SYSTEMATIC REVIEW

Pain management associated with arteriovenous fistula cannulation among children undergoing haemodialysis: Systematic review

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Abstract

Objective: To evaluate studies related to pain management associated with arteriovenous fistula cannulation among children.

Method: The systematic review comprised literature search on Embase, ProQuest, Science Direct, Scopus, SpringerLink and Wiley Online databases for studies published in English between 1998 and 2021. The search used key words, including pain management OR analgesia AND child OR paediatric AND haemodialysis OR dialysis AND arteriovenous fistula OR arteriovenous fistula cannulation OR fistula needle OR arteriovenous fistula insertion OR needle insertion. The quality of the studies was evaluated using the Joana Briggs Institute checklist. General characteristics of the and pain outcomes were noted.

Results: Of the 2,877 studies initially identified, 8(0.27%) were analysed; 7(87.5%) quasi-experimental and 1(12.5%) randomised controlled trial. Overall, there were 283 participants aged 6-18 years. The strategies used for reducing arteriovenous fistula puncture-related pain among children undergoing haemodialysis included cryotherapy, lidocaine agents, virtual reality (VR), guided visualisation, balloon inflation, aromatherapy, and other programmed distractions. The strategies had a positive effect on reducing arteriovenous fistula cannulation-related pain among children.

Conclusion: Non-pharmacological pain management is an easier, simpler, inexpensive and more effective method of atraumatic care among children undergoing haemodialysis.

Keywords: Dialysis, Lidocaine, Aromatherapy, Catheterisation, Fistula, Cryotherapy, Analgesia, Punctures.

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Introduction

Chronic kidney disease (CKD) is a disorder characterised by irreversible kidney damage that can further progress slowly to end-stage kidney disease (ESKD). CKD is recognised as one of major health problems with high cost on the community.[1] The prevalence of CKD in children is 74.7 cases per one million children, and the most common aetiology in children aged <5 years includes congenital malformations, such as congenital aplastic, hypoplastic, dysplastic kidney, and obstructive uropathy.[2]

Generally, children with ESKD require specific therapies, such as peritoneal dialysis (PD), haemodialysis (HD), and kidney transplantation. Nearly two million patients in the world are dialysis-dependent, with 90% needing HD therapy (HDT).[3] HD is the most commonly used renal replacement treatment. It requires well-functioning vascular access. However, the arteriovenous fistula (AVF) procedure may lead to pain in children during needle insertion. Generally, a child undergoing routine HD receives >20 AVF punctures per month. These frequent exposures to punctures with using large-gauge needles create a stressful condition among children and their families.[4] Children undergoing HDT need a long-term compliance, and children's comfort during the therapy influence their compliance. Nurses have a significant role in improving children's quality of life (QOL) in terms of pain management as part of atraumatic care in paediatric nursing.[5]

There are many ways of minimising pain caused by AVF cannulation. Pain management can be grouped into two categories; non-pharmacological and pharmacological. The pharmacological pain management is based on analgesic agents, while the non-pharmacological management uses distraction techniques.[3]

The current systematic review was planned to evaluate published studies related to pain management associated with AVF cannulation among children undergoing HD.

Materials and Methods

The systematic review comprised literature search on Embase, ProQuest, Science Direct, Scopus, SpringerLink and Wiley Online databases for studies published in English between 1998 and 2021. The search used key words and Boolean operators, including "pain management OR analgesia" AND "child OR paediatric" AND "haemodialysis OR dialysis" AND "arteriovenous fistula OR AVF cannulation

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OR fistula needle OR AVF insertion OR needle insertion". The references given in relevant literatures were also manually searched.

The studies included were those focussing on AVF puncture-related pain as part of HDT in paediatric patients, and whose full-text versions were available. Reviews were excluded, and so were studies comprising adult subjects, or focussing on any element other than pain caused by AVF puncture.

The studies were screened using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[6] The quality of the studies was evaluated by using Joana Briggs Institutes (JBI) critical appraisal checklist.[7] General characteristics of the studies and pain outcomes were noted.

Results

Of the 2,877 studies initially identified, 8(0.27%) were analysed (Figure); 7(87.5%) quasi-experimental and 1(12.5%) randomised controlled trial (RCT) (Table).[1,3,4,7-11] Overall, there were 283 participants aged 6-18 years.

In 3(37.5%) studies, there was no intervention made in the control group, while remaining studies did not mention it. Besides, 5(62.5%) studies described the characteristics of children, dialysis and AVF cannulation. In 5(62.5%) studies, the children had been on dialysis for 1-3 years with a frequency of 2-3 times per week, and 3 hours per session. Only 3(37.5%) studies described the location of AVF as left arm and its duration was 1-3 years.

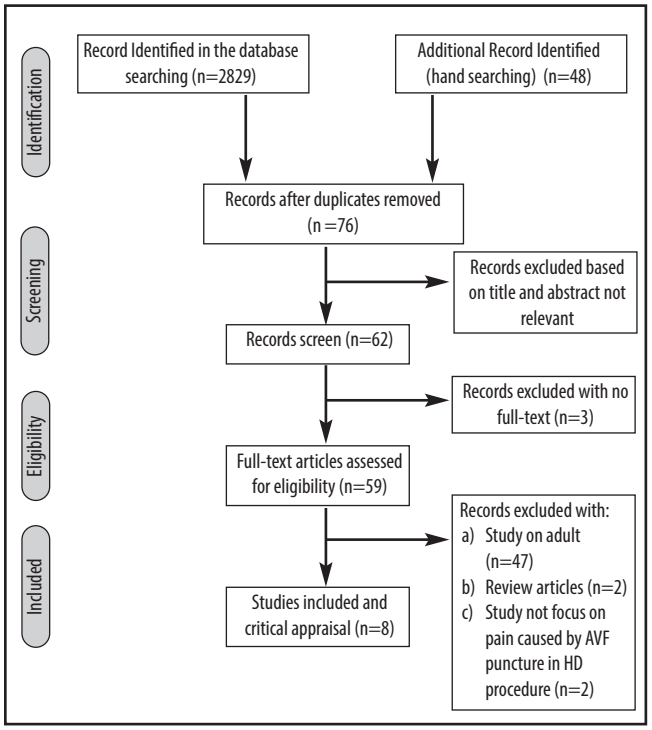

Figure: Method of selecting articles Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

There were seven different interventions that were used to reduce pain in children. There were 2(25%) studies that used pharmacological agents, such as lidocaine, while others used non-pharmacological strategies, such as cryotherapy (ice bag), aromatherapy, VR, guided visualisation, balloon inflation and the other programmed distractions.

One (12.5%) study used the eutectic mixture of local anaesthetics (EMLA) cream containing lidocain which was effective in controlling cannulation-related pain, while 1(12.5%) study used lidocain spray and lidocain gel along with elliptical plate. Lidocain spray 20mg was used and was left for 10 seconds to evaporate, while lidocain gel or EMLA were applied 5 min before cannulating.

The study used cryotherapy, and to lessen the risk of ice-burn before intervention, the researchers applied 1-2 drops of olive oil and massaged in slow circular movements until the child felt skin numbness. Before the skin numbness was gone, the dialysis attendant punctured the skin.

In 1(12.5%) study, before intervention the researchers conducted ice sensitivity test in the contralateral site of AVF to detect child sensitivity to ice. The procedure was started 5 min before venipuncture and continued until skin numbness was felt.[8]

There was 1(12.5%) study that compared cryotherapy to balloon inflation. Balloon inflation was applied 2 seconds before venipuncture and was continued throughout the procedure. Cryotherapy was then applied by placing 3-4 pieces of ice in a plastic bag with a small towel and placing it between the contralateral arm of AVF site for 10 min. This was done throughout the venipuncture procedure. One (12.5%) study compared cryotherapy to aromatherapy. Before inserting the needle, the researcher reassessed the AVF puncture site, and 2 drops of pure organic lavender essential oil were placed on cotton which the child was asked to breathe deeply with eyes closed. The result revealed that during AVF puncture, mean pain and distress scores were lower among children in the cryotherapy group than those in the aromatherapy group.[9]

One (12.5%) study applied gameplay among the teenagers who were undergoing HD. Before intervention, the researchers provided 2 cartoon pictures with some similarities and differences. The children were asked to look at the pictures throughout the procedure and note the differences.[4] In addition, 1(12.5%) study used VR and guided visualisation. The child viewed three-dimensional

Table: Characteristic of the studies analysed.

References	Study Design	Country	Participant	Intervention	Tools	Findings
Ravanshad et al. 2021[1]	RCT	Iran	20 children (≥ 8 years old)	I. Elliptical plate II. Lidocaine gel (EMLA) III. Lidocaine spray	VAS tool	VAS mean in the lidocaine spray: 47.87, lidocaine cream 51.31, and in the needle plate 49.43, which less than the control with VAS mean 60.60 lidocaine spray vs. control *p*-value = 0.001, lidocaine gel vs. control P value = 0.001, and needle plate vs. control P value = 0.003). The use of needle plate, lidocaine spray, & lidocaine gel are all equally effective ways in controlling the degree of pain in AVF needling.
Dawood et al. 2021[3]	Quasi experimental	Egypt	30 children (6-16 years old)	Virtual reality vs guided visualization	I. Structured interview schedule (sociodemographic characteristic, about child's caregiver, disease and fistula) II. Wong baker faces pain rating scale III. Pain anxiety symptom scale short form	53.33% and 33.33% of the studied children had moderate and severe pain anxiety symptoms pre-intervention respectively while 73.33% and 46.67%of them had mild pain anxiety symptoms during application of virtual reality and guided visualization respectively. Visual reality was the preferred method which given the greater relief of pain and anxiety than guided visualization.
Ebrahem et al. 2019[11]	Quasi experimental	Egypt	45 children (8-18 years old)	Cryotherapy vs ballon inflation	I. Structured interview sheet (demographic data about child, medical history (disease, dialysis & AVF). II. Physiological measurements (BP, HR, RR). III.Pain behavioural observational checklist IV. Numerical pain rating scale	A highly statistical significance difference between mean scores of observed behavioural response to pain and pain intensity among haemodialysis children across pre intervention, cryotherapy and balloon inflation before and immediately after AVF punctures
Elhalafawy et al., 2020[10]	Quasi experimental	Egypt	60 children (6-15 years old)	Cryotherapy vs aromatherapy	I. Structured interview schedule (sociodemographic of children, medical history (disease, dialysis, AVF) II. Subjective pain assessment – wong-Baker faces pain rating scale III. Observational scale of behavioural distress IV. Pshysiological measurement (RR, BP, Pulse, SpO2) V. Assessment of AVF puncture site	Mean score of Wong Baker faces pain and total behavioural distress scale scores was lower among children in cryotherapy group than those in aromatherapy. Post cryotherapy, children had lower mean pulse, respiration and higher mean O2 saturation than pre cryotherapy. Both cryotherapy and aromatherapy had a positive effect in reduction of AVF puncture pain for children undergoing HD but cryotherapy was more effective in pain reduction than aromatherapy
El Said et al., 2019[8]	Quasi experimental	Egypt	40 children (6-18 years old)	Cryotherapy	I. Structured interviewing questionnaire (characteristic of child, past & present medical history, data related AVF) II. Subjective pain rating scale (Wong baker face pain rating scale III. Objective pain scale: pain behaviours scale (4 behaviors) and physiological measures (vital sign) IV. Numeric pain rating scale	The mean of score of Wong-baker faces pain rating scale, objective pain rating scale, and numerical pain rating scale pre and post intervention, there were highly statiscally significant difference. Cryotherapy was effective on diminishing pain intensity at puncture sites of AVF among children undergoing hemodialysis.
Attia & Hassan., 2017[10]	Quasi experimental	Egypt	40 children	Cryotherapy	I. Structured interviewed (characteristic of children, medical history; disease, dialysis, AVF) II. Wong-baker face pain rating scale III. Observed pain rating scale (8 behaviours) IV. Physiological assessment (vital sign and oxygen saturation) Wong Baker faces pain rating scale	The Won-baker faces pain scoreand all observed pain behaviors significantly decreased after cryotherapy. Significant improvements in respiratory rate before and after puncture and oxygen saturation after needle puncture. A Lower skin dryness was observed after cryotherapy than before cryotherapy. Cryotherapy can effectively reduce the AVF related pain among children undergoing HD

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References	Study Design	Country	Participant	Intervention	Tools	Findings
Alhani., 2010[4]	Quasi experimental	Iran	21 children (case group) 21 children (control group)	Distraction: 2 similar cartoon pictures with some differences)	Wong Baker faces pain rating scale	There were 12 sessions Nonsignificant difference in pain between posttest session 1-5 and pretest. The significant difference began from the sixth session and continued up to ninth session. The distraction programme can decrease the pain caused venipuncture in adoleseccent undergoing HD.
Benini et al., 19981[5]	Quasi experimental	Italia	6 children (12-18 years old)	EMLA cream	VAS, patient's mood and fear	The EMLA cream might be effective in controlling cannulation-related pain, but emotional factors (fear and stress) can interfere with the global efficacy of the analgesic.

RCT: Randomised controlled trial, EMLA: Eutectic mixture of local anaesthetics, VAS: Visual analogue scale, AVF: Arteriovenous fistula, O2: Oxygen, HD: Haemodialysis, BP: Bloof pressure, HR: Heart rate, RR: Respiratory rate. SpO2: Oxygen saturation.

(3D) VR cartoons or videos while lying on the bed and wearing VR goggles that were attached to the child's head about 20 min before HD. In the guided visualisation group, the researchers provided a quiet environment, and the children were asked to lie in a supine position, take a deep breath, close their eyes until feeling relaxed for 2 min and imagine a beautiful surrounding for 20 min before puncture.[3] VR and cryothrerapy were found to be most effective.

All 8(100%) studies measured the pain level using self-reported measures; 5(62.5%) Wong Baker Face Scale (WBFS), 2(25%) Visual Analogue Scale (VAS), and 1(12.5%) used a combination of WBFS and Numerical Rating Scale (NRS). All 8(100%) studies revealed that pre-intervention, the children had moderate to severe pain, but post-intervention, the children had mild pain or even no pain.

Overall 5(62.5%) studies assessed the effect of pain management strategies using Behavioural Measurement Rating Scale. Among them, 4(80%) studies used the Pain Behavioural Observational Checklist (PBOC), while 1(12.5%) used the Observational Scale of Behavioural Distress (OSBD) to observe discomfort. Objective pain was measured by 1(12.5%) study incorporating 4 pain behaviour; crying, movement, agitation, and verbalisation. Observed Pain Behaviour Rating Scale (OPBRS) measured observable behaviours; verbalised pain, verbalised anxiety, verbal stalling, screaming, crying, physical resistance, muscle tension, and use of restraint. There was 1(12.5%) study that used Pain Anxiety Symptom Scale-Short Form (PASS-SF), which included 4 subscales that reflected on the aspects of cognitive anxiety, avoidance or escape behaviour, fear, and physiological anxiety. Of the total, 1(12.5%) study did not mention the tool or criteria to measure mood and fear. Only 3(37.5%) studies used physiological measurements to evaluate pain related to AVF cannulation. They included blood pressure (BP), heart rate (HR) and respiratory rate (RR). Only 2(25%) studies assessed oxygen saturation (SpO2).[9,10]

Discussion

Based on the review, both pharmacological and non-pharmacological pain management strategies can be used to alleviate pain related to AVF cannulation in children undergoing HDT. It is important to choose the appropriate pain management technique based on the child's age, preference and skin sensitivity, as well as the duration and effectiveness of the technique.[1]

Non-pharmacological pain management is commonly used in children, and cryotherapy is one such method. Cryotherapy involves the application of cooling to the affected area of the skin to reduce the speed of nerve conduction in C- and A-delta fibres. This slows the transmission of pain signals as the cold application decreases sensory transmission and reduces acetyl-choline release, which affects pain. Cryotherapy is a simple, non-invasive and safe strategy that has been shown to reduce pain related to AVF puncture in children undergoing HD. Before using cryotherapy, it is important to assess skin sensitivity to ice in order to detect any local skin reactions. such as redness, swelling or thrombophlebitis. A study combined the use of lavender oil and cryotherapy, which significantly decreased skin dryness, possibly due to the emollient effect of the olive oil drops.[10]

Balloon inflation is a pain management method that is just as effective as cryotherapy. It works as a distraction technique that diverts the child's attention away from the pain stimuli during medical procedures, resulting in a reduction in pain and anxiety. Cryotherapy and balloon inflation are both effective in reducing pain caused by AVF cannulation in children undergoing HD.[11] Aromatherapy, on the other hand, involves inhaling lavender oil, which enters directly through the nasal mucosa's large surface area and then relaxes the body systems and mind. Children who inhale lavender oil experience no negative side effects except feeling sleepy, which is likely due to the oil's relaxing effects.[9]

Another pain distraction technique for children is focussing on two similar pictures and identifying the differences between them. This technique has been shown to significantly reduce the pain caused by AVF in children. In a study,[4] although there was no significant reduction in pain during the first 5 intervention sessions, there was a significant decrease in pain from the 6th session onwards. This delay in the intervention's effectiveness may be due to factors, such as the child's age, previous traumatic experiences, and parental factors as anxiety, encouragement to use distraction, and parenting style.[4]

VR is a non-pharmacological strategy used to manage AVF cannulation pain among children. This technique involves distracting the child's attention from the painful procedure by engaging them in a virtual reality environment that requires a large portion of their conscious attention. The brain receives information about pain from the pain receptors through neural signals, and distraction techniques work by redirecting the brain's attention to something other than the pain. VR has been found to be more effective than guided visualisation, as it provides visual effects in addition to sound, which makes it easier to attract the child's attention and increase its effectiveness.[3]

Distraction techniques are considered the most effective non-pharmacological interventions for mitigating the pain experienced by children undergoing needle-related procedures. The choice of distraction techniques should be adjusted based on the child's age and preference.[3,4,12]

The current systematic review found that pharmacological and non-pharmacological treatments were both effective in relieving and reducing pain. However, due to the potential side effects of medications, healthcare professionals may prefer to use non-pharmacological strategies for managing children's pain. Nevertheless, implementing these techniques accurately and effectively can be challenging, which highlights the need for additional studies on the use of various non-pharmacological approaches.[13]

Conclusion

The systematic review revealed that both pharmacological and non-pharmacological pain management approaches were effective in reducing pain in children undergoing HDT. Non-pharmacological techniques were easier, simpler and inexpensive, and could be selected according to the child's age and preference.

Limitations: This systematic review has limitations as it was not registered with the International Prospective Register of Systematic Reviews (PROSPERO).[14]

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