ORIGINAL ARTICLE

Investigating of augmented reality and cold vibration therapy on anxiety in children during intravenous insertion: a quasi-experimental study

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ABSTRACT

Anxiety tends to escalate when children undergo intravenous insertion. The success rate of the first attempt at intravenous insertion is suboptimal, leading to increased anxiety in children and prolonged treatment. Unfortunately, current interventions are not yet optimal. This study aimed to determine the influence of augmented reality and cold vibration on children's anxiety during intravenous insertion procedure. This research used an experimental pre-post-test nonequivalent control group design. Purposive sampling was employed, taking into consideration inclusion and exclusion criteria. The instrument used demographic data and Child Anxiety Meter (CAM). The independent variables in this study are augmented reality and cold vibration. The dependent variable is anxiety. The total sample consisted of 60 respondents divided into an intervention group (n=30) and comparison group (n=30). Descriptive statistics, frequency distribution, percentages, Paired T-test, Wilcoxon, and Independent T-test were applied for data analysis. Participants in the intervention group experienced a decrease in mean higher anxiety score (2.03), compared to the comparison group (0.59). The independent t-test indicated <0.001 (<0.05) for a p-value. Based on these results, the application of augmented reality and cold vibration can be considered as non-pharmacological therapy to reduce anxiety. The results of this research are very useful for preparing operational plans and developing inpatient service systems, especially in providing health services to pediatric patients during intravenous insertion.

Key words:
anxiety; augmented reality; children, intravenous insertion; vibration cold.

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INTRODUCTION

Hospitalization is one of the most stressful events for children. Hospitalization is closely associated with emotional changes. Medical procedures that can cause pain and the lack of prior hospitalization experience can further exacerbate emotional changes. Emotional changes in children during hospitalization are manifested through anxiety, fear, and stress. [1] The World Health Organization reports that the prevalence of anxiety among children during hospitalization reaches 45%. The United Nations Children's Fund states that every year, 75% of the 57 million children experience fear and anxiety during hospitalization. In the United States, over 50% of children experience anxiety, fear, and stress due to hospitalization. This condition contributes to the increase in inpatient admissions and healthcare costs in the United States. In Indonesia, around 30.82%, or approximately 35 out of 100 children, experience anxiety as a result of hospitalization.

Intravenous procedures are invasive processes that nurses often perform on children during hospitalization. However, administering intravenous insertion to children is often a challenge. It is common for nurses to fail on the first attempt at infusion. [2] This is in line with previous research, which states that in children, the rate of failure of intravenous insertion in the first trial was very high, namely 64%, of which 23% required four times or more attempts. Factors that can complicate intravenous insertion were as follows: 54.6% experienced venous access difficulty, 43.3% encountered difficulty in inserting the cannula, 41.2% found it difficult to see veins, 38.1% experienced difficulty in feeling veins, 28.9% faced challenges related to officer's ability, 19.6% were affected by child movements, 12.4% reported phobia of needles, and others. Ways that can contribute to the insertion success in the first trial include 84.5% of trained officers, 47.9% hydration, 40.8% tools for seeing veins, 35.9% local anesthesia, 33.8% distraction, and 32.4% hand position. This situation can significantly increase anxiety and pain in children during hospitalization. [3] Childhood anxiety can lead to cognitive and psychological changes. This is because intravenous insertion can cause pain and potentially lead to trauma and even needle phobia. Children also often express concerns before undergoing infusion. This condition can cause nurses to experience more difficulty when giving IV fluids to children. [4,5] Common responses to children experiencing anxiety or fear include crying, restlessness, aggression, withdrawal, lack of cooperation, rebellion, and even resistance to the insertion procedure. When this condition occurs, it can necessitate repeated actions. Repeated insertion attempts can lead to inefficiencies in treatment and even prolong the duration of care.[6,7] Therefore, intravenous insertion should be made as comfortable as possible to minimize anxiety in children.

Pharmacological and non-pharmacological interventions can be applied to reduce anxiety. Non-pharmacological methods are often employed to minimize anxiety because they have few side effects, are easy to use, and are cost-effective.[8] Distraction is one suitable method for addressing anxiety in children.[9] The purpose of using distraction is to divert the child's focus away from pain and enhance pain tolerance. Distraction can also make the child feel more comfortable and relaxed, creating a pleasant state. There is ample research showing that distraction methods are effective in reducing pain and anxiety. Examples of distraction methods include hypnosis, cognitive behavioral therapy, and guided imagery.[10] Previous research results showed that the created distraction can effectively reduce pain and stress symptoms during infusion

procedures. The distraction methods designed for children must be attractive, immersive, and able to stimulate as many of their senses as possible. Therefore, distraction methods come in various forms, such as visual, auditory, and intellectual forms. Visual distraction is one effective technique used to reduce anxiety in children. [11]

One distraction method that is gaining prominence is augmented reality. Augmented reality has become a cutting-edge tool that has been used in science and medicine since the 1990s. It has rapidly evolved and become more accessible, immersive, flexible, and portable. Augmented therapy differs from virtual reality. Virtual reality creates a different reality from the user's reality. It surrounds the user as if they are looking or moving in a different reality than the real world. Virtual reality is so immersive that it often makes users forget the actual situation. Virtual reality often causes symptoms such as disorientation, discomfort, and headaches. [12] While augmented reality is guided by the integration of the digital world with the natural world. Augmented reality has the advantage of adding layers of information on top of the natural world and combining a person's perception of the real world with the digital world. Another advantage of using augmented reality is that it can be used with various devices such as smart glasses or smartphones, and it enhances the user's perception of the real world by incorporating digital elements into it. [13]

Augmented reality is a device capable of creating an interactive three-dimensional real-time environment, sensing and perceiving stimuli related to visual images, and providing responses while interacting directly with the virtual environment. It aligns with previous research indicating that children experiencing anxiety due to invasive procedures prefer augmented reality over virtual reality when undergoing intravenous insertion. This preference is due to augmented reality 's interactivity and enjoyment. The application of augmented reality has also proven superior to virtual reality as it can maintain visual contact with the child. Other studies have highlighted augmented reality's significant potential in addressing mental health issues such as phobias. [14] Augmented reality can divert attention from a threatening object and focus on a preferred object.

Augmented reality in health education has been proven to provide more satisfaction and improve services than other media. Augmented reality has proven therapeutic benefits in psychology, physical medicine, and rehabilitation.[15] Anxiety in children who are about to undergo intravenous insertion can also arise from the fear of experiencing pain due to needle insertion. To address this, researchers have combined augmented reality with another non-pharmacological technique. Another non-pharmacological technique used to reduce pain involves the combination of cold compression and vibration. Both methods can reduce pain sensations without side effects and are cost-effective. Research shows that cold compression and vibration effectively reducing pain. Physiologically, this therapy can suppress pain nerves in the body and provide natural pain relief in seconds.[16,17]

Other studies have also indicated that the combination of cold compression and vibration can reduce anxiety and pain sensations in children during vaccination. The combination of these two techniques has an optimal anesthetic effect. The sensation of cold and vibration can quickly close the gate of control of pain through the stimulation of alpha and beta wave mechanoreceptors. Cold compresses' physiological effects can stimulate the skin's surfaces area.[18] At the same time,

cold also closes the gate of pain control through presynaptic inhibition in the spinal cord. When pain is reduced, it is expected that children will not experience anxiety when undergoing invasive procedures such as intravenous insertion. Based on this background, the researchers conducted a study on the application of augmented reality and cold vibration to reduce anxiety in children undergoing intravenous insertion. This study aims to determine of augmented reality and cold vibration therapy on anxiety in children during intravenous insertion for the purpose of developing inpatient service systems, especially in providing health services to pediatric patients.

METHODS

Research Design

This study utilized a quasi-experimental pre-posttest nonequivalent control group design. The population was children aged 6-14 years who received care in the pediatric ward of Dr. Moewardi Hospital, Indonesia, from June to July 2023. Cochran formula and Morgan's Table were used to determine the sampling size, and 60 patients were included in the study. Samples were selected using purposive sampling. Inclusion and exclusion criteria to ensure a homogeneous sample. Inclusion criteria: 1) undergoing intravenous insertion procedures, 2) not experiencing a loss of consciousness. Exclusion criteria: 1) experiencing emergency conditions, 2) patients sensitive to cold.

The principal researcher recruited potential respondents based on predetermined inclusion and exclusion criteria. The aims and methodology of the study were communicated to all participants and families to ensure transparency. Participants, through their families, were free to refuse the study at any time without facing any consequences. Consent is represented by the parent/guardian. Once participants agreed to participate, they were asked to sign a consent form. Participants were informed about the study but did not know the start time of observations. Two research assistants were responsible for implementing the intervention and collecting research data. The initial assessment used the Child Anxiety Meter (CAM). Before pretest, the research assistants cross-verified the respondents' age with their parents using demographic form. In the pre-test stage, 60 people were divided into two, namely the intervention group (n=30) and the comparison group (n-30).

The comparison group received treatment in line with the hospital's standard operating procedure, which included relaxation techniques involving deep breathing. The intervention group received augmented reality and cold vibration interventions. Augmented reality was provided when the nurse prepared the intravenous equipment until the intravenous insertion procedure was completed. The augmented reality was administered for 3 minutes, while cold vibration was applied just before the intravenous needle insertion. Cold vibration was applied for 30 seconds and placed 5 centimeters proximal to the dorsum of the hand where the intravenous needle was to be inserted. After obtaining ethical approval, the principal investigator (PI) coordinated with the head of the pediatric ward to implement the research procedure.

Data collection involved two instruments: one for collecting demographic data and the other for anxiety scores. The demographic data instrument aimed to determine respondent characteristics and medical information such as age and gender. Respondent anxiety was measured using the Child Anxiety Meter (CAM), which utilizes a scoring range of 0-10. Higher scores indicate higher

anxiety levels. This instrument has been validated and tested for reliability. It has an internal reliability coefficient of 0.80 and a Cronbach's alpha of 0.74. The comparison group received deep breathing relaxation therapy during the intravenous insertion, while the intervention group received augmented reality and cold vibration therapy.

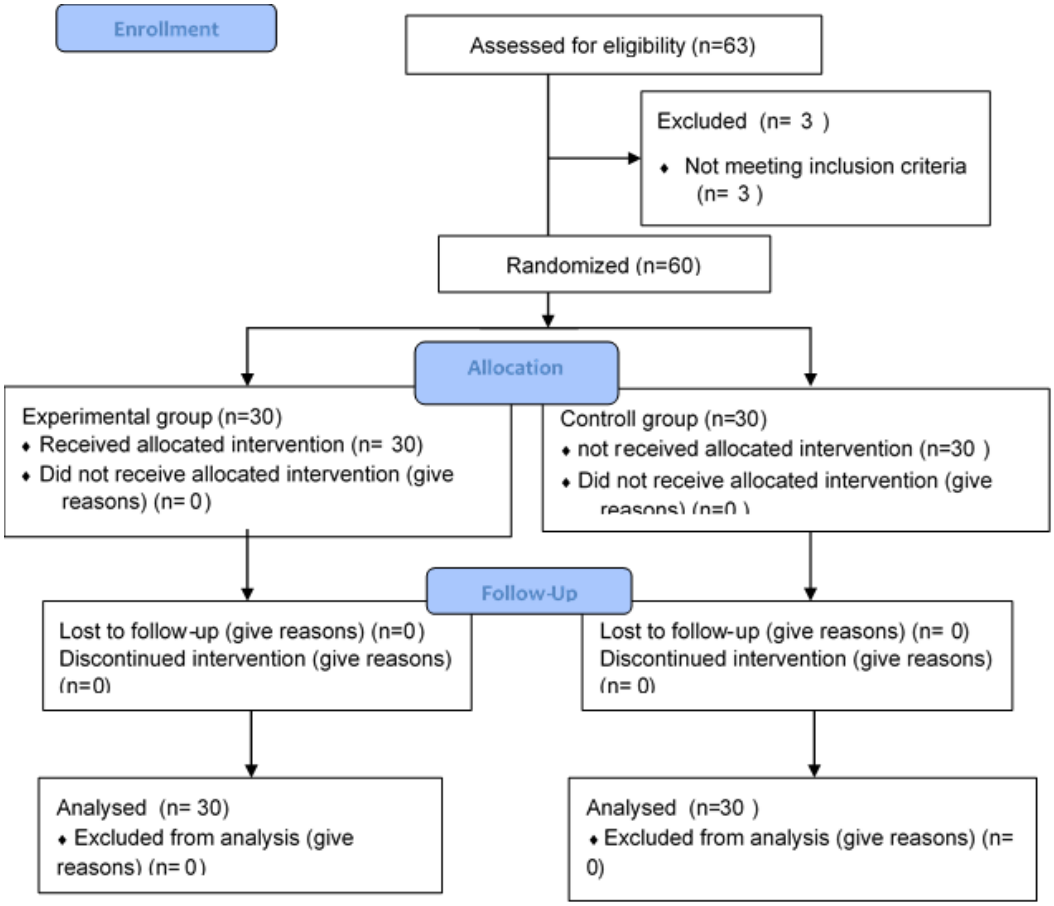

Chart 1. Research Flow

Here are the stages of administering the interventions:

1. Application of Cold Vibration

Cold vibration involves the use of two components: a vibration device and an ice gel. The procedure for cold vibration is as follows: (1) Remove the ice gel from the freezer and let it sit for about 2 minutes. (2) Position the vibration device 2-5 cm near the intravenous insertion site. (3) Secure the strap (tourniquet) 2-5 cm near the intravenous insertion site. (4) Attach the cold vibration device under the strap (tourniquet). (5) Place the ice gel under the cold vibration device. (6) Press the "on" button to activate the vibration on the cold vibration device. Vibration should start 30 seconds before intravenous needle insertion and continue until the needle is successfully inserted. (7) After the needle insertion is successful, remove the cold vibration device and ice gel from the respondent's hand.

2. Application of Augmented Reality

The components of creating augmented reality include 3D modeling. The process of creating mobile augmented reality is as follows:

a. Develop characters for the story.
b. Create a preliminary sketch of the characters
c. Generate rigs (character bones) for 3D animation.
d. Produce animations.
e. Conduct testing on AR platforms.

The procedure for using augmented reality, as is follows:

a. Make sure the connection is good
b. Access the link https://asblr.com/bG2LL
c. Open the QR code in the application and click “place in room”
d. Press the yellow part on the screen
e. If the image appears, the patient can interact by pressing the arrow on the right
f. Repeat the process until the scene ends

Picture 1. Augmented Reality

Data Analysis

This analysis was done using the SPSS version 25.0 program. Demographic data were analyzed through descriptive statistics, frequency distribution, and percentages. Paired t test was carried out to assess differences in anxiety levels before and after intervention in the intervention group. At the same time, the Wilcoxon test was used to assess the level of anxiety before and after the intervention in the comparison group. An independent t-test was conducted to assess differences in anxiety levels in the comparison and intervention groups. Analysis of these results was carried out while maintaining the confidentiality of the respondents.

Ethical Consideration

This research received ethical approval from the ethical commission of Dr. Moewardi Regional Public Hospital, Indonesia, with reference number 484/III/HREC/2023. All participants were verbally informed and provided informed consent. All collected information was kept confidential. No names appeared in any results, and a coding system known only to the researchers was developed.

RESULTS

Univariate Data

a. Characteristics of Respondents

A total of 60 individuals participated in this study until its completion. Most respondents were female, with 19 (63.33%) in the intervention group and 20 (66.67%) in the comparison group. The average age of the respondents in this study was six years.

Table 1. Characteristics of Respondents (N=60)

Characteristics	**Intervention (n=30)**			**Comparison (n=30)**			**p-value**
	mean	**SD**	**Min-max**	**mean**	**SD**	**Min-max**	
Age	6.4	1.6	4-10	6.4	1.6	4-9	.54
Gender	**f**	**%**		**f**	**%**		**p-value**
- Male	11	36.67		10	33.33		.10
- Female	19	63.33		20	66.67		.34

b. Anxiety Score

The measurement results show that the difference in anxiety scores in the intervention group is higher than in the comparison group. In the intervention group, the difference is 2.03, while in the comparison group, it is 0.59. This difference in scores indicates a more significant reduction in anxiety scores in the intervention group compared to the comparison group.

Table 2. Anxiety Scores (N=60)

Anxiety	**Intervention (n=30)**		**Comparison (n=30)**	
	Mean±SD	**Min-Max**	**Mean±SD**	**Min-Max**
Pre	5.90+2.04	1-10	5.56+2.17	1-9
Post	3.87+1.63	1-7	4.97+1.58	1-9

Bivariate Data

a. Differences of Anxiety Scores Before and After Treatment in the comparison and intervention groups

The data normality test was carried out using Kolmogorov-Smirnov. Test effectiveness was performed on normal data using the paired t test and abnormal data using the Wilcoxon test. Table 3 shows that in the intervention group there was a difference in anxiety scores before and after implementing augmented reality (p-value <0.001). On the other hand, in the comparison group there was no difference in anxiety scores before and after applying the deep breathing technique (p-value 0.12)

Table 3. Differences of the pretest and post-test quality of life scores in the comparison and intervention groups (N=60)

Group	*n*	*Pre-test*	*Post-test*	*Mean rank*	*p-value*
		Mean±SD	**Mean±SD**		
Comparison group	30	5.56±2.17	4.97±1.58	4.90	0.12*
				2.87	
Intervention group	30	5.90±2.04	3.87±1.63		<.001***

Wilcoxon Test, * Paired T-test*

b. Differences Of Anxiety Scores Between Comparison Group and The Intervention Group

This study also demonstrates a significant difference in anxiety scores between the intervention and comparison groups, as indicated by a p-value of 0.001 in the unpaired t-test.

Table 4. Differences of the posttest anxiety scores in the comparison group and the intervention groups (N=60)

Group	Mean	S.D.	Mean Difference (post-test)	*p-value*
Comparison group	0.59.	1.87	1.44	<.001*
Intervention group	2.03	1.83		

**Unpaired T-test*

DISCUSSION

This research shows that non-pharmacological interventions are especially suitable for children undergoing infusion. Therefore, this study uses augmented reality and cold vibration to reduce children's anxiety during the infusion procedure. This research shows that the average anxiety score in the intervention group is higher compared to the comparison group. It means the reduction in anxiety scores in the intervention group was a more significant than the comparison group. In this study, PI used augmented reality and cold vibration technology as an enjoyable distraction and relaxation technique in the intervention group to reduce anxiety.

Anxiety disorders are the result of a rather complex mechanism.[19] The hippocampus, which serves as the primary target and stress mediator, is closely related to anxiety modulation. Further exploration of the hippocampus neurotransmitter systems, including the glutamatergic, cholinergic, dopaminergic, GABAergic, and serotonergic systems, has contributed to understanding the neural mechanisms underlying anxiety. Additionally, neuropeptides and nervous system inflammation factors are involved in modulating anxiety.[20] Intravenous insertion in children is often considered one of the most painful aspects of hospitalization and can lead to anxiety. Anxiety experienced by children before intravenous insertion can disrupt the success of the procedure and increase pain.[21] The application of augmented reality and cold vibration technology in this research has been proven to reduce anxiety in children during

intravenous insertion. Furthermore, the application of augmented reality and vibration cold also improved the success rate of intravenous insertion on the first attempt. These findings align with previous research indicating that the appropriate use of visual distraction can reduce anxiety, consequently increasing the success of first-time intravenous insertion.[22]

Augmented reality is superior because it can provide a strong experience and immerse patients in virtual and real-world objects. Based on this, researchers used augmented reality as an intervention to reduce anxiety in children who are undergoing intravenous insertion. Augmented reality allows patients to divert their attention from symptoms such as depression, fatigue, pain, and anxiety, resulting in a high indicator of intervention success as it helps to alleviate or feel these symptoms at a lower level. It is in line with the performance of imagination, which involves activating and synchronizing the body's sensory receptors through the senses of sight, hearing, touch, smell, kinesthetics, and proprioception. Augmented reality can also deepen knowledge and understanding for users. This application is easy to use, attractive to children, and increases motivation. This is why augmented reality can reduce anxiety in children.

The researchers also used cold vibrations along with augmented reality. The aim of using cold vibration is to optimize the distraction experienced by the patient. Cold vibrations can produce a chilly sensation that acts on the A-Delta fibers and small vibrations that act on the C fibers. Next, the impulse will end up in the central nervous system. Patients will recognize the presence of pain and show different variations in pain perception in each individual. The last process is perception, where the message of pain is conveyed to the brain and produces an experience that is not fun.[23] This is the researcher's reason to combine augmented reality with cold vibration . Cold vibration contributes to reducing pain, which can have a direct impact on reducing anxiety during infusion.[4,18] Its effectiveness has been demonstrated in adults, specifically in children between 6 and 12 years. Several studies highlight the importance of distraction in intravenous insertion. High success rates in adults and significant appeal in preschoolers through adolescents have been observed.[24] Augmented reality and cold vibration maximize the body's organ functions in diverting and reducing anxiety about intravenous insertion. This intervention is also a good distractor because it provides sensory stimulation, engages the respondents, and is very easy to capture children’s attention.[25] However, there is limitations of this study, such as the area studied was restricted to RSUD Dr. Moewardi Surakarta only.

RECOMMENDATION

The results of this research are very useful for preparing operational plans and developing inpatient service systems, especially in providing health services to pediatric patients so that they can experience the benefits and effectiveness of these interventions. The research results can also be used as an alternative non-pharmacological intervention to reduce anxiety during intravenous infusion. However, future research must be expanded to other research locations to examine various problems that could potentially arise during the infusion procedure.

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AUTHOR'S CONTRIBUTION

Anis Laela Megasari : Drafting the work and final approval of the version to be published

Ika Subekti Wulandari: Substantial contributions to the conception or design of the work

Sri Mulyani: Agreement to be accountable for all aspects of the work

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