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Comparison of 10% Dextrose Versus Sterile Water for Pain Relief in Neonates Undergoing IV Cannulation: A Randomized Controlled Trial

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ABSTRACT

Objective: To compare the average pain score resulting from the administration of oral dextrose to that of sterile water in intravenous cannulation (IV cannulation).

Study design: Randomized controlled trial.

Place and Duration of the Study: Nursery, Sir Ganga Ram Hospital Lahore, from 19th January to 18th July 2023.

Methodology: A total of 60 term neonates were randomly assigned to two groups, with 30 in each. Group A (10% Dextrose group) received 2 ml of 10% dextrose orally, and Group B (Sterile water Group) received sterile water, each administered 2 minutes before intravenous cannulation. Pain response was assessed using the Modified Behavioral Pain Scale (MBPS) 2 minutes post-procedure.

Results: The groups were comparable in baseline characteristics, with non-significant variations in gestational age and weight. The mean APGAR scores at 1 minute were 7.2 ± 1.3 for Group A and 6.8 ± 1.2 for Group B, indicating no significant difference ($p = 0.18$). In contrast, the mean pain scores measured by the Modified Behavioral Pain Scale (MBPS) showed significantly lower scores in Group A (3.70 ± 1.02) than in Group B (6.27 ± 1.05), with a p-value of 0.001.

Conclusion: The use of 10% dextrose significantly reduced procedural pain in neonates compared to sterile water, indicating its effectiveness for pain relief in neonates undergoing intravenous line placement and potential utility in clinical practice.

Key words: *Neonates, 10% Dextrose, Pain Management, IV cannulation*

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INTRODUCTION

For years, it was believed that newborn infants were unable to perceive pain. However, current evidence now confirms that, while the nociceptive system of neonates is still developing, it is sufficiently functional to respond to painful stimuli. Consequently, neonates can experience pain in a manner similar to adults and children. It is essential to recognize that, due to their immature nervous system, neonates are particularly vulnerable to the potential long-term effects of unaddressed pain, which can lead to neurodevelopmental issues.[1-2]

Without proper pain management, neonates are at greater risk of experiencing adverse physiological outcomes, maladaptive behaviors, and hormonal disruptions. This is especially true because they exhibit limited behavioral responses to pain, making it more difficult to assess and address. In the first few days of life, even healthy newborns often undergo iatrogenic pain, including procedures such as vitamin K injections, heel pricks, IV cannula insertion, blood sampling, immunizations, nasogastric tube insertion, catheterization, circumcision, and various forms of suction.[3-4] This risk is even higher among infants who are ill or born prematurely, who experience heightened levels of discomfort and distress.

Various pharmacological and non-pharmacological options are available for neonatal pain management, balancing efficacy and safety. Pharmacological methods include intravenous (IV) opioids like morphine and fentanyl, typically used for severe or prolonged pain in NICU settings, with careful monitoring for side effects such as respiratory depression.[5] Paracetamol, administered orally or intravenously, is commonly used for moderate pain or as an adjunct for postoperative care.[6] Local anesthetics, such as lidocaine, are effective for minor procedures when applied topically or by injection. IV methods are not typically used due to their invasiveness, potential complications, need for close monitoring, especially with opioids that carry risks like respiratory depression, fragile veins, and these methods may not be readily available in resource-limited settings.

Non-pharmacological approaches, such as oral sucrose and glucose solutions, are favored for minor procedural pain due to their safety and ease

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of use. These solutions stimulate sweet taste receptors, promoting the release of endogenous opioids, thereby providing analgesia without pharmacological risks.[7] Breastfeeding, expressed breast milk, non-nutritive sucking, facilitated tucking, and swaddling also offer analgesic benefits and maternal bonding, though their availability may be limited in some settings.[8] Combining pharmacological and non-pharmacological methods ensures comprehensive pain management, reducing distress and potential long-term effects of untreated pain in neonates.

For this study, 10% dextrose was chosen for its practical advantages. Unlike 25% sucrose solutions, which may not be available in all healthcare settings, particularly in resource-limited regions. While 25% dextrose also provides analgesic effects, it is generally not preferred in routine neonatal care due to concerns about hyperosmolarity, which can irritate the sensitive oral mucosa, and the increased risk of metabolic disturbances such as hyperglycemia and the development of necrotizing enterocolitis, especially in preterm or low-birth-weight infants.[9] Additionally, 25% dextrose is less accessible and more expensive in resource-limited settings. In contrast, 10% dextrose offers a safer, more feasible alternative, balancing efficacy with availability and affordability, making it a preferred choice for neonatal pain management.[10]

These findings highlight that various interventions can be employed to minimize pain in neonatal care settings and focus on the potential benefits of using oral dextrose as an effective intervention. Furthermore, these findings indicate gaps in the existing literature regarding the underlying mechanisms and long-term effects of such interventions, thereby justifying the need for further exploration in this area. Also, there is limited data available on the role of 10% dextrose water in alleviating pain after the insertion of an intravenous (IV) line in the past five years. Therefore, this study aims to contribute to the existing knowledge by examining the effect of administering oral 10% dextrose water two minutes prior to the insertion of an IV cannula in term neonates and evaluating the pain experienced using the Modified Behavioral Pain Scale (MBPS). Incorporating these insights into our study aims to contribute to a more nuanced understanding of effective pain management for vulnerable neonatal populations.

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Methodology

This randomized controlled trial was conducted at the Nursery of Sir Ganga Ram Hospital, Lahore, between January 19, 2023, and July 18, 2023. The study received ethical approval from the Institutional Review Board (IRB) of the hospital. A total of 60 neonates from the nursery's outpatient, emergency, and inpatient departments were screened for eligibility, and written informed consent was obtained from the parents or guardians to ensure confidentiality.

Sample Size Calculation

The sample size was determined using 80% statistical power with a 5% margin of error, based on previously observed mean pain scores for a painful procedure, which were 4.99 ± 0.805 with 10% dextrose and 6.89 ± 0.822 in a placebo group. This yielded a required sample of 60 neonates, with 30 allocated to each group.[11]

Eligibility Criteria

Inclusion criteria were term babies of either gender, age ≤14 days, gestational age >37 weeks, birth weight >2.5 kg, and an APGAR score ≥6 at 1 minute. Exclusion criteria included critically ill neonates requiring cardiac support, those who were intubated, neonates with asphyxia, sepsis with septic shock (TLC <4000/mm³ or >30,000/mm³, PLT >100,000/µL), or those whose mothers had received epidural anesthesia.

Randomization and Intervention

Participants were randomly assigned to either Group A or Group B using a lottery method. Group A received 2 ml of oral 10% dextrose solution, and Group B received 2 ml of oral sterile water. Two minutes after administration, an IV cannulation procedure was performed on both groups.

Pain Assessment

The response to pain was assessed two minutes after IV cannulation using the Modified Behavioral Pain Scale (MBPS), which scores pain based on three parameters: facial expression, crying, and movement. Expression and movement were scored from 0 to 3, and crying was scored from 0 to 4, for a maximum total score of 10.

Data Analysis

Data were entered and analyzed using SPSS version 25. Quantitative variables, including gestational age, postnatal age, weight, and MBPS scores, were reported as mean ± standard deviation (SD). Qualitative variables, such as gender and breastfeeding status, were reported as

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frequencies and percentages. Data were stratified by age, weight, and gender to analyze potential associations. Independent t-tests were used to compare MBPS scores between groups, with statistical significance set at $p \leq 0.05$.

RESULTS

A total of 60 neonates were included in this study and randomized into two groups: Group A (10% Dextrose Group, n=30) and Group B (Sterile Water Group, n=30). The baseline characteristics were largely balanced between the 10% dextrose (Group A) and sterile water (Group B) groups across gender, gestational age, post-natal age, and weight. However, a slightly higher proportion of neonates in Group B were breastfed (23.3% vs. 13.3%) and had APGAR scores of 8-10 at the first minute (53.3% vs. 33.3% in Group A). The detailed baseline characteristics is summarized in **Table 1**.

The overall mean MBPS (Modified Behavioral Pain Scale) score was significantly lower in Group A (3.70 ± 1.02) compared to Group B (6.27 ± 1.05, p = 0.001), indicating better pain control with 10% dextrose. Subgroup analysis revealed consistent findings across gender, post-natal age, and weight categories, with Group A showing significantly lower pain scores than Group B in each subgroup. These results suggest that 10% dextrose is more effective than sterile water for neonatal pain management. The detailed stratified mean MBPS score is summarized in **Table 2.**

Table-1: Comparison of baseline characteristics between groups*

Baseline Characteristics		**Group A (10% Dex**
Gender	Male	15 (50.0%
	Female	15 (50.0%
Gestational age	37-38 weeks	20 (66.7%
	39-40 weeks	10 (33.3%
Post-natal age	≤4 days	25 (83.3%
	5-10 days	1 (3.3%)
	11-14 days	4 (13.3%)
Weight of child	2.5-3.5 kg	26 (86.7%

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	3.6-4 kg	4		11-14 days	3.75±0.
	≥4.1kg	0			
Breastfed	Yes	4	**Stratified MBPS score by weight**	2.5-3.5kg	3.73±1.
	No	26			
APGAR score at 1st minute of life	6-7	20		3.6-4kg	3.50±1.
	8-10	10			
				≥4.1kg	0

*Data presented with absolute number (percentage)

Table-7: Comparison of pain score between groups

Outcomes		**Group A (10% Dextrose) Mean ± SD**	**Group B (Sterile water) Mean ± SD**	**P- value**
Overall mean MBPS Score		**3.70±1.02**	6.27±1.05	0.001
Stratified MBPS score by gender	Male	3.47±1.06	6.19±1.05	0.001
	Female	3.93±0.96	6.36±1.08	0.001
Stratified MBPS score by post-natal age	≤4 days	3.68±1.11	6.32±0.95	0.001
	5-10 days	4.00	5.83±1.33	0.001

DISCUSSION

The Modified Behavioral Pain Scale (MBPS) utilized in our investigation is a score that has been thoroughly validated and deemed highly reliable for the purpose of evaluating pain in neonates. The MBPS assesses neonatal pain through three key components: facial expression (brow bulge, eye squeeze, nasolabial furrow), body movement (motor responses such as thrashing) and crying intensity and duration.[12] Crellin et al. conducted a systematic review of 28 studies, including 20 randomized controlled trials and 8 psychometric evaluations, and found that

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while the Modified Behavioral Pain Scale (MBPS) is valid for assessing immunization pain in infants aged 2–22 months.[13] Crying, which serves as an expression of distress and discomfort, is significantly reduced with interventions like sucrose or dextrose. The study by Smethers and Mennella suggests that sweet taste, especially through added sugars, can influence infant crying behavior. Sweet flavors have been found to have a soothing effect on infants, potentially reducing their crying, as they are associated with positive reinforcement in early developmental stages.[14] The study by Angeles et al. (2018) found that oral dextrose effectively reduced facial grimacing, eye closure, and brow furrowing in preterm neonates undergoing painful procedures, indicating pain relief without altering cellular ATP metabolism.[15] Body movements and heart rate fluctuations are key indicators of neonatal pain. Our study demonstrates that the administration of 10% dextrose effectively reduces these behavioral and physiological responses, aligning with prior research.[9] However, responses can vary, with some studies noting increased heart rate in neonates receiving sucrose, although oxygen saturation typically remains unaffected.[16] Adverse effects such as oxygen desaturation are rare and usually resolve on their own, reinforcing the safety of dextrose and sucrose as pain management options. These findings highlight the importance of individualized pain management for neonates.

Various other pain scores, such as the CRIES score, neonatal facial coding score, PIPP-R score and DAN score, have also been utilized in earlier studies aimed at assessing pain in this population, highlighting diverse approaches.[10,17] Furthermore, the efficacy of utilizing a 2-minute interval between the administration of glucose and the application of noxious stimulation corresponds to previous research, which implies the existence of a mechanism that is triggered by the presence of the solution in the oral cavity, rather than being influenced by gastric or metabolic factors.[18]

The analgesic effect of sucrose was found to be comparable to glucose, with no significant differences in pain scores between 24% sucrose and glucose solutions at 30 seconds (MD 0.26, 95% CI -0.70 to 1.2) and 60 seconds after lancing (MD -0.02, 95% CI -0.79 to 0.75).[9] A recent investigation that meticulously assessed the safety of sucrose analgesia ultimately determined that the employment of sucrose analgesia for recurring distressing procedures administered to neonates did not engender any discernible

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discrepancy in the immediate neurobehavioral outcome.[19]

In addition to sucrose and glucose, oral dextrose has also been demonstrated to effectively alleviate pain during neonatal procedures, further expanding the range of viable sweet solutions for managing procedural discomfort in infants. The study by Sasidharan et al. (2020) found that 25% dextrose is noninferior to 24% sucrose in reducing pain during heel lancing in preterm infants, based on PIPP scores.[20] A randomized controlled trial (RCT) conducted in 2024 indicates that 10% dextrose significantly reduces pain during procedures such as heel pricks compared to alternatives like expressed breast milk, as evidenced by lower pain scores on the PIPP-R scale (1.69 ± 1.53 vs 4.28 ± 1.65 at 1 min).[10] A scientific inquiry conducted within the NICU at Valiasr hospital in Italy, showed that oral dextrose (3.58 ± 0.34), was more effective than facilitated tucking (5.58 ± 0.53) and routine method of blood sampling, which had an average score of 8.91 ± 0.18 (P < 0.001), in reducing pain during intravenous cannulation.[21] In a 2023 study in India, Kumar and Anand compared the efficacy of 10% and 25% dextrose solutions for pain relief in late preterm neonates (34-37 weeks) during heel lancing. The 10% dextrose solution significantly reduced pain indicators, such as heart rate, oxygen desaturation, and PIPP scores ($p < 0.05$).[22] A RCT conducted in the Military Hospital, Rawalpindi (2013), found that 10% dextrose significantly reduced pain as measured by the MBPS, with a mean score of 4.99±0.805 compared to 6.89±0.822 in the sterile water group.[11] Similarly, a study in Gujranwala (2020) found that 25% dextrose water (mean Neonatal Infant Pain Scale (NIPS) score 5.02±1.46) led to higher pain scores than expressed milk (mean NIPS score 3.56±1.59), with p value<0.001, but still indicated dextrose's notable effect on pain reduction.[23] These findings underscore the utility of dextrose as an effective, non-invasive intervention for managing neonatal pain during routine procedures.

There are few limitations of 10% dextrose, including its brief analgesic duration, typically lasting 5 to 10 minutes. There is also concern about its varying efficacy in neonates, and its use might not always be as effective as higher concentrations of sucrose. Additionally, repeated or prolonged exposure to dextrose, even at 10%, could contribute to adverse outcomes like blood glucose fluctuations in certain vulnerable populations. More studies are needed to optimize dosages and explore long-term effects.

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Additionally, the study's observational nature may introduce biases, such as selection or measurement bias. We also did not control for confounding factors, such as the neonates' underlying health conditions, which could influence pain response. Moreover, the short-term nature of pain assessment and potential variations in the clinical settings may have impacted the consistency of results. Further larger, randomized studies with controlled variables are needed to validate these findings. Moreover, incorporating diverse neonatal populations could enhance the generalizability of the results.

CONCLUSION

The study demonstrates that 10% dextrose is an effective and safe analgesic for reducing procedural pain in neonates compared to sterile water. Its use during minor neonatal procedures, such as intravenous line placement, highlights its potential for improving neonatal care practices. Further research could explore its broader applicability and long-term effects.

CONFLICT OF INTEREST

Authors declared no conflict of interest.

DISCLOSURE

No

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No

PATIENT CONSENT

Consent of the parent/guardian was taken prior to the writing of the manuscript.

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