain (Berman, Snyder, & Frandsen, 2021). Cryotherapy involves the local application of cold to inhibit pain transmission by stimulating non-nociceptive nerve fibers. Exposure to cold temperatures reduces sympathetic neurotransmitter release, slows pain signal transmission, suppresses nociceptor sensitivity, and triggers endorphin release, producing analgesic and local anesthetic effects (Garcia et al., 2021; Yam et al., 2018; Algafly & George, 2007).

Several studies have shown that cryotherapy is effective in reducing AVF cannulation pain in hemodialysis patients. It is a low-risk and simple procedure. When applied for 10 minutes or more before needle insertion, cryotherapy is more effective in reducing both the physical and psychological impacts of cannulation pain (Sasani et al., 2024; Beydokhti et al., 2021; Jafari-Koulae et al., 2020). Cryotherapy is a non-invasive, cost-effective, and safe method for relieving AVF cannulation pain in hemodialysis patients, with a success rate of up to 80% without the need for additional medications. As an independent nursing intervention, cryotherapy effectively reduces AVF cannulation pain without complications and is therefore recommended as a non-pharmacological pain management method in hemodialysis care (Neamah & Abd Ali, 2023; Porromezani et al., 2019). The purpose of this study was to assess the effectiveness of cryotherapy in reducing pain during arteriovenous fistula (AVF) puncture in hemodialysis patients.

METHOD

The objective of this evidence-based nursing practice (EBNP) application was to evaluate the effectiveness of cryotherapy in reducing cannulation pain in hemodialysis patients at Dr. H. Abdul Moeloek Regional General Hospital, Lampung. This EBNP implementation was guided by a literature review conducted through the PubMed and ProQuest databases. The main source was an article titled "Effect of Cryotherapy on Arteriovenous Fistula Puncture-Related Pain in Hemodialysis Patients: A Systematic Review and Meta-Analysis", using a one-group pre-test and post-test design. The implementation was carried out from April 22nd to April 28th, 2025. The population of study included hemodialysis patients with arteriovenous fistula (AVF) access who met the inclusion criteria: patients who undergo regular hemodialysis, have used AVF access, and have been on hemodialysis for more than three months. Exclusion criteria included patients who had taken pain medication within three hours before dialysis and those with dysfunctional fistulas. The sample size was determined using G*Power software, with an effect size of 0.85, alpha error probability of 0.05, and power of 0.95, resulting in a total of 19 participants. The intervention consisted of applying cryotherapy in the form of an ice gel pack to the cannulation area for 10

minutes before needle insertion. Pain levels were measured using the Visual Analogue Scale (VAS) before and after the intervention. Data were analyzed using paired t-tests to assess differences in pain levels and Chi-square tests to determine the relationship between pain levels and patient characteristics. This study received ethical approval from the Nursing Ethics Committee, with ethical exemption number: 483/KEPK-RSUDAM/III/2025.

RESULT

Table 1
Patient Characteristics Based on Age, Gender, and Duration of Hemodialysis in Chronic Kidney Disease Patients Undergoing Hemodialysis

Patient Characteristics	Category	f	%
Age	26–46 years	9	47,4
	47–66 years	10	52,6
Gender	Male	9	47,4
	Female	10	52,6
Duration of HD	<1 year	7	36,8
	1–3 years	11	57,9
	>3 years	1	5,3

The table shows that 52.6% of patients were aged between 47–66 years, and 47.4% were aged 26–46 years, with the average age being 47.6 years. Female patients accounted for 52.6% (10 patients), while male patients made up 47.4% (9 patients). The majority of patients (57.9%) had been undergoing hemodialysis for 1–3 years. Meanwhile, 36.8% had been on HD for less than 1 year, and only 5.3% (1 patient) had been on HD for more than 3 years.

Table 2
Pain Level Distribution Before Cryotherapy in Chronic Kidney Disease Patients Undergoing Hemodialysis

Variable	Category	f	%
Pre-test pain level	Light (1-3)	0	0
	Medium (4-6)	5	26,3
	Heavy (7-10)	14	73,7

This table shows that before cryotherapy was applied, none of the patients experienced mild pain, and 73.7% of patients reported severe pain.

Table 3
Pain Level Distribution After Cryotherapy in Chronic Kidney Disease Patients Undergoing Hemodialysis

Variable	Category	f	%
Post-Test 1 Pain Level	Mild	2	10,5
	Moderate	14	73,7
	Severe	3	15,8
Post-Test 2 Pain Level	Mild	f	%
	Moderate	7	36,8
	Severe	10	52,7
Post-Test 1 Pain Level	Mild	2	10,5

Table 3 shows that after the first cryotherapy intervention, 10.5% of patients experienced mild pain, and only 15.8% reported severe pain. Following the second application of cryotherapy, 36.8% of patients reported mild pain, and only 10.5% suffered severe pain. Table 4 indicates that there is no significant correlation between age, gender, or duration of hemodialysis and AVF cannulation pain levels, with all p-values > 0.05.

Table 4

The Correlation Between Age, Gender, and Duration of Hemodialysis and Cannulation Pain Levels in Chronic Kidney Disease Patients Undergoing Hemodialysis

Variables	Pain Level						Total	<i>p value</i>
	Mild		Moderate		Severe			
	f	%	f	%	f	%	f	%
Age								
26-46 years	1	11,1	6	66,7	2	22,2	9	100
47-66 years	1	10,0	8	80,0	1	10,0	10	100
Gender								
Male	1	11,1	7	77,8	1	11,1	9	100
Female	1	10,0	7	70,0	2	20,0	10	100
Duration of HD								
<1 year	0	0	6	85,7	1	14,3	7	100
1-3 years	2	18,2	7	63,6	2	18,2	11	100
> 3-year	0	0	1	100	0	0	1	100

Table 5.

Differences in Mean Pain Levels Before and After Cryotherapy Intervention in AVF Cannulation Among Hemodialysis Patients

Variables	N	Mean	t	df	Sig.(2 tailed)
Pain Level					
Pre test	19	7.32	20.000	18	<0.001
Post test 1	19	5.21			
Pre test	19	7.32	14.366	18	<0.001
Post Test 2	19	4.16			

The results show that the average pain level before cryotherapy was 7.32. After the first cryotherapy intervention, the average pain level decreased to 5.21, and further decreased to 4.16 after the second intervention. This indicates a difference in pain intensity before and after the application of cryotherapy, with values of 2.105 and 3.158, respectively, and a significance value of $p < 0.05$, meaning that there is a statistically significant difference in pain levels before and after cryotherapy.

DISCUSSION

Patient Characteristics and Pain Level

The results of this study indicate that there is no significant correlation between age, gender, and duration of hemodialysis with AV fistula cannulation pain level, with a p -value > 0.05 . According to Berman, Snyder, & Frandsen (2021), age can affect an individual's ability to detect and communicate pain. Infants and the elderly tend to have difficulty expressing pain, while younger adults are more capable but may be more sensitive to invasive procedures. Physiological changes related to aging also affect pain perception; however, these are not the dominant factors, as psychological, cultural, and gender aspects also play roles. The relationship between age and pain is non-linear: younger individuals may be more sensitive to pain, while older adults may experience reduced sensitivity but are more prone to chronic pain due to neurological and psychological changes.

This is consistent with findings from studies by Golda et al. (2016) and Arab et al. (2017), which reported no statistically significant correlation between post-intervention pain scores and socio-demographic variables such as age, gender, education, occupation, family income, duration of AV fistula use, number of hemodialysis sessions per week, psychological support sources, or the use of distraction therapy. Neamah & Abd Ali (2023) also reported no significant correlation between age and pain intensity in hemodialysis patients undergoing AV fistula cannulation. Pain mechanisms involve complex perception processes and are not solely determined by a person's biological age. While older adults may experience decreased peripheral nerve sensitivity, this does not necessarily impact subjective pain perception.

Additionally, there was no significant correlation between gender or duration of hemodialysis and AV fistula cannulation pain levels ($p > 0.05$). According to Berman, Snyder, & Frandsen (2021), gender may influence the response and expression of pain due to hormonal, cultural, and gender role factors. However, the lack of significance in this study may be due to individual variation, small sample size, participant homogeneity, or psychological and environmental factors, including past pain experiences.

Sasani et al. (2024) also reported no significant correlation between gender or duration of hemodialysis and cannulation pain levels, stating that pain response is more strongly influenced by psychological factors, anxiety, and prior experiences. In this study, female patients accounted for the majority (52.6%), possibly due to a higher risk of recurrent urinary tract infections that can progress to kidney disease. This aligns with findings by Bikbov, Perico, & Remuzzi (2018) and CDC (2021), which reported higher kidney disease prevalence in women.

Theoretically, the longer a patient undergoes hemodialysis, the more accustomed they become to cannulation procedures. However, experience does not always significantly reduce pain perception, as some patients may continue to experience psychological trauma or tissue damage. Sasani et al. (2024) also noted that the length of hemodialysis was not related to cannulation pain, as adaptation to pain is highly individualized and non-linear. Factors such as cannulation technique, fistula condition, and nurse expertise play a greater role in pain perception than the length of time the patient has been on hemodialysis.

These findings demonstrate that demographic factors and hemodialysis duration do not directly affect pain perception during cannulation. Pain perception is subjective and is more influenced by individual pain thresholds, psychological conditions, anxiety, personal experience, and environmental factors. Therefore, pain response is highly individualized and cannot be predicted solely based on demographic or clinical variables.

Differences in Pain Levels Before and After Cryotherapy in Hemodialysis Patients

The analysis revealed that the mean pain score before cryotherapy was 7.32, which decreased to 5.21 after the first intervention and further reduced to 4.16 after the second intervention. This shows a reduction in pain intensity of 2.105 and 3.158, respectively, with a p -value < 0.001 , indicating a statistically significant difference in pain levels before and after the application of cryotherapy. Cryotherapy intervention was statistically proven to reduce arteriovenous fistula (AVF) cannulation pain during hemodialysis, demonstrating meaningful clinical effectiveness. Previous studies support this finding. Neamah & Ali (2022) and Jafari-Koulaee et al. (2020) also reported significant pain reduction following cryotherapy. A systematic review and meta-analysis by Arshad et al. (2024) confirmed that cold compress intervention to AVF puncture sites effectively reduced cannulation pain. Studies by Sivan et al. (2024) and Rekha & Madhavi (2024) similarly demonstrated that cryotherapy intervention significantly reduced pain.

Pain is a sensory and emotional experience associated with actual or potential tissue damage, consisting of sensory and discriminative components as well as physiological and emotional responses to various stimuli (Potter & Perry, 2017). The pathophysiology of pain begins with a response to trauma or a stimulus applied to tissues, activating nociceptors (nerve receptors), which transmit pain impulses to the spinal cord and brain for pain perception (Smeltzer, Bare, Hinkle & Cheever, 2010). Cryotherapy is a non-pharmacological therapy that uses local cold application to reduce pain by stimulating sensory nerves and inhibiting pain transmission. This therapy is simple to administer, safe, and can be self-applied by patients (Attia & Hasan, 2017). Using ice or cold packs, cryotherapy lowers local skin temperature at the AVF puncture site, slowing the conduction of A δ and C nerve fibers and thereby inhibiting pain transmission to the spinal cord in accordance with gate control theory. Clinically, this therapy has been shown to reduce VAS pain scores by 1–2 points compared to placebo (Jafari-Koulaee et al., 2020; Back & Lee, 2020; Asthma Sivan et al., 2024).

Cryotherapy works by stimulating non-pain nerve fibers to transmit non-painful sensations, effectively "blocking" or inhibiting pain signal transmission. Exposure to cold reduces the release of neurotransmitters from sympathetic nerves to the arteriovenous anastomosis muscle layer, slows pain signal conduction, and produces analgesic and anesthetic effects (Garcia et al., 2021; Yam et al., 2018). According to Berman et al. (2021) in Kozier & Erb's Fundamentals of Nursing, applying ice compresses reduces pain impulse transmission by slowing nerve conduction velocity. At low temperatures, A-delta and C fibers (which carry pain signals) become less active, causing the brain to receive fewer pain signals during cannulation. The cold compress stimulates large-diameter sensory fibers that can block pain transmission at the spinal cord level, preventing pain signals from reaching the brain (gate control theory).

This theory explains that pain is not solely influenced by physical stimuli, but also by neurological control mechanisms in the spinal cord, particularly in the substantia gelatinosa of the dorsal horn. This area contains a "gate" that determines whether pain signals from the periphery are transmitted to the brain. Activation of large A-beta fibers (carrying non-painful sensations like touch, pressure, or vibration) can close this gate, thereby reducing pain. When a cold compress or touch is applied, A beta fibers are stimulated, the pain gate closes, and the pain impulse from cannulation does not reach the brain, reducing or eliminating the sensation of pain (Merchand, 2021). Several verbal responses from patients after the cryotherapy intervention during hemodialysis cannulation were observed. Most patients stated, "It feels more comfortable than usual; it didn't hurt as much during the needle insertion." One patient, Mr. A, said: "It felt numb, so the needle insertion wasn't too painful." Another, Mrs. S, reported: "The cold helped; the pain was less."

Currently, more and more patients are choosing non-pharmacological methods because they are more cost-effective and easily accessible. The results of this study are consistent with the findings of Ali Abdrabouh et al. (2022), which showed that applying cold compresses with ice cubes at the puncture site significantly reduced pain. The effectiveness of cryotherapy in relieving pain has been demonstrated in various studies. Furthermore, cryotherapy has clinical implications, as nurses can easily apply it to alleviate fistula puncture pain within a relatively short period of time (Neamah & Abd Ali, 2023). Based on these results, cryotherapy is proven effective in reducing pain in hemodialysis patients during AV fistula cannulation. The statistically significant reduction in pain suggests that cryotherapy can be considered a simple, cost-effective, and minimally invasive non-pharmacological alternative for reducing discomfort during invasive procedures.

CONCLUSION

Cryotherapy has been statistically proven to reduce AVF cannulation pain levels in hemodialysis patients. These findings indicate that cryotherapy is a promising intervention for reducing needle insertion pain in arteriovenous fistula access and should be further explored. This has important implications for the clinical application of cryotherapy in pain management and supports the development of evidence-based nursing practices.

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