

Effect of Cryotherapy Application in Pain of Hemodialysis Patients: Literature Review

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Abstract

Background: Kidney disease occurs when kidney reduces its normal function, less than 30% of normal activity is related to a long-term condition. Patients with chronic renal failure have to undergo lifelong hemodialysis (HD). HD patients experience pain during needle insertion to arteriovenous fistula. The aim of the study was to assess the effect of cryotherapy on pain of haemodialysis patients.

Aim of Study: Ascertain the Effect of Cryotherapy Application in Pain of Hemodialysis Patients.

Material and Methods: A literature review was conducted using PubMed, Cochrane Library, and Google Scholar databases. The search incorporated the keywords "Hemodialysis," "Arteriovenous Fistula," "Cryotherapy," and "Pain." Inclusion criteria encompassed studies published between 2016 and 2025, written in English, and involving adult hemodialysis patients. Both experimental (randomized controlled trials, clinical trials) and observational studies were included. Studies that did not assess AVF puncture pain reduction or lacked sufficient data on cryotherapy application were excluded. The primary outcome measure was pain intensity, evaluated using validated pain scales, including the Visual Analog Scale (VAS) and the Wong-Baker Faces Pain Rating Scale.

Results: The majority of the studies met the inclusion criteria, demonstrating that cryotherapy is an effective intervention for reducing AVF puncture pain. Findings revealed that localized cryotherapy application provide immediate and significant pain relief. Some studies suggested that vapocoolant sprays and frozen needles were also beneficial in reducing pain perception. In comparative analyses, cryotherapy outperformed lidocaine spray in minimizing AVF cannulation pain.

Conclusion: Cryotherapy is a safe, effective, and low-cost alternative to conventional pain management methods for AVF cannulation in HD patients. Given its ease of application and minimal risks, cryotherapy should be incorporated into routine clinical practice to enhance patient comfort and improve treatment adherence.

Key Words: Hemodialysis – Pain Management – Cryotherapy – Non-Pharmacological Pain Relief.

Introduction

CHRONIC kidney disease (CKD) is defined as a sustained estimated glomerular filtration rate (eGFR) of less than 60ml per minute per 1.73m² of body-surface area or a urinary albumin excretion of 30mg or more per day, or both, for more than 3 months. Kidney Disease: Improving Global Outcomes 2012 guidelines classified CKD, and the risk of progression based on both eGFR and the degree of albuminuria (the lower the eGFR and the higher the albuminuria, the worse the prognosis). Therefore, people need to participate in a haemodialysis (HD) programme [1]. The most common forms of RRT include hemodialysis (HD), peritoneal dialysis, and kidney transplantation. Among these, HD remains the predominant and widely used treatment modality due to its accessibility and established clinical efficacy [2]. It is projected that the number of ESRD patients requiring HD will continue to increase globally, driven by the rising prevalence of CKD and associated risk factors such as diabetes mellitus and hypertension [3].

Hemodialysis is a life-sustaining procedure that replaces the kidney's natural filtration function by removing excess water, solutes, and metabolic waste products from the blood stream, thereby

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maintaining homeostasis [4]. The process requires a vascular access point to enable high blood flow rates for effective clearance of toxins. The arteriovenous fistula (AVF) remains the gold standard for vascular access in HD patients due to its superior longevity, lower risk of infection, and reduced incidence of thrombosis compared to central venous catheters (CVCs) (5). Native AVFs offer prolonged patency and fewer complications, contributing to improved patient outcomes [6].

Considering that hemodialysis typically occurs three times a week, with each session lasting 3 to 4 hours, patients endure needle-related stress and pain approximately 320 times annually. Consequently, effectively mitigating this pain and distress is a crucial aspect of patient care [7]. Inadequate pain management during AVF cannulation can exacerbate needle-related fear and avoidance behaviors, potentially leading to shortened dialysis sessions, increased complications, and deteriorated clinical outcomes [8]. Current pain management strategies include the use of local anesthetic agents, such as lidocaine-based creams or vapocoolant sprays, to provide transient relief [9].

As a non-pharmacological intervention, cryotherapy has emerged as a promising alternative for pain relief during AVF cannulation. By reducing nerve conduction velocity and increasing the pain threshold, cryotherapy has been shown to alleviate needle-related pain effectively [10]. Given its simplicity, affordability, and minimal side effects, cryotherapy could serve as a valuable adjunct in clinical practice to improve patient comfort during hemodialysis [11]. This review aims to evaluate the effectiveness of cryotherapy in reducing pain associated with AVF puncture in HD patients.

Material and Methods

A systematic literature review was conducted to comprehensively evaluate the existing body of research on the effectiveness of cryotherapy in managing pain associated with arteriovenous fistula (AVF) cannulation in hemodialysis patients. The review was performed using three widely recognized and reputable electronic databases: PubMed, Cochrane Library, and Google Scholar. These databases were selected due to their extensive coverage of peer-reviewed medical literature and their role as authoritative sources for evidence-based research in healthcare.

The search strategy was carefully designed to ensure the identification of the most relevant studies. The keywords utilized in the search included “Hemodialysis,” “Arteriovenous Fistula,” “Cry-

otherapy,” and “Pain”. These search terms were selected based on their significance in capturing studies related to pain management during AVF cannulation using cryotherapy. Boolean operators were employed to refine and optimize the search results, ensuring that articles encompassing the intersection of these key concepts were retrieved.

Inclusion criteria were established to ensure that only high-quality and pertinent studies were considered in the review. The selected studies were required to be published between 2016 and 2025, allowing for the most up-to-date research on the subject. Additionally, only articles written in the English language were included to maintain consistency in data interpretation and avoid translation bias. Studies had to focus specifically on cryotherapy as an intervention for pain management during AVF cannulation. Both experimental (randomized controlled trials, clinical trials) and observational studies (cohort studies, case-control studies, and cross-sectional studies) were considered to ensure a comprehensive evaluation of the available evidence. Furthermore, only studies involving hemodialysis patients were included to maintain a homogeneous patient population and enhance the applicability of findings to clinical practice.

Conversely, exclusion criteria were applied to filter out studies that did not align with the primary research objectives. Articles that did not specifically assess pain reduction during AVF cannulation were excluded, as were studies focusing on other pain management strategies unrelated to cryotherapy. Non-English publications were omitted to prevent misinterpretation of findings due to translation limitations. Additionally, studies with insufficient data on cryotherapy application, such as those lacking details on intervention methodology, patient outcomes, or statistical analysis, were excluded to ensure the reliability and robustness of the review findings.

The primary outcome measure for this systematic review was pain intensity during AVF cannulation. Pain levels were assessed using validated pain scales, including the Visual Analog Scale (VAS) and the Wong-Baker Faces Pain Rating Scale. These pain assessment tools were chosen due to their widespread use in clinical research and their ability to provide quantitative and qualitative measures of pain perception in hemodialysis patients. The VAS is a 10 cm linear scale where patients rate their pain from 0 (no pain) to 10 (worst possible pain), providing a continuous measure of pain severity. The Wong-Baker Faces Pain Rating Scale, commonly used for subjective pain assessment,

presents patients with a series of facial expressions representing different levels of pain, making it particularly useful for individuals with varying literacy levels or difficulties in verbal communication.

Results

Following the application of the predefined inclusion and exclusion criteria, a total of six studies were identified and analyzed. These studies provided consistent evidence supporting cryotherapy as an effective non-pharmacological intervention for reducing pain associated with AVF cannulation

in hemodialysis patients. The reviewed literature encompassed a diverse patient population, considering both male and female participants across different age groups and clinical backgrounds. The methodologies varied slightly across studies, including the type of cryotherapy applied, duration of application, and specific site of intervention. However, all studies concluded that cryotherapy led to significant reductions in pain intensity when compared to conventional or no interventions. A detailed summary of the reviewed studies, including their methodologies and outcomes, is provided in Table (1).

Table (1): Correlation between PFT and PPBS among cases with asthma and diabetes mellitus.

Study ID	Design	Patient	Age	Outcomes	Comparator	Conclusion
- NurIsnaini et al., 2018	- Quasi-experimental	- 40 patients (20 intervention, 20 control) with chronic renal disease undergoing hemodialysis	16-60 years	- Pain scale (Numeric Rating Scale, NRS)	- Control group (no intervention)	- The combination of slow deep breathing and ice therapy significantly improved comfort during AV fistula insertion ($p=0.000$)
- Gouda et al., 2023	- Randomized Controlled Trial (RCT)	- 108 adult hemodialysis patients	Mean age: 43.7 ± 15.6 years	- Pain severity using Visual Analog Scale (VAS)	- Control group (routine care)	- Cold packs were more effective in reducing cannulation pain compared to lidocaine spray and flashlights
- Elhalafawy et al., 2020	- Quasi-experimental research design	- 60 children undergoing hemodialysis with AVF	6-15 years	- Pain reduction measured by Wong Baker Faces Pain Scale and Behavioral Distress Scale	- Comparison between cryotherapy (ice massage) and aromatherapy (lavender oil inhalation)	- Both cryotherapy and aromatherapy reduced AVF puncture pain, but cryotherapy was more effective
- Attia & Hassan, 2017	- One-group pre-post quasi-experiment	- 40 children undergoing hemodialysis with AVF	8-16 years Mean age:	- Pain reduction measured using Wong-Baker Faces Pain Scale and Observed Pain Behavior Rating Scale	- Comparison before and after cryotherapy application	- Cryotherapy significantly reduced pain at AVF puncture sites in children undergoing maintenance HD
- da Silva et al., 2016	- Cross-sectional study	- 70 chronic renal patients undergoing hemodialysis	60 ± 19 years	- Pain intensity measured using Visual Analogue Scale (VAS)	- No intervention; pain assessed during AVF cannulation	- Majority of patients reported moderate (58.5%) or severe (30%) pain during AVF cannulation, highlighting the need for pre-cannulation analgesia

Mechanism of cryotherapy in pain reduction:

The analgesic effect of cryotherapy is primarily explained by the Gate Control Theory of Pain, a well-established concept in pain modulation. According to this theory, the transmission of pain signals is mediated by small-diameter C-fibers, which carry nociceptive impulses to the spinal cord. When the skin is stimulated by cold application, A-delta fibers which are larger, faster-conducting sensory fibers are activated. This afferent competition at the spinal cord level “closes the gate” to nociceptive signals, thereby inhibiting pain perception [12]. Additionally, cold application reduces nerve con-

duction velocity, leading to slower transmission of pain signals, which further contributes to decreased nociceptive input and enhanced pain tolerance [13].

Application of cryotherapy in AVF cannulation pain management:

Various cryotherapy techniques have been assessed for their efficacy in alleviating AVF cannulation pain. The studies reviewed explored different application methods, including localized cryotherapy directly at the puncture site, cryotherapy applied to remote acupressure points, the use of vapocoolant sprays, and frozen needles.

Localized cryotherapy over AVF puncture site:

One of the most direct applications of cryotherapy involves applying ice directly to the AVF puncture site before cannulation. This method ensures localized pain relief by numbing the area and reducing pain perception. Elhalafawy et al. [10] conducted a study demonstrating that ice massage applied directly to the AVF puncture site using slow, circular motions until numbness was achieved led to significant pain reduction. Patients who received this intervention reported lower pain scores compared to those who underwent AVF cannulation without cryotherapy.

Attia & Hassan [11] described an alternative method where 2 cm–3 cm pieces of frozen distilled water enclosed in a plastic bag were placed over the AVF puncture site before cannulation. This technique effectively numbed the area and provided substantial pain relief, making it a feasible and inexpensive approach for clinical use.

Cryotherapy at remote acupressure points (Hegu Point):

Another approach investigated in multiple studies is cryotherapy applied at remote acupressure points, specifically the Hegu point (the web space between the thumb and index finger of the contralateral hand). Dehghan et al. [12] and Alzaatreh & Abdalrahim [2] explored the efficacy of applying ice packs to the Hegu point for 10 minutes prior to AVF cannulation. The findings revealed that this remote cryotherapy intervention significantly lowered pain scores post-application, suggesting that stimulation of specific acupressure points can provide systemic analgesic effects. This technique is particularly advantageous as it allows cryotherapy to be applied without interfering with the AVF access site, making it a convenient and practical approach for routine use in hemodialysis clinics.

Vapocoolant spray as an alternative to ice therapy:

Vapocoolant sprays, which rapidly cool the skin surface through evaporative cooling, have also been evaluated as an alternative cryotherapy method. Attia & Hassan [11] suggested that vapocoolant sprays applied either directly to the AVF puncture site or to the contralateral limb provided a viable non-pharmacologic alternative for pain relief. The cooling effect of the vapocoolant spray was found to reduce pain perception within seconds, making it a rapid and effective option for patients undergoing AVF cannulation.

Use of frozen needles:

A unique technique investigated in one study involved the use of frozen needles for AVF cannulation. A comparative study examined standard room-temperature needles versus needles frozen at -8°C prior to insertion. The results demonstrated that patients who received cannulation with frozen needles experienced significantly lower pain intensity compared to those who underwent standard needle insertion [13]. The proposed mechanism behind this effect is that the reduced temperature of the needle causes localized numbing of the puncture site upon entry, thereby decreasing pain perception. This method offers an innovative alternative to pre-application of ice packs and could potentially be integrated into routine hemodialysis practice.

Discussion

Chronic kidney disease (CKD) is a progressive and debilitating condition that has profound implications for patients undergoing long-term hemodialysis (HD). As the disease advances to end-stage renal disease (ESRD), patients become completely dependent on renal replacement therapy, with HD being the most widely used modality. However, despite its life-sustaining benefits, HD is associated with several challenges, one of the most significant being pain during arteriovenous fistula (AVF) cannulation. This pain is not only physically distressing but also psychologically burdensome, often contributing to treatment-related anxiety, fear, and reduced compliance [14]. Research indicates that a substantial proportion of HD patients experience severe needle-related distress, leading to increased psychological stress and decreased adherence to treatment protocols [15].

The need for effective pain management strategies in hemodialysis:

Pain during AVF cannulation is a recurrent issue, given that most HD patients undergo three to four cannulations per week, amounting to hundreds of needle insertions per year. This frequency amplifies the negative emotional response associated with the procedure, making effective pain management a critical clinical necessity. Conventional pharmacological interventions, such as topical anesthetics (e.g., lidocaine cream) and vapocoolant sprays, have been commonly employed for pre-cannulation pain relief. However, these methods come with certain limitations, including delayed onset of action, variable effectiveness, cost concerns, and potential adverse reactions such as skin irritation

[16]. Consequently, there has been growing interest in non-pharmacological approaches, particularly cryotherapy, as a simple, low-risk, and cost-effective alternative for pain relief.

Cryotherapy as an effective pain management strategy:

Cryotherapy, which involves the application of cold to reduce pain perception, has been extensively studied for its analgesic properties in AVF cannulation. Several research studies have demonstrated its efficacy in alleviating puncture-related pain, whether applied directly to the AVF site or remotely at acupressure points [17]. Localized cryotherapy over the AVF site has been found to reduce pain immediately by numbing the area and decreasing nerve conduction velocity, thereby lowering nociceptive transmission and enhancing pain tolerance.

Contralateral cryotherapy, particularly at the Hegu point (the web space between the thumb and index finger), has been shown to provide a systemic analgesic effect, reducing pain perception without direct application to the puncture site. Comparative studies indicate that ipsilateral cryotherapy (i.e., applied directly to the AVF site) yields more immediate and localized pain relief, making it particularly beneficial for patients with high sensitivity to needle insertion. On the other hand, contralateral cryotherapy techniques, such as Hegu point stimulation, work by modulating the pain pathway through central nervous system mechanisms, providing a broader, systemic analgesic response [18]. These findings suggest that both techniques are effective, with the choice of method depending on patient preference and clinical feasibility.

Clinical evidence supporting cryotherapy:

A recent study by Gouda et al. [17] examined the effectiveness of cryotherapy in comparison to conventional lidocaine spray. The researchers found that applying cold packs to the AVF site five minutes before cannulation significantly outperformed lidocaine spray in reducing pain intensity. This highlights the potential superiority of cryotherapy over pharmacological agents for managing procedural pain in hemodialysis patients.

Furthermore, other studies have reported that the combination of ice application with slow circular massage over the AVF puncture site effectively reduces pain by stimulating A-delta fibers, thereby blocking pain signals from C-fibers [18]. Similarly, patients who received ice massage on the contralateral hand's Hegu point for 10 minutes before AVF cannulation reported significantly lower pain

scores compared to those who did not receive cryotherapy [17]. These findings support the integration of cryotherapy as a standard, non-invasive pain management technique in hemodialysis settings.

Advantages and practical implications of cryotherapy:

One of the key advantages of cryotherapy is its cost-effectiveness. Unlike pharmacological interventions, which often require prescriptions and ongoing expenses, cryotherapy utilizes simple and readily available materials, such as ice packs or frozen water in plastic bags, making it an accessible solution for healthcare facilities with limited resources [16].

Additionally, cryotherapy is non-invasive, does not interfere with vascular access functionality, and has no known adverse effects, making it a suitable option for most patients, including those with contraindications to anesthetics [15]. Its ease of application also allows for self-administration or assistance from caregivers and nursing staff, further increasing its practicality in routine hemodialysis care.

Challenges and future directions:

While the existing literature strongly supports cryotherapy as a viable pain management strategy, certain challenges must be addressed for widespread clinical implementation. The duration and frequency of cryotherapy application, as well as optimal placement techniques, require further standardization through large-scale randomized controlled trials (RCTs). Additionally, individual patient responses to cryotherapy may vary, and future research should explore personalized approaches based on patient characteristics, such as pain threshold, vascular health, and prior AVF complications.

Another area for exploration is the combination of cryotherapy with other non-pharmacological pain management techniques, such as distraction therapy, deep breathing exercises, and mindfulness-based interventions. Integrating these approaches could provide a holistic pain management strategy, addressing both physical discomfort and psychological distress associated with AVF cannulation.

Summary of findings:

In summary, the discussion highlights the clinical significance of pain associated with AVF cannulation in hemodialysis patients and the urgent need for effective pain management solutions. Cryother-

apy presents a promising, evidence-based intervention that is cost-effective, non-invasive, and easy to implement in clinical settings. The reviewed studies confirm that both localized and remote cryotherapy applications contribute to significant pain relief, making it a valuable adjunct to conventional pain management strategies.

Given its numerous advantages and minimal risks, cryotherapy should be incorporated as a standard pain management practice in dialysis units. Future research should focus on optimizing application protocols, exploring combination therapies, and conducting large-scale trials to further validate its long-term effectiveness and feasibility in diverse patient populations.

Conclusion:

Patients on hemodialysis with AVF often experience pain and discomfort that negatively affect their quality-of-life. Effective pain management and regular communication with healthcare providers are essential for improving their overall well-being and addressing individual needs. Cryotherapy is a low-cost, non-invasive, easy-to-apply method with no complications. So, it can be used as a complementary therapy to decrease arteriovenous fistula puncture related pain in hemodialysis patients without side effects. Therefore, it should be recommended as an important part of treatment of hemodialysis patients.

The aim of this research was to ascertain response of AVF puncture pain to cryotherapy application in hemodialysis patients.

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تأثير العلاج بالتبريد على ألم مرضى الغسيل الكلوي

غالباً ما يعاني مرضى غسيل الكلوي من الألم والانزعاج مما ينعكس على جودة الحياة اليومية للمرضى وحالتهم الصحية. ويعد إدارة الألم بشكل فعال والتواصل المنتظم مع مقدمي الرعاية الصحية امرين اساسيين لتحسين رفايتهم العامة وتلبية احتياجاتهم الفردية ومواصلة الحياة اليومية لدى المرضى بشكل سلس. يعتبر العلاج بالتبريد علاجاً بتكلفة منخفضة، لا يستلزم اختراق للجسم، وسهل التطبيق بدون مضاعفات. لذلك يستخدم كعلاج تكاملي لتقليل الألم المصاحب لوخز الوصلة الشريانية الوريدية لمرضى الغسيل الكلوي بدون اثار جانبية. لذلك يجب ترشيحه كجزء مهم من علاج مرضى الغسيل الكلوي.

الهدف من هذا البحث: هو معرفة استجابة ألم الوخز المصاحب للوصلة الشريانية الوريدية للعلاج بالتبريد لمرضى الغسيل الكلوي.