

Original Research

Effectiveness of Nursing Interventions in Managing Arteriovenous Fistula Insertion Pain in End-Stage Renal Failure Patients Undergoing Hemodialysis: Systematic Review

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ABSTRACT

End-stage renal failure (ESRD) is a global health issue requiring hemodialysis as a life-sustaining therapy. The insertion of an arteriovenous (AV) fistula, the primary vascular access for hemodialysis, often causes recurrent pain, impacting patient comfort and quality of life. Objective: To evaluate the pharmacological and non-pharmacological interventions for managing pain associated with AV fistula insertion in hemodialysis patients. Methods: A systematic review was performed by searching ScienceDirect, PubMed, EBSCO, and ProQuest databases. Articles were identified using Medical Subject Headings (MeSH) terms and relevant keywords related to hemodialysis, arteriovenous fistula, pain, and pain management interventions. Studies were screened following the PRISMA guidelines using Rayyan and critically appraised using the Joanna Briggs Institute (JBI) Critical Appraisal Tools. Results: The database search identified 381 records. After screening and eligibility assessment, 17 studies met the inclusion criteria. Both pharmacological and non-pharmacological interventions were associated with reduced pain during AV fistula insertion. Among the reviewed interventions, 2% lidocaine gel and cryotherapy at the Hegu point were the interventions most consistently associated with pain reduction. Conclusion: Both pharmacological and non-pharmacological interventions were associated with reduced pain during AV fistula insertion. Among the reviewed interventions, 2% lidocaine gel and cryotherapy at the Hegu point showed the most consistent associations with pain reduction. These findings may inform pain management practices in hemodialysis settings.

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INTRODUCTION

Chronic Kidney Disease (CKD) is a major global public

health problem, affecting approximately one in ten people worldwide, with many individuals remaining unaware of their condition until it progresses to an advanced stage

(Francis et al., 2024; M. A. Ibrahim et al., 2022; World Health Organization, 2019). In 2021, CKD affected an estimated 843.6 million people globally, and its burden is expected to continue increasing, with mortality projected to rise by 41.5% by 2040 (World Health Organization, 2021). As CKD progresses to end-stage renal disease (ESRD), patients require kidney replacement therapies, such as dialysis or kidney transplantation, to sustain life. These treatments impose substantial economic and healthcare burdens, and the demand for such therapies continues to increase worldwide (Harris et al., 2019).

In Indonesia, the Indonesian Renal Registry (IRR) reported a growing number of patients undergoing hemodialysis, the most commonly used kidney replacement therapy for end-stage renal disease (ESRD) (United States Renal Data System, 2023). Hemodialysis requires reliable vascular access, with arteriovenous fistula (AV fistula) considered the gold standard due to its long-term effectiveness and lower complication rates. However, AV fistula cannulation involves repeated needle insertions, often up to 300 punctures annually, which can cause tissue trauma, pain, discomfort, and reduced quality of life (Jafarikoulaee et al., 2020; Saputra et al., 2020). A study involving 632 hemodialysis patients reported that 49% experienced moderate pain, 29% severe pain, and 22% mild pain during AV fistula cannulation (Ibrahim et al., 2022; Peralta et al., 2022).

Pain management is a fundamental component of nursing care for patients undergoing hemodialysis, particularly those who experience pain during arteriovenous (AV) fistula cannulation (Chocarro-Haro et al., 2025; Pinto et al., 2022). Nurses play a critical role in delivering holistic pain management through the implementation of both pharmacological and non-pharmacological interventions based on the principles of evidence-based practice (EBP). Effective pain management not only reduces patient discomfort but also enhances treatment adherence, patient satisfaction, and overall quality of care (Alzaatreh & Abdalrahim, 2020).

Various pharmacological and non-pharmacological interventions have been used to manage AV fistula cannulation pain, including topical anesthetics, cryotherapy, distraction techniques, aromatherapy, and acupuncture. Previous studies have primarily evaluated individual interventions, such as topical anesthetics, cryotherapy, aromatherapy, or acupuncture, in separate clinical settings. However, to our knowledge, no previous review has comprehensively synthesized both pharmacological and non-pharmacological nursing interventions for AV fistula cannulation pain (Alzaatreh & Abdalrahim, 2020). This lack of synthesized evidence limits

evidence-based clinical decision-making and hinders the identification of the most effective pain management strategies for patients undergoing hemodialysis.

Given the high prevalence of AV fistula cannulation pain among patients with end-stage renal disease undergoing hemodialysis and the pivotal role of nurses in pain management, this study aimed to evaluate the effectiveness of pharmacological and non-pharmacological nursing interventions for reducing AV fistula cannulation pain. The findings of this study are expected to provide a robust evidence base for clinical practice, guide the selection of effective pain management strategies, and ultimately improve the quality of nursing care and patient outcomes.

METHOD

Study Design

This study employed a systematic review methodology following the PRISMA 2020 guidelines. The PICOT framework (Population, Intervention, Comparison, Outcome, Time) was used to define the eligibility criteria and guide the literature search strategy (Page et al., 2021). The review protocol was registered in the Open Science Framework (OSF) and is available at https://doi.org/10.31219/osf.io/4xfpz_v1.

Search Strategy

A systematic search was conducted across four electronic databases: ScienceDirect, PubMed, EBSCO, and ProQuest. The search was limited to articles published between 2019 and 2024 to ensure the inclusion of the most recent evidence on pain management interventions for arteriovenous fistula cannulation. Boolean operators ("AND", "OR") were used in combination with keywords related to arteriovenous fistula, pain management, pharmacological interventions, non-pharmacological interventions, hemodialysis, and renal dialysis. The search strategy used the following search string: ("arteriovenous fistula" OR "AV fistula") AND ("pain management" OR pain OR analgesia) AND ("hemodialysis" OR "renal dialysis") AND (pharmacological OR non-pharmacological).

Eligibility Criteria

Eligibility criteria were established according to the PICOT framework (Table 1). Studies were eligible for inclusion if they involved adult patients undergoing arteriovenous fistula (AVF) cannulation for hemodialysis and evaluated pharmacological and/or non-pharmacological interventions for pain management. Only original research articles published in peer-reviewed journals, available in full text, written in English, and published between 2019 and 2024 were included. Studies were excluded if they involved pediatric populations, addressed vascular access procedures other than AVF cannulation, did not evaluate pain management interventions or pain-related outcomes, or

were duplicate publications, review articles, editorials, commentaries, conference abstracts, study protocols, or unavailable in full text.

and key findings. Findings were synthesized using a narrative synthesis approach, whereby studies were compared and grouped according to similarities and differences in pain management interventions and outcomes. Following JBI appraisal, 17 studies met the quality threshold and were included in the final review.

Table 1. PICOT Framework

PICOT element	Description
Population (P)	Patients with end-stage renal disease (ESRD) undergo hemodialysis with an arteriovenous fistula (AVF)
Intervention (I)	pharmacological and non-pharmacological interventions for pain management during AVF cannulation.
Comparison (C)	Patients undergoing standard procedures without additional for pain management interventions.
Outcome (O)	Reduction in pain intensity and improvement in patient comfort during the AVF cannulation
Time (T)	Studies published between (2019-2024)

Note. AVF= Arteriovenous Fistula; ESRD= End-Stage Renal Disease.

Study Selection Process

The study selection process followed the PRISMA 2020 flow diagram (Figure 1). Articles identified through database searching were screened using the Rayyan web application based on predefined inclusion and exclusion criteria through title, abstract, and full-text review. The screening and data extraction processes were conducted by three researchers, comprising two independent reviewers and one researcher who acted as the final decision-maker in cases of disagreement. Any disagreements between reviewers were resolved through discussion and consultation with the third researcher until consensus was reached.

Quality Appraisal

The methodological quality of all potentially eligible studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Tools. A minimum quality score of 70% was established as the eligibility threshold for inclusion in the review. Following appraisal, 17 studies (85%) met the quality criteria and were retained for the final review, while 3 studies (15%) were excluded due to insufficient methodological quality. The selected studies subsequently proceeded to data extraction, thematic analysis, and narrative synthesis.

Data Extraction and Synthesis

Data were extracted using a standardized extraction form containing study characteristics, interventions, outcomes,

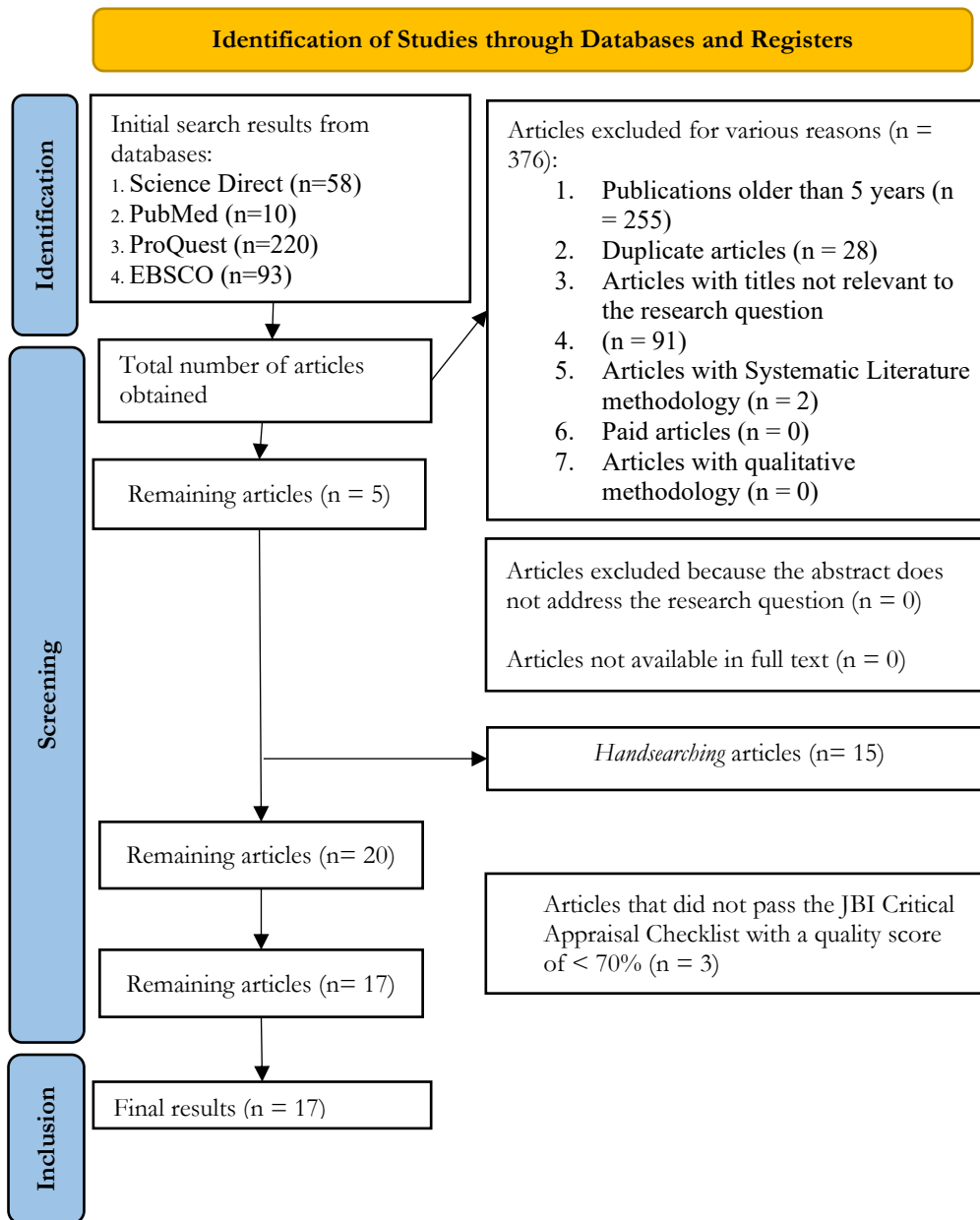


Figure 1. PRISMA flow diagram

RESULT

The characteristics and methodological quality of the included studies are presented in table 2. Study quality was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Tools, with most studies demonstrating good methodological quality.

Table 2. Study Characteristics and Quality

Author (Year)	Study Design	Sample (n)	Age (years)	Intervention	Pain Assessment Tool	Main Findings	JBI Score
Ibrahim al. (2022)	et Cross-sectional study	616 patients	20 to >80	2% Lidocaine gel applied 15–20 min before cannulation	NRS	Pain score decreased from 5.04 to 2.61, indicating a reduction from moderate to mild pain	8/8 (100%)
Fujimoto al. (2020)	et RCT	32 patients	66.2 ± 10.7	EMLA cream (1 g; 25 mg lidocaine + 25 mg prilocaine) applied 1 h before cannulation	VAS	Pain score decreased from 29.8 mm to 10.9 mm; significantly lower than lidocaine tape (p=0.00001)	10/13 (76.92%)
Fujimoto al. (2020)	et RCT	34 patients	65.5 ± 10.6	Lidocaine tape (18 mg) applied 30 min before cannulation	VAS	Pain score decreased from 29.8 mm to 19.4 mm; less reduction than EMLA cream	10/13 (76.92%)
Maghbool al. (2020)	et RCT	34 patients	<50 to >60	4% topical eugenol nanoemulsion	VAS	Pain score decreased from 5.03 to 3.29; significantly lower than placebo (p<0.001)	13/13 (100%)
Lee al. (2023)	et RCT	38 patients	23–86	Vapocoolant spray (ethyl chloride) applied 3–4 s before cannulation	VAS	Arterial pain scores decreased from 4.45 to 2.98 and venous pain scores from 3.05 to 1.97 (p = 0.009).	13/13 (100%)
Marvi al. (2023)	et RCT	47 patients	18–20	Two sprays of 10% lidocaine (20 mg) applied 5 min before cannulation	VAS	Pain scores decreased from 3.79 to 2.62 and showed greater reduction than rhythmic breathing (p < 0.001).	10/13 (76.92%)
Gouda al. (2023)	et RCT	108 patients	43.7 ± 15.6	Two puffs of 10% lidocaine spray applied 10 min before cannulation	VAS	Pain scores changed from 4.7 to 4.3, with no significant difference compared with the control group (p = 0.054).	11/13 (84.6%)
Ebrahim (2019)	Quasi-experimental	45 patients	8–18	Cryotherapy (ice bag at Hegu point for 10 min before and during cannulation)	NPRS	Pain scores decreased from 7.16 to 2.36, indicating a reduction from severe to mild pain (p<0.0001).	8/9 (88.8%)
Abunab et al. (2021)	RCT	50 patients	31.1 ± 10.1	Cryotherapy alone (ice bag at Hegu point for 10 min)	NRS	Pain scores decreased from 5.34 to 3.92; less reduction than cryotherapy combined with distraction (p<0.05).	10/13 (76.9%)
Gouda et al. (2023)	RCT	108 patients	43.7 ± 15.6	Cold packs applied at fistula site 5 min before cannulation	VAS	Pain scores decreased from 4.7 to 4.0; no statistically significant reduction compared with control (p=0.051).	11/13 (84.6%)

Author (Year)	Study Design	Sample (n)	Age (years)	Intervention	Pain Assessment Tool	Main Findings	JBI Score
Back & Lee (2020)	RCT	77 patients	>50–60	Thermotherapy (10 or 20 min before cannulation)	VAS	Both thermotherapy durations significantly reduced pain scores compared with control ($p<0.001$).	12/13 (92.3%)
Tüzün Özdemir & Akyol (2023)	RCT	90 patients	18–25	Topical lavender massage	VAS	Pain scores decreased from 52.0 to 17.83, indicating a reduction from moderate to mild pain ($p<0.001$).	10/13 (76.9%)
Kılıç Akça et al. (2021)	RCT	75 patients	32–74	Aromatherapy massage (lavender and tea tree oils)	VAS	Pain scores decreased from 5.23 to 2.43, with effects maintained at 8-week follow-up ($p<0.001$).	10/13 (76.9%)
Kılıç Akça et al. (2021)	RCT	75 patients	32–74	Olive oil massage	VAS	Pain scores decreased from 5.60 to 2.61, but effects diminished at follow-up.	10/13 (76.9%)
Dewan et al. (2022)	Quasi-experimental	60 patients	41–60	Acupressure at Hegu (LI4) point before and during cannulation	NPRS	Pain scores decreased from 7.3 to 2.6, indicating a reduction from severe to mild pain ($p<0.05$).	9/9 (100%)
Razavi et al. (2022)	RCT	50 patients	56.2 ± 10.1	Foot reflexology for 20 min before cannulation	VAS	Pain scores decreased from 5.57 to 4.03 across three sessions ($p<0.05$).	11/13 (84.6%)
Ebrahim (2019)	Quasi-experimental	45 patients	8–18	Balloon inflation distraction	NPRS	Pain scores decreased from 7.16 to 2.72, indicating a reduction from severe to mild pain ($p<0.0001$).	8/9 (88.8%)
Aghbolagh et al. (2020)	RCT	120 patients	68–69	Visual distraction (nature images)	NRS	Pain scores decreased from 6.70 to 4.26 and showed greater reduction than auditory distraction ($p=0.001$).	11/13 (84.6%)
Aghbolagh et al. (2020)	RCT	120 patients	68–69	Auditory distraction (nature sounds)	NRS	Pain scores decreased from 6.70 to 5.48 but were less reduced than with visual distraction ($p=0.001$).	11/13 (84.6%)
Şen & Lafcı Bakar (2024)	RCT	60 patients	>50	Virtual reality glasses	VAS	Pain scores decreased from 3.89 before cannulation to 0.47 after the procedure ($p<0.05$).	11/13 (84.6%)
Gouda et al. (2023)	RCT	108 patients	43.7 ± 15.6	Flashlight distraction	VAS	No significant reduction in pain scores compared with control ($p=0.054$).	11/13 (84.6%)

Author (Year)	Study Design	Sample (n)	Age (years)	Intervention	Pain Assessment Tool	Main Findings	JBI Score
Malayjerdy & Malekzadeh (2019)	Quasi-experimental	30 patients	18–49	Mirror therapy	VAS	Pain scores decreased from 4.8 to 3.25, with the greatest reduction observed during the adaptive phase ($p < 0.001$).	8/9 (88.8%)
Marvi et al. (2023)	RCT	47 patients	18–20	Rhythmic breathing	VAS	Pain scores decreased from 2.54 to 2.03; statistically significant but modest reduction ($p = 0.023$).	11/13 (84.6%)
Abunab et al. (2021)	RCT	50 patients	29.9 \pm 8.6	Cryotherapy combined with distraction	NRS	Pain scores decreased from 5.20 to 2.12 and patient satisfaction was higher than with cryotherapy alone ($p < 0.05$).	10/13 (76.9%)
Tüzün Özdemir & Akyol (2023)	RCT	90 patients	18–65	Lavender inhalation	VAS	Pain scores decreased from 63.16 to 16.82, indicating a reduction from severe to mild pain ($p < 0.001$).	10/13 (76.9%)
Şahin et al. (2021)	RCT	74 patients	50.7 \pm 18.0	Lavender aromatherapy inhalation	NRS	Pain scores decreased from 6.24 to 3.56 and anxiety levels were also reduced.	12/13 (92.3%)

Note. AVF = Arteriovenous Fistula; EMLA = Eutectic Mixture of Local Anesthetics; JBI = Joanna Briggs Institute; LI4 = Large Intestine 4 (Hegu point); NRS = Numeric Rating Scale; NPRS = Numeric Pain Rating Scale; RCT = Randomized Controlled Trial; VAS = Visual Analog Scale.

The findings of the included studies were synthesized into two main categories: pharmacological and non-pharmacological interventions for pain management during arteriovenous fistula (AVF) cannulation in patients receiving hemodialysis. Based on the PRISMA synthesis (Figure 1), the findings were categorized into pharmacological and nonpharmacological intervention groups.

Pharmacological interventions

Pharmacological interventions were reported in six randomized controlled trials (RCTs) involving 641 hemodialysis patients across different age groups. Pain outcomes were primarily measured using the Visual Analogue Scale (VAS) in five studies and the Numeric Rating Scale (NRS) in one study. The interventions mainly consisted of local anesthetic approaches, including topical anesthetic creams and spray formulations. Across studies, topical anesthetic interventions consistently demonstrated greater reductions in post-procedural pain scores compared to baseline measurements,

whereas spray-based interventions showed more variable effects, with some studies reporting minimal changes in VAS scores (Figure 2).

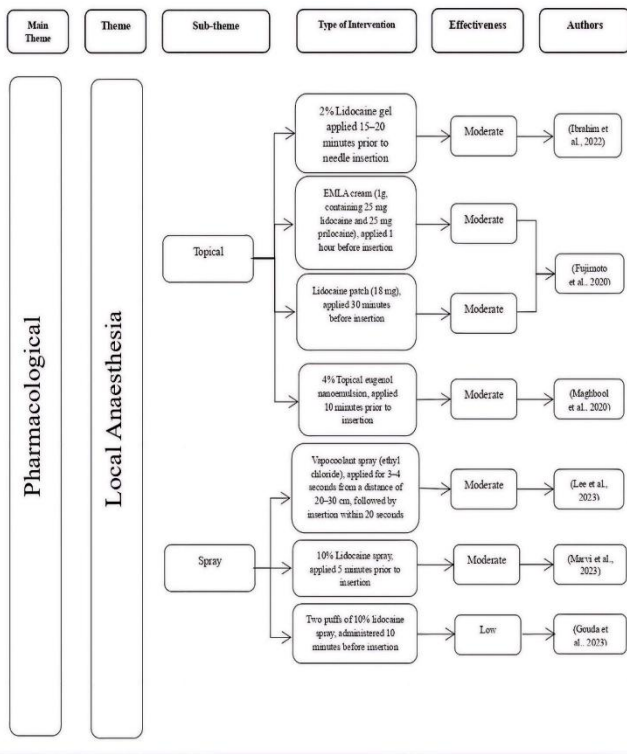


Figure 2. Mind map of pharmacological intervention themes and sub-themes

Non-pharmacological intervention

Non-pharmacological interventions were reported in 13 RCTs and 4 quasi - experimental studies involving 550 hemodialysis patients with AV fistula access. These interventions were grouped into five categories: psychological/cognitive techniques (e.g., distraction, breathing exercises, mirror therapy), physical therapies (e.g., cryotherapy, thermotherapy, massage), sensory/complementary approaches (e.g., acupressure), aromatherapy (inhalation), and combined interventions. Pain outcomes were assessed using VAS in 10 studies and NRS in 7 studies, with most studies reporting reduction in post-intervention pain scores compared to baseline. Among psychological and cognitive intervention, breathing techniques and distraction-based strategies demonstrated variable reduction in pain scores, while some studies reported minimal change, indicating heterogeneity in intervention effects. Physical therapies, particularly cryotherapy and massage, showed more consistent reductions in VAS/NRS score across studies. Combined intervention (e.g., cryotherapy with distraction) tended to produce greater reduction in pain scores compared to single-modality approaches in several studies. However, variation in study design, intervention protocols, and measurement timing limited direct comparison across studies (Figure 3).

Overall, the evidence suggests that both pharmacological and non-pharmacological interventions contribute to pain reduction during AV fistula cannulation, with topical anesthetics and multimodal non-pharmacological approaches showing more consistent reductions in reported pain scores. However, heterogeneity in study

design and outcome measurement precluded quantitative synthesis or calculation of pooled effect size.

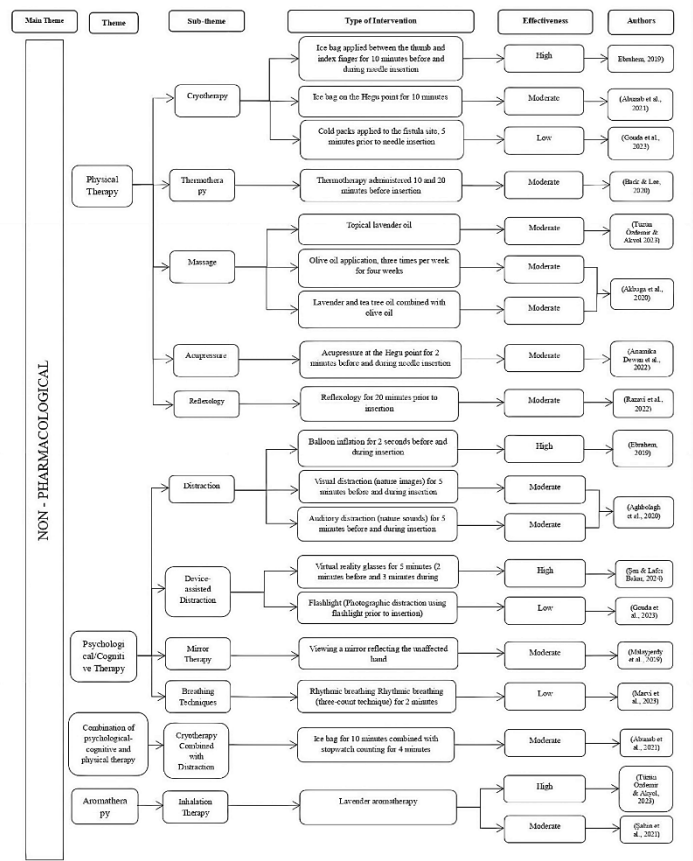


Figure 3. Mind map of non-pharmacological intervention themes and sub-themes

DISCUSSION

The findings of this review indicate that both pharmacological and non-pharmacological interventions may contribute to reducing AV fistula cannulation pain, although the strength of evidence varies across intervention types. Collectively, the included studies highlight several potentially beneficial interventions while also revealing substantial variability in effectiveness across different approaches.

Evidence on AV Fistula Pain Management Interventions

Pain assessment in patients undergoing AV fistula cannulation plays a crucial role in evaluating the effectiveness of pain management and the quality of care provided, whether through pharmacological or non-pharmacological interventions. Unmanaged pain can significantly impact patient comfort and adherence to hemodialysis therapy (Bjelkaroy et al., 2024; Rao et al., 2022). Given that AV fistula cannulation is performed repeatedly throughout long-term hemodialysis treatment, effective pain management represents an important component of patient-centered care. Appropriate pain control may improve patients' treatment experiences, reduce

procedural distress, and support continued engagement with hemodialysis therapy (Alzaatreh & Abdalrahim, 2020; Pinto et al., 2022). Across the reviewed studies, both pharmacological and non-pharmacological interventions were generally associated with reductions in AV fistula cannulation pain. However, the magnitude of pain reduction varied across studies, reflecting differences in study populations, intervention protocols, and outcome assessment methods. Most studies used standardized pain assessment tools, which improved consistency in outcome evaluation across studies. In studies involving a control group, patients who did not receive specific interventions tended to experience persistent moderate to severe pain without significant change. In contrast, intervention groups generally reported reductions in pain scores. However, although most studies reported positive findings, many involved relatively small sample sizes and short-term outcome assessments, limiting the overall strength of the evidence (Rao et al., 2022).

Several non-pharmacological interventions were associated with substantial reductions in pain scores. However, direct comparisons with pharmacological interventions remain difficult because of differences in study design, intervention protocols, patient characteristics, and outcome assessment methods. Consequently, while both approaches appear beneficial, the current evidence is insufficient to determine the superiority of any specific intervention. In practice, non-pharmacological interventions were frequently used as complementary or supplementary options, while in many cases of chronic pain, pharmacological therapy alone did not result in clinically significant pain reduction (Wang et al., 2025). Therefore, non-pharmacological interventions may be considered complementary or alternative approaches, depending on patient preferences, clinical conditions, and available resources. Interpretation of these findings should be undertaken cautiously because considerable heterogeneity was observed across studies in terms of intervention duration, timing of pain assessment, sample characteristics, intervention protocols, and outcome measurement tools, limiting direct comparisons of intervention effectiveness. Therefore, while the overall findings suggest that both pharmacological and non-pharmacological interventions may reduce AV fistula cannulation pain, the current evidence base is limited by methodological heterogeneity and the predominance of small single-center studies. Future adequately powered randomized controlled trials using standardized pain assessment methods are needed to determine the relative effectiveness and clinical significance of these interventions (Alzaatreh & Abdalrahim, 2020; Chocarro-Haro et al., 2025).

Pharmacological Interventions

Across pharmacological studies, topical anesthetic agents were consistently associated with reductions in AV fistula cannulation pain. Lidocaine-based preparations, including 2% lidocaine gel, lidocaine tape, and EMLA cream, generally demonstrated beneficial effects on pain reduction, while topical eugenol nanoemulsion also showed promising results (Arab et al., 2017; Fujimoto et al., 2020; Maghbool et al., 2020). However, the available evidence remains

limited because each intervention was evaluated in only a small number of studies, often with relatively small sample sizes. In addition, variations in study design, sample characteristics, and outcome assessment methods make direct comparisons between pharmacological interventions challenging. The favorable outcomes observed with lidocaine-based agents and eugenol nanoemulsion suggest that these topical analgesics may be useful options for reducing AV fistula cannulation pain in clinical practice. Nevertheless, further high-quality comparative studies are required to determine their relative effectiveness and support stronger clinical recommendations (Maghbool et al., 2020).

Non-Pharmacological Interventions

The reviewed studies identified a broad range of non-pharmacological interventions for AV fistula cannulation pain, including cryotherapy, acupressure, aromatherapy, distraction techniques, device-assisted therapies, and multimodal approaches. Among these interventions, cryotherapy, acupressure, lavender aromatherapy, and distraction-based approaches demonstrated the most consistent reductions in pain scores across the included studies. Evidence supporting cryotherapy is particularly notable, as findings from a systematic review and meta-analysis indicated a significant overall benefit in reducing AV fistula cannulation-related pain (Jafari-koulaee et al., 2020). Similarly, randomized trials reported favorable effects of distraction-based interventions and acupressure on pain reduction during needle insertion (Abunab et al., 2021).

Despite these promising findings, the overall strength of evidence remains limited. Most interventions were evaluated in single-center studies with relatively small sample sizes, restricting confidence in the reproducibility and generalizability of the results. Furthermore, substantial heterogeneity in study designs, intervention protocols, and pain assessment methods complicates direct comparisons between approaches and limits the ability to identify a clearly superior intervention. While cryotherapy, acupressure, lavender aromatherapy, and distraction techniques may represent feasible, low-cost strategies for routine hemodialysis practice, further well-designed comparative trials are needed to establish their relative effectiveness and determine their clinical significance (Dewan et al., 2022; Ebrahim et al., 2019).

CONCLUSIONS

A review of 17 studies indicates that both pharmacological and non-pharmacological interventions may help reduce pain associated with arteriovenous fistula (AV fistula) cannulation in hemodialysis patients. As summarized in the evidence synthesis matrix, 2% lidocaine gel was the most consistently studied pharmacological intervention, while cryotherapy using ice packs demonstrated the most favorable and consistent findings among non-pharmacological approaches. However, substantial heterogeneity in study design, sample characteristics, intervention protocols, pain assessment tools, and outcome measures limits direct comparisons between interventions. Therefore, pain management strategies should be

individualized according to patient preferences, clinical conditions, and available resources. These findings support the integration of evidence-based pain assessment and management approaches into nursing protocols and hemodialysis care. Further high-quality comparative studies and meta-analyses are needed to clarify the relative effectiveness of available interventions.

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