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Is virtual reality an effective pain management treatment during wound care of pediatric burn patients?

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ABSTRACT

Objective: The objective of this selective EBM review is to determine whether or not "Is virtual reality an effective pain management treatment during the wound care of pediatric burn patients?"

Study Design: Systematic review of three randomized controlled trials (RCTs) published, in English, in peer-reviewed journals between 2008-2014.

Data Sources: The three RCTs were found using the PubMed and Ovid databases.

Outcomes measured: All three studies measured pain perception and intensity using self-reporting questionnaires, and visual analogue scales.

Results: Jeffs et al. and Miller et al. both showed that patients using the virtual reality (VR) or augmented reality (AR) mechanisms reported less pain during wound care than passive distraction or standard distraction groups. Mott et al. found that there was no difference in total pain between the control and virtual reality treatment groups requiring medium dressing times (<30 min). However, for long dressing times, the multi-modal distraction (MMD) device group reported significantly less pain than the control groups.

Conclusions: Based on the results of these three studies, it appears that there is a benefit in using virtual or augmented reality devices to supplement pain management in the pediatric population. There may be more benefit in patients that have more extensive injuries that require longer dressing times, but additional investigation is needed. Furthermore, there are multiple types of virtual or augmented reality devices and more studies are needed to show if one particular apparatus is more superior for pain management during wound care in pediatric burn patients.

Key words: Virtual reality, burns, children

INTRODUCTION

Burn injuries are one of the most common injuries for both children and adolescents. They are classified by the amount of body surface area affected, depth, age, and associated injury or illness.[1] Depth describes the number of skin layers affected, whereas body surface area is determined by using either the "Rule of Nines" or the Lund-Browder chart. Each of these aspects is used to determine the severity of the burn, which drives the overall treatment and pain management approach. Prompt clinical assessment and treatment of burn injuries are vital in preventing further complications like dehydration, infection, shock, and death. Trauma from the initial injury and subsequent treatments can cause a decrease in the overall quality of life and significant psychological injury to burn patients, especially in children. Reactions like treatment anxiety, anger, and uncooperativeness in affected kids can be attributed to the repeated painful experiences associated with wound care.[2]

Pediatric burn injuries can occur in any environment and result in approximately 100,000 hospitalizations, 120,000 emergency room visits, and over 66,000 days of inpatient hospital care annually.[3] Since these injuries can occur in any environment including the household, it is common to see these types of injuries in children in a variety of healthcare settings including urgent care, pediatrics, dermatology, and emergency settings. Costs associated with burn care can be incredibly high; with more than $200 million spent in 2005.[4] The overall mean costs for hospitals is about $9,000 but this estimate increases depending on the total body surface area (TBSA) and the need for skin grafting.[4]

Burn treatment has been well established, but alternatives to the management of pain perception and prevention of psychological distress during wound care, remains under investigation. While not all children share the same pain or emotional experiences, certain

factors make them more susceptible to prolong psychological issues. Aspects like their developmental level, coping mechanisms, and external sources of support each impact the amount of long term effects that the injury and treatments have on them.[5] In an effort to lessen these effects and decrease pain perception, current methods employed include a mixture of medications and distraction techniques. Opioid and nonopioid analgesics are commonly used throughout treatment, whereas adjunctive anxiolytics are used as needed for patient anxiety and agitation.[6] Standard distraction techniques include movies, books, toys, and relaxation techniques.

While the treatment options are all effective pain management treatments during wound care, the psychological distress and breakthrough pain perception throughout these procedures can cause long term harm on patients.[5] The use of virtual reality (VR) or augmented reality (AR) devices aim to provide non-pharmacological relief from pain and emotional traumas by providing an immersive experience during routine wound care in pediatric burn patients. By immersing the patient's senses using a variety of VR or AR devices, it is hypothesized that the patient will experience less pain and a better psychological outcome.

OBJECTIVE

The objective of this systematic review is to determine whether "virtual reality is an effective pain management treatment during wound care of pediatric burn patients?"

METHODS

Three randomized controlled trials were selected for this study, including pediatric patients between the ages of 3 to 17 with burns that affected more than 1% of their TBSA. The intervention used in each of these studies was the use of AR or VR equipment, such as hand-held

devices or helmets. Comparisons used in each study involved standard distraction techniques such as television, video games, age appropriate toys, nursing staff soothing, and care giver support; passive distraction with an age appropriate movie; or multi-dimensional cognitive techniques like positive reinforcement, relaxation techniques, and an age appropriate video game. Acute pain perception and intensity were the outcomes measured in these studies.

All articles were published in English in peer-reviewed journals, and found in PubMed and OVID using the key words: “virtual reality”, “burns”, and “children”. Inclusion criteria comprised randomized controlled trials that used VR or AR as an adjunct to pain management in burn patients that were published after 2001. Excluded from this review were studies involving patients over the age of 18 and AR or VR used during treatments other than wound care, like physical therapy, occupational therapy, and hydrotherapy. Statistics reported included p-values, standard deviations, independent and paired t-scores, and means. Study specific demographics and characteristics are found in Table 1.

Table 1: Demographics and Characteristics

Study	Type	# Pts	Age (yrs)	Inclusion Criteria	Exclusion Criteria	W/D	Interventions
Jeffs, 2014	RCT	30	10-17	-Pts undergoing burn wound care as a first-time visit to the outpatient burn clinic or first clinic visit without conscious sedation -English speaking.	-Burns that would interfere with study procedures -History of motion sickness or seizure disorder -Incarcerated minors -Minors in foster care -Presence of cognitive developmental disability as determined by section 504 accommodation plan or Title VIII individualized educational plan in school	2	Standard care with no distraction vs Passive distraction vs Virtual Realty helmet distraction during dressing changes

Miller, 2011	RCT	40	3-10	-Pts with a new burn -TBSA >1%, who attended outpatient clinics -Required standard analgesia only	-Sedation and anxiolytics -Cognitive impairment that negated the use of pain outcome measures -Visual impairment that could not be corrected by lenses -Non-English speaking	0	Combined Multi-modal distraction (MMD)with an MMD hand-held device vs standard distraction prior to, and during dressing changes
Mott, 2008	RCT	42	3-14	-Pts undergoing acute burn care or initial post-operative burn dressing changes<br->1% TBSA affected	- No children were excluded on the basis of the site of their burn or impaired intellectual ability	0	Basic multi-dimensional cognitive techniques vs Augmented reality hand-held device

OUTCOMES MEASURED

Patient-reported acute pain perception was measured using various questionnaires and assessment tools including the Adolescent Pediatric Pain Tool with Word Graphic Rating Scale (APPT-WGRS), Faces Pain Scale-revised (FPS-R), Visual Analogue Scale (VAS), and the Wong Baker Faces Scale (FACES). APPT-WGRS involves descriptive phrases and pain scale measured in millimeters, to determine a score from 0 to 100.[2] FPS-R, VAS, and FACES each include a 0 - 5 pain scale.[7-8] The type of tool used in each study depended on the age of the child involved and their ability to describe or verbalize their responses. In Mott et al., verbalizing children ages 4 to 8 used the FPS-R, whereas the VAS was used for patients between the ages of 8 and 14.[8] Furthermore, Miller et al and Mott et al also looked at how pain scores changed over time among their respective treatment groups.[7-8]

RESULTS

Three randomized controlled trials were analyzed in this review, each exploring the utilization and efficacy of VR devices as pain management therapy in pediatric patients undergoing wound care for burns. Results from each study were presented as continuous data that could not be converted into dichotomous form; therefore, Relative Risk Reduction, Relative Benefit Increase, Absolute Benefit Increase, and Number Needed to Treat could not be calculated for these studies.

The study by Jeffs et al[2] was completed in the United States in conjunction with the University of Arkansas, and published in the Journal of Burn Care and Research. The other two studies by Miller et al and Mott et al[7-8] were completed in Australia in conjunction with the University of Queensland, and were published in Burns: Journal of the International Society for Burn Injuries.

In the study by Jeffs et al[2], 30 burn patients between the ages of 10 to 17 with mean age of 13.5 years were evaluated as three separate treatment groups: the VR group (N=8), the passive distraction group (PD) (N=10), and the standard care group (SC) (N=10). Patients with burns that would interfere with study procedures, history of motion sickness or seizure disorders, incarcerated minors, minors in foster care, presence of cognitive developmental disability as determined by section 504 accommodation plan or Title VIII individualized educational plan in school were excluded from this study. The VR intervention was provided through a mounted device that utilized interactive three-dimensional gaming software called SnowWorld. The PD group watched an age-appropriate movie, while the SC group was subjected to typical nursing care. Each group answered an APPT-WGRS after completion of dressing changes to rate the perceived pain intensity during the procedure. A Kruskal-Wallis test was used to determine significance for these ordinal and continuous variables. Two subjects were lost to follow-up due

to withdrawal prior to treatment and medically required sedation. Their results were not included in the final data summary. No participants reported adverse effects associated with the VR device. This study showed that subjects in the VR group reported significantly less procedural pain than the PD group (95% CI: 2.4-45.0; P=0.029; difference= 23.7mm). The estimated effect size between VR and PD was 1.25, which is large given this type of study. There was no significant difference between the VR and SC groups.

Graph 1: Adjusted APPT-WGRS procedural pain scores per treatment group in Jeffs et al[2]

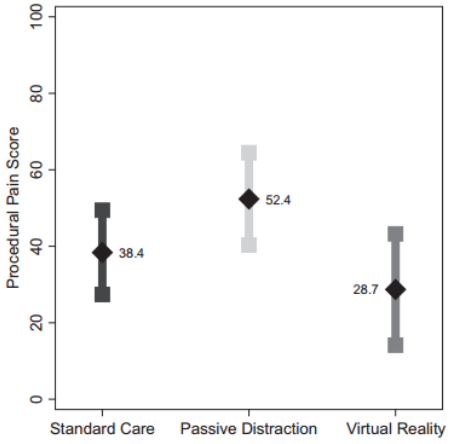

Figure 2. Estimated procedural pain scores by group adjusting for age, sex, state anxiety, opioid analgesic use, treatment length, and preprocedural pain.

Table 2: Comparison of procedural pain scores between groups in Jeffs et al[2]

Treatment Groups	Difference (mm) on the APPT-WGRS scale	95% CI	P-value	Size Effect
VR vs PD	23.7	2.4-45.0	0.029	1.25
VR vs SC	9.7	-9.5-28.9	0.32	0.535

The study conducted by Miller et al[7] involved 40 children, ages 3 to 10 years old, was randomized into two separate groups: Standard Distraction (SD) (N=20) and Multi Modal Distraction (MMD) (N=20). Participants were excluded based on previous administration of anxiolytics or sedatives, cognitive impairment that negated the use of the pain outcome measures, visual impairment that could not be corrected by lenses, and non-English speaking. The SD group had access to regular distraction tools like a television, video games, nursing staff

and caregiver support throughout the dressing change. The MMD group used a hand-held device that included procedure preparation and distraction content throughout the procedure. Pain intensity was measured through self-report using the FACES model at four time points: pre-procedurally, after dressing removal, prior to application of a new dressing, and post-procedurally. Independent and paired t-tests were used to compare the differences between continuous variables, like pain intensity. No subjects were lost to follow-up and no adverse events related to the MMD device were reported. This study showed that the MMD group reported significantly less pain than the SD group in both pre-procedural ($p<0.01$) and procedural pain ($p<0.01$). The MMD group reported levels of mild pain (FACES <2/5) in comparison with the SD group; which reported severe pain levels (FACES >4/5), resulting in a 30% decrease in pain perception overall.

Table 3: Comparison of pain intensity at procedural time intervals in Miller et al[7]

Time interval	SD	MMD	P value
FACES pre-removal	1.56 ± 1.5	0.4 ± 0.68	0.004
FACES post-removal	4.03 ± 1.00	2.15 ± 1.46	<0.001
FACES pre-application	2.39 ± 1.09	0.70 ± 0.86	<0.001
FACES post-application	3.95 ± 1.13	1.9 ± 1.65	<0.001

The study by Mott et al[8] followed 42 children between the ages of 3 and 14 years old who underwent a total of 56 dressing changes. Participants were randomized into two treatment groups: augmented reality (AR) group (N=20) and a control group (N=22). No subjects were excluded based on their burn site or intellectual disabilities. The control group utilized basic multi-dimensional cognitive techniques like attention-distraction, positive reinforcement, and an age appropriate video program. The AR system involved a handheld interactive device used by the patient with help from the parent or caregiver. Pain intensity was reported using two different

scales depending on the age and ability of the child, and were measured pre-procedurally, at ten-minute intervals throughout the procedure, and post-procedurally. A Wilcoxon Rank sum test was utilized to compare the sums of each pain score, and a Repeated Measures of Analysis was used to compare how each group's pain score changed over time. Each group was further divided based on the length of treatment time, into medium dressing times (<30 min in duration) and long dressing times (>30 min in duration). No child or parent reported any adverse effects from the AR device. Data from this study shows that there is no significant difference between the pain scores in the control and AR groups for those patients with medium dressing times; however, patients with long dressing times reported significantly less pain in the AR group than in the control ($p=0.01$). Furthermore, analysis showed that pain significantly decreased over time for both medium ($p < 0.0006$) and long ($p < 0.0001$) treatment groups using the AR system as shown in Graph 2.

Table 4: Comparison of AR vs Control procedural pain scores in Mott et al[8]

Treatment Groups	Mean dressing time	Overall pain score	P-value
AR group (N=20)	33.8 min	2.81 ± 0.89	0.0060
Control group (N=22)	34.1 min	5.38 ± 0.58	0.1978

Graph 2: Comparison of patient pain scores over time in Mott et al[8]

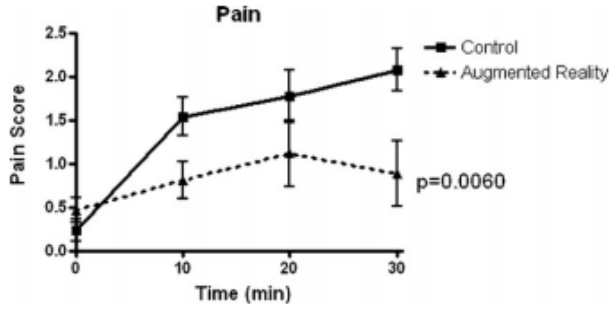

Fig. 3 – Pain scores at 10, 20, and 30 min in AR and Control groups for patients with long dressing times (>30 min). Data points are average ± standard error of the mean.

DISCUSSION

This systematic review compared the results of efficacy of VR and AR systems on pediatric patients undergoing wound care. Various limitations were noted in each of the three studies reviewed, including the following aspects. First, each of the studies presented consisted of a relatively small sample size of less than 50 participants and were each confined to the patients being treated at one outpatient treatment center respectively[2,7-8]. Therefore, widespread implications and inpatient use could not be determined. Second, due to the nature of the study, blinding the assessor to distraction techniques of burn care procedures was not possible. Jeffs et al[2] and Miller et al[7] ensured that patients and research assistants were blinded to the group assignment until the beginning of treatment. Similar measures were not reported in Mott et al.[8] Third, the developmental stage, personality of the child. and intellectual abilities may influence cesthe participant's answers to the pain assessment questionnaires. Also, the parent or caregiver interaction could have also skewed responses. Also, baseline psychological experiences of the child can affect the child's pain perception. Jeffs et al[2] also looked at state anxiety experienced by participants, but Miller et al[7] and Mott et al[8] did not. Lastly, mechanical difficulties with the equipment were reported as a limitation for Jeffs et al.[2]

While the use of VR or AR systems have proven to be useful in reducing pain in pediatric burn patients, it has only been studied as an adjunct to pain-relieving medication. Each study described that all study participants received standard analgesic doses prior to onset of the respective procedure.[2,7-8] The costs of analgesia, wound care, and virtual reality equipment may not be feasible for some burn units. Personnel training and technology maintenance would add additional costs as well. Furthermore, as this is a relatively new technology in this medical specialty, it is unsure whether health insurance companies will cover these treatments. Virtual

reality is presently classified as a type of exposure therapy that is primarily used to treat mental health disorders like phobias and PTSD.[9] Currently, the psychological traumas described in this population have not been specifically included as covered under insurance. In addition, there are many different types of VR or AR devices, other than those included in this review. Implementation and comparison studies should be considered for these alternative devices to determine which is most effective in pediatric burn patients.

Other limitations for this equipment include potential adverse effects that may be experienced by users. Jeffs et al[2] and Miller et al[7] specifically mention possible adverse effects to include nausea, motion-sickness, and seizures. While no studies examined in this paper reported adverse effects experienced by their participants, these symptoms may still appear in other participants using VR systems. Moreover, studies have shown that VR can also interact with a person's spatial cognitive capability, or a person's understanding of where they are in space.[10] These capabilities are weaker in children, which may make them more prone to adverse events to VR.[10]

CONCLUSION

The studies included in this systematic review seem to indicate that virtual reality is an effective pain management treatment for pediatric burn victims receiving wound care; however, these studies suggest that it should be used as an adjunct to typical pain medications. There is no evidence in these research papers to suggest that VR or AR should be used as a monotherapy. Though these studies described multiple restrictions to their validity and overall implementation, VR and AR systems seem to be useful in aiding with pain perception and decreasing psychological traumas experienced by children with burns. It is important to note that there are

certain patients that will not be able to use this type of technology, including those with mental or physical disabilities. Research for these patients should be conducted separately.

Future studies should be conducted on larger patient populations over a longer period to further explore the efficacy of these systems. Initial studies presented in this review suggest that there may be more benefit in patients that have more extensive injuries and require longer dressing times, but further investigation is needed. Additionally, further research should consider specific population. For example, examining the effectiveness of VR systems in adolescents versus school age children with burns. Severity and mechanism of the burn as treatment group classifications may also provide more insight into pain perception. More studies are also needed to investigate which method of VR or AR systems are the most clinically useful, safe, and cost effective. As these technologies are still new, it is likely that the implementation of VR and AR in the healthcare setting will continue to be explored in the future.

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