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ORIGINAL ARTICLE

Effect of using normal saline, alcohol and acetone on pain during removal of polyacrylate adhesive dressings in children aged 10–15 years: a pilot randomized controlled trial

Edith Sumaregita Rinhastyanti[1], Herman Yosef Limpat Wihastyoko[2], and Tommy Alfandy Nazwar[3]

[1]Department of Medicine, Faculty of Medicine Universitas Brawijaya, Malang, Indonesia
[2]Department of Plastic, Reconstructive and Aesthetic Surgery, Saiful Anwar Regional General Hospital, Malang, Indonesia
[3]Department of Surgery, Faculty of Medicine Universitas Brawijaya, Saiful Anwar Regional General Hospital, Malang, Indonesia

*** Correspondence Author:**
Wihastyoko@ub.ac.id

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ABSTRACT

BACKGROUND
Removing wound dressings containing polyacrylate adhesives can cause pain, especially in pediatric patients with more sensitive skin and lower pain thresholds. This study aimed to evaluate the effects of normal saline, alcohol, and acetone on pain during dressing removal in children and evaluate their associated side effects.

METHODS
The study used a pilot randomized controlled trial involving 16 children aged 10-15 years at the Surgical Clinic of Dr. Saiful Anwar Regional General Hospital, Malang. Pain levels were measured using the Wong-Baker Faces Pain Scale, while side effects were assessed using the Skin Irritation Score and Itchyquant Score. The children's pain was assessed 1 min after the procedure. Kruskal-Wallis test, followed by Dunn's post hoc test were used for data analysis.

RESULTS
The results demonstrated that acetone was significantly more effective than normal saline and alcohol in reducing pain during dressing removal ($p<0.050$). Normal saline and alcohol did not show significant differences compared to the control group, likely due to their limited ability to dissolve the polyacrylate adhesive. Mild irritation and temporary pruritus occurred in all groups, with acetone producing the least reaction. Acetone's effectiveness is attributed to its ability to disrupt van der Waals forces and polymer bonds within the adhesive, thereby reducing the force required for removal.

CONCLUSIONS
Acetone is the most effective agent for reducing pain during dressing removal, with minimal side effects compared to other solvents. Further research is necessary to determine optimal formulations and assess the stability of acetone for the development of acetone swab products.

Keywords : Pain management, pediatric, polyacrylate adhesive, acetone, children

INTRODUCTION

Disruption of tissue integrity, such as in the skin, mucosa, or organs, can lead to wounds. This process can occur as a result of physical trauma, infection, or surgery.[1] Wound healing is a complex biological process that aims to restore the structural and functional integrity of injured tissues.[2] There are four main phases in the wound healing process: hemostasis, inflammation, proliferation, and remodeling, which occur gradually to achieve optimal recovery of skin and tissue function.[3] The appropriate selection of wound care methods, including the type of wound dressing, is essential for supporting the wound healing process. Practitioners need to consider the differences between medical adhesives and dressings. Medical adhesives are generally polyacrylate-based.[4] A wound dressing comes into direct contact with the wound, while a bandage secures the dressing in place. An ideal wound dressing maintains a moist wound environment, prevents infection, provides mechanical protection, controls exudate, allows easy application and removal, and remains cost-effective.[5]

The use of medical adhesives can pose risks, especially in patients with sensitive skin, such as pediatric patients. Adhesives that adhere too strongly to the skin may cause separation of skin layers—either between epidermal cells or between the epidermis and dermis. This condition is known as medical adhesive-related skin injury (MARSI). This injury can cause significant pain, especially in pediatric patients who have a lower pain threshold and thinner skin, which can be a source of fear and anxiety.[6] According to the Indonesian Surgical Association (PABI) and Indonesian Pediatric Society (IDAI), as reported in the 2023 MARSI consensus, MARSI incidents in pediatric patients in the Pediatric Intensive Care Unit (PICU) are quite high, with a prevalence ranging from 23.5% to 54%.[7]

Pain management during wound dressing removal poses a unique challenge in clinical practice. Pain associated with dressing removal is often overlooked by healthcare providers, even though it may trigger additional inflammatory responses, delay healing, and increase the risk of wound complications. Medical professionals have developed several approaches to minimize pain during dressing changes, including the use of adhesive removers. While medical professionals commonly use normal saline and alcohol as adhesive removers, the effectiveness of the latter in reducing pain is still limited. Despite the critical need for better pain management, comparative studies evaluating alternative solvents specifically for polyacrylate adhesive removal in vulnerable pediatric populations remain heavily under-researched. Acetone is recognized as a suitable solvent for polymers, making it an ideal choice for dissolving the polyacrylate contained in medical adhesives. Several studies have demonstrated the high effectiveness of acetone in reducing the strength of cyanoacrylate adhesives and facilitating their removal without leaving residues. However, acetone may cause skin irritation; therefore, special attention is required, particularly in pediatric patients.[8]

Previous studies investigating the use of solvents to facilitate medical adhesive removal have reported inconsistent results. A study by Van Schaik et al.,[9] which evaluated various solvents—including water, alcohol, arachis oil, sunflower oil, and leukotape remover—in pediatric patients, found that these agents were not effective in reducing pain during adhesive removal. In contrast, Chottanapund et al.[10] demonstrated that an organic-based solution derived from citrus extract was effective in reducing pain during dressing removal in postoperative wound patients, without significant side effects.

Despite these findings, the evidence remains limited and inconsistent, particularly regarding commonly used medical solvents and their effectiveness in pediatric populations. Furthermore, direct comparisons between organic and inorganic solvents in a controlled clinical setting are still lacking.

Therefore, this study utilizes both organic solvents (acetone and alcohol) and an inorganic solvent (normal saline), which are widely available and commonly used in clinical practice, to provide a direct comparison of their effectiveness in reducing pain during polyacrylate adhesive dressing removal.

METHODS

Research design

This study being a pilot randomized controlled trial (RCT) was conducted from 1 August 2024 to 31 December 2024 at Dr. Saiful Anwar Regional General Hospital, Malang.

Research subjects

The research subjects consisted of pediatric patients undergoing treatment at the Plastic, Reconstructive and Aesthetic Surgery Clinic of Dr. Saiful Anwar Regional General Hospital, Malang. Inclusion criteria were: (i) pediatric patients aged 10–15 years treated at the Plastic Surgery Clinic of Dr. Saiful Anwar Regional General Hospital, Malang for lower extremity wounds during the study period; (ii) a minimum distance of 2 cm between the outer adhesive dressing and the skin; and (iii) patients who provided informed consent to participate as research subjects. Exclusion criteria were: (i) a history of allergy to normal saline, alcohol, or acetone; (ii) a history of irritant contact dermatitis; (iii) cognitive impairment; (iv) a history of chronic pain; (v) incomplete wound care; and (vi) wounds that were infected or inflamed. This study was designed as a pilot study,[11] with a total of 16 participants divided equally into four groups (n=4 per group). This sample size was considered sufficient to identify initial trends, feasibility, and variability in results prior to conducting a larger-scale study with adequate statistical power. The baseline characteristics of the subjects, such as age, gender, and wound location, were ensured to be homogeneous across groups before the intervention.

Randomization and blinding

Participants were allocated to four treatment groups (acetone, alcohol, normal saline, and control; n=4 per group) using a randomized block design with a block size of 4. This method was chosen to ensure an equal distribution of subjects across all intervention arms. Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes.

In the control group, the adhesive bandage was removed without using any solvent. The entire bandage removal process was performed by the same medical staff to ensure consistency in technique.

This study was conducted as a non-blinded (open-label) study, as blinding of participants and treating clinicians was not feasible due to the nature of the intervention. However, the statistical analyst was unaware of group allocation to minimize assessment bias.

Interventions

Each group received a specific solvent (90% acetone, 70% alcohol, normal saline, or 0.9% NaCl) applied to the edges of the dressing prior to removal. Acetone was chosen as the organic solvent due to its proven ability to dissolve polyacrylate-based adhesives. Although it is highly volatile, acetone was applied in a controlled manner using a limited amount on a cotton swab and only on the edges of the bandage, thereby minimizing direct exposure to the skin.

In the control group, dressings were removed manually without any solvent. For consistency, standard techniques were used across all groups, with a single piece of cotton applied to the edges of the bandage before removal. In the control group, dry cotton was used to mimic the same procedure without solvent application. Due to the varying physical properties of the solvents (e.g., odor and evaporation), a non-blinded method was used for participants and staff. However, outcome assessments were standardized, and the statistical analysts were unaware of group allocation to reduce potential bias. The same medical personnel performed all dressing removals to ensure consistency in technique.

Study outcomes

Primary outcome: pain was assessed using the Wong -Baker Faces Pain Scale. This scale uses pictorial diagrams depicting expressions ranging from neutral to pain, accompanied by a numerical scale. Unlike numerical pain scales, this scale does not require cognitive skills related to serial numbers or ordinal positions, making it suitable for children aged 3–18 years.[12] The children's pain was assessed 1 min after the procedure.

Secondary outcomes: side effects of solvent use assessed using the skin irritation score (to assess redness/edema) and the Itchyquant Score (to assess itching).[13,14] Side effects were observed at 30-60 minutes and at 24, 48, and 72 hours after the intervention.

Statistical analysis

Data normality was assessed using the Shapiro-Wilk test due to the small sample size (n=16). Categorical data (gender and wound location) were analyzed using Fisher's Exact Test. Comparisons of pain, irritation, and itch scores between groups were analyzed using the nonparametric Kruskal-Wallis test, followed by Dunn's post hoc test to identify specific differences between pairs of groups. All statistical analyses were performed using SPSS software with a $p<0.05$.

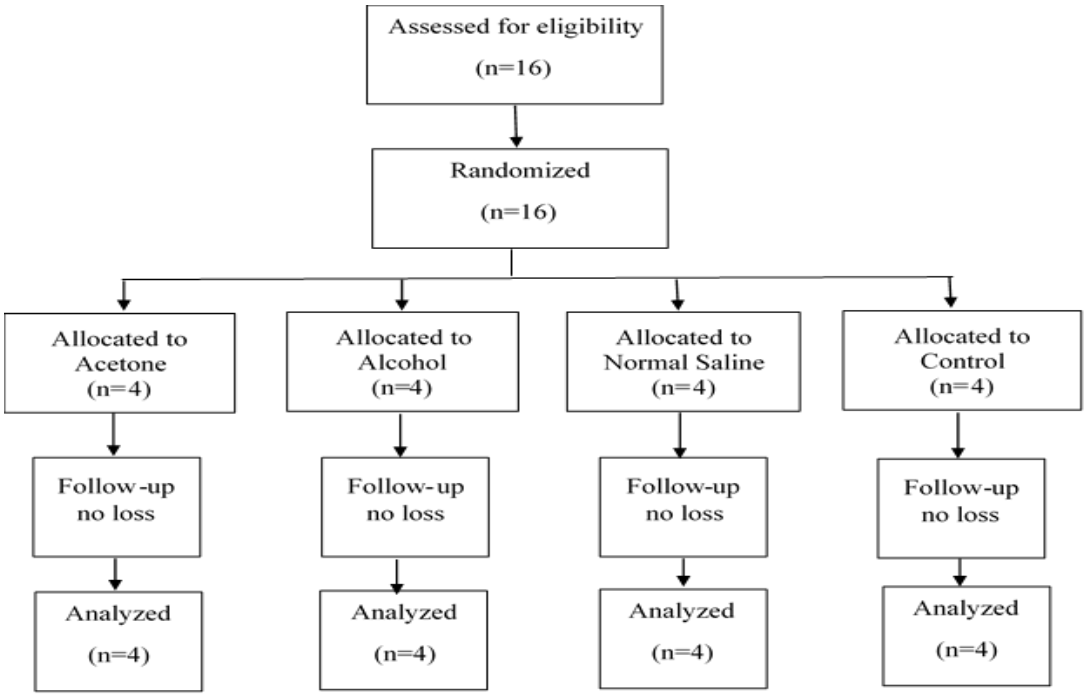

Figure 1. Flow chart of the participants

Ethical approval

This study was conducted after obtaining ethical approval from the Faculty of Medicine, Universitas Brawijaya, with reference No. 230/EC/KEPK–S1–PD/07/2024.

RESULTS

Sixteen eligible subjects were randomly assigned to four treatment groups: acetone, alcohol, normal saline, and control. Baseline demographic and clinical characteristics are presented in Table 1. Statistical analysis indicated no significant differences in mean age between groups (p=0.396), confirming age homogeneity. The majority of subjects were male (75.0%), with 12 males and 4 females. Fisher's Exact test revealed no significant difference in gender distribution (p=0.859), confirming gender balance. All subjects had abrasions, resulting in a constant wound-type variable. Most wounds were located in the crural region (56.3%), followed by the gastrocnemius (18.8%), knee (12.5%), ankle (6.3%), and dorsum of the foot (6.3%). The Fisher-Freeman-Halton test showed no significant difference in wound location distribution (p=0.531). These results confirm that all treatment groups were equivalent and homogeneous at baseline.

Table 1. Baseline demographics and wound description by treatment group

Characteristics	Acetone (n=4)	Alcohol (n=4)	Normal Saline (n=4)	Control (n=4)	p value
Age (years)	11.75± 2.36	11.75± 1.25	10.50± 1.00	10.50± 1.00	0.396
Gender					
Male	4 (100.0)	3 (75.0)	2 (50.0)	3 (75.0)	0.859
Female	0 (0.0)	1 (25.0)	2 (50.0)	1(25.0)	
Wound Location					
Regio cruris	1 (25.0)	3 (75.0)	3 (75.0)	2 (50.0)	
Regio genu	2 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Regio gastrocnemius	1 (25.0)	0 (0.0)	1 (25.0)	1 (25.0)	0.531
Regio talocruralis (ankle region)	0 (0.0)	0 (0.0)	0 (0.0)	1 (25.0)	
Regio dorsum pedis	0 (0.0)	1 (25.0)	0 (0.0)	0 (0.0)	

Note : data presented as n (%), except age as mean ± SD

Table 2. Comparison of pain scores during dressing removal among treatment groups

Variable	Acetone (n=4)	Alcohol (n=4)	Normal saline (n=4)	Control (n=4)	p value
Wong Baker faces pain scale	0 (0-0)	3 (3-4)	3 (3-4)	5 (4-5)	0.004

Note : data presented as median; The children's pain was assessed 1 min after the procedure.

The Kruskal–Wallis test for pain scores (Table 2) revealed significant differences among groups (p=0.004). The Dunn post-hoc test (Table 3) revealed a significant difference only in the acetone–control group (p=0.001), while the other comparisons were not significant (p>0.05). For skin irritation scores, the Kruskal–Wallis test (Table 4) also showed a significant difference (p=0.005). Dunn's post-hoc analysis (Table 5) revealed significant differences in the acetone–control group (p=0.001), alcohol–control group (p=0.016), and normal saline–control group (p=0.016). For Itchyquant scores, the Kruskal–Wallis test (Table 4) showed significant differences only at the 30–60-minute observation time (p=0.003), while no significant differences were found at 24 hours (p=0.543), 48 hours (p=1.000), and 72 hours (p=1.000). The Dunn post-hoc test at the 30–60-minute time point (Table 6) revealed significant differences between the acetone–normal saline group (p=0.027), the acetone–control group (p=0.001), and the alcohol–control group (p=0.015).

Table 3. DUNN test for pain scores between the acetone, alcohol, normal saline, and control groups

Sample 1- sample 2	Mean rank	p-value
Acetone-Alcohol	6.13	0.058
Acetone-Normal Saline	6.13	0.058
Acetone-Control	11.75	0.001
Alcohol- Normal Saline	0.00	1.000
Alcohol-Control	5.62	0.082
Normal Saline-Control	5.62	0.082

Table 4. Comparison of side effects among treatment groups assessed at 30–60 minutes, and at 24, 48, and 72 hours after intervention using the Skin Irritation Score and Itchiquant Score

Variable	Acetone (n=4)	Alcohol (n=4)	Normal saline (n=4)	Control (n=4)	p value
Skin irritation score	0.5 (0-1)	1 (1-1)	1 (1-1)	2 (2-2)	0.005
Itchiquant score					
30-60 min	0.5 (0-2)	2 (2-3)	3.5 (3-4)	6.5 (6-8)	0.003
24 hrs	0 (0-0)	0 (0-2)	0 (0-0)	0 (0-2)	0.543
48 hrs	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	1.000
72 hrs	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	1.000

Note : data presented as median

Table 5. DUNN test for irritation scores between the acetone, alcohol, normal saline, and control groups

Sample 1- sample 2	Mean rank	p-value
Acetone-Alcohol	3.00	0.301
Acetone-Normal Saline	3.00	0.301
Acetone-Control	10.00	0.001
Alcohol- Normal Saline	0.00	1.000
Alcohol-Control	7.00	0.016
Normal Saline-Control	7.00	0.016

Table 6. DUNN test for itch scores at 30-60 minutes between the acetone, alcohol, normal saline, and control groups

Sample 1- sample 2	Mean rank	p-value
Acetone-Alcohol	3.50	0.292
Acetone-Normal Saline	7.37	0.027
Acetone-Control	11.62	0.001
Alcohol- Normal Saline	3.87	0.244
Alcohol-Control	8.12	0.015
Normal Saline-Control	4.25	0.201

DISCUSSION

This pilot randomized controlled clinical trial demonstrated that acetone is significantly more effective than alcohol, normal saline, or the use of no solvent in the control group in reducing pain during the removal of polyacrylate adhesive bandages in pediatric patients. This is consistent with previous research, that acetone is an effective solvent for polyacrylate- and cyanoacrylate-based adhesives due to its ability to disrupt intermolecular interactions within the polymer structure, thereby reducing adhesive strength and facilitating removal.[15–17] Its ability to dissolve polyacrylate adhesive bandages is also consistent with the findings of a study comparing soapy water, surgical alcohol, and acetone in removing microporous tape adhesive.[18] Acetone is an effective polymer solvent due to its polarity and its ability to disrupt non-covalent interactions, particularly van der Waals forces, which stabilize the polymer structure.[15,19] This mechanism weakens the adhesive properties of polyacrylate, allowing for removal with minimal force, which supports the finding that acetone is more effective than other solvents.

In contrast, normal saline showed no significant difference, likely due to its mechanism of action occurring gradually. In solution, saline dissociates into sodium and chloride ions that can interact with acrylate polymers and trigger hydrolysis, particularly in pressure-sensitive adhesives based on acrylic acid.[20,21] However, this process requires a longer exposure time, so removal still requires greater mechanical force and causes pain.

The use of alcohol also did not lead to a significant reduction in pain, as ethanol is only capable of dissolving some components of the polyacrylate adhesive. This mechanism involves an increase in the solubility of acrylate compounds and changes in the interchain spacing of the polymer, which enhances water absorption and the diffusion of solutes.[22] Additionally, ethanol can trigger hydrogen atom transfer, which affects the strength of the acrylate polymer.[23] However, this process is insufficient to completely weaken the adhesive's strength, so removal still requires force that can cause pain.

Analysis of irritation scores showed significant differences between the acetone, alcohol, and normal saline groups compared to the control, with the acetone group exhibiting lower irritation levels. This is likely related to reduced mechanical tensile force during removal, due to more effective adhesive degradation.[20,22] Significant differences in itch scores were only observed during the first 30–60 minutes, indicating temporary irritation resulting from disruption of the skin barrier function during the removal process. Activation of pruriceptors and the penetration of inflammatory mediators are known to stimulate unmyelinated C-fibers, which play a role in the sensation of itching.[24]

Although the relatively small sample size limits the generalizability of these findings, the study results indicate that acetone is the most effective option for reducing pain with minimal side effects compared to normal saline and alcohol. Clinically, the use of acetone as an adhesive-releasing agent has the potential to improve patient comfort, reduce anxiety, and minimize the risk of medical adhesive-related skin injury (MARSI), particularly in pediatric patients.

CONCLUSION

Based on the results of this study, acetone was found to be more effective in reducing pain during the removal of polyacrylate adhesive dressings in pediatric patients compared to alcohol, saline solution, and the control group. The use of acetone also showed minimal side effects, indicating a good safety profile when applied in a controlled manner. These findings suggest that acetone could be a practical option for improving patient comfort during dressing changes. However, further research with a larger sample size is needed to reduce potential bias, and studies on optimal material concentrations are required to determine the most suitable levels and minimize side effects.

Conflict of Interest

The authors declare no conflict of interest

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Authors' Contributions

ESR: methodology, data collection, data analysis, writing original draft preparation. HYLW: conceptualizing research, validation, supervision, and reviewing the manuscript. TAN: validation, supervision, and review of the

manuscript. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

The data included in this manuscript are original data generated from the research.

Declaration of AI Usage in Scientific Writing

None.

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