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The Efficacy of Different Strengths of Dextrose on Pain Level During Intravenous Cannulation Among Neonates: A Scoping Review

Madhu Jeengar
PhD Scholar, Sai Tirupati University, Udaipur, Rajasthan

Vijay Singh Rawat
Professor Cum Principal, Sai Tirupati University, Udaipur, Rajasthan

Abstract: **Introduction**: Intravenous (IV) cannulation is a frequently performed and painful procedure in neonates, particularly in the hospital setting. Effective pain management is crucial to mitigate both immediate distress and potential long-term adverse neuro developmental consequences. **Methodology**: This review synthesizes relevant literature from 2000 to 2024 related to current evidence on the efficacy of various dextrose concentrations (5%, 10%, and 25%) as non-pharmacological interventions for pain reduction during IV cannulation in neonates. A comprehensive literature search was conducted across major medical databases. **Results**: The review indicates that while 25% dextrose consistently demonstrates a significant analgesic effect for venipuncture and similar minor invasive procedures, direct evidence specifically for IV cannulation at this strength is often extrapolated from venipuncture studies. The efficacy of 10% dextrose for procedural pain is mixed, and 5% dextrose is generally not considered effective for analgesia. **Conclusion**: While generally safe for oral administration, the review emphasizes the need for more specific research on dextrose's role in IV cannulation pain, distinct from venipuncture, and consistent use of higher effective concentrations.

Keywords: Efficacy, Dextrose, Pain Level, Intravenous Cannulation, Neonates.

1. Introduction

Neonates, especially those requiring hospitalization, frequently undergo invasive procedures. Among the most common and acutely painful is intravenous (IV) cannulation, essential for administering fluids, medications, and blood products [1, 2]. Despite advancements in neonatal pain assessment and management, procedural pain remains a significant challenge, with consequences ranging from acute physiological stress (e.g., changes in heart rate, oxygen saturation, and intracranial pressure) to potential long-term neurodevelopmental alterations, altered pain thresholds, and adverse behavioral outcomes [3, 4].

The recognition of pain in neonates and the imperative for its effective management have led to the widespread adoption of non-pharmacological interventions. Sweet solutions, primarily sucrose and dextrose (D-glucose), are cornerstone strategies due to their rapid onset of action, ease of administration, and favorable safety profiles [5]. The analgesic effect of these solutions is believed to be mediated by the activation of sweet taste receptors on the tongue, which, in turn, triggers the release of endogenous opioids (endorphins) and activates descending inhibitory pain pathways in the central nervous system. This leads to a calming effect, reduced crying, and

improved physiological stability during painful stimuli [6]. While the general efficacy of sweet solutions for minor procedural pain is well-established, specific guidance on the optimal concentration of dextrose for IV cannulation pain remains an area requiring clarity. Many studies often lump IV cannulation with venipuncture, even though cannulation might involve a slightly longer duration of discomfort due to vein seeking and catheter insertion. This review aims to critically evaluate the existing literature on the use of different strengths of dextrose solutions (5%, 10%, and 25%) specifically for reducing pain during intravenous cannulation in neonates, highlighting their effectiveness, safety, and implications for clinical practice.

2. Methodology

A systematic literature search was conducted across several electronic databases, including PubMed, Scopus, Web of Science, and Google Scholar, to identify relevant studies. The search was performed using a combination of keywords: "neonatal pain," "dextrose," "glucose," "pain relief," "analgesia," "5% dextrose," "10% dextrose," "25% dextrose," "newborn," "infant," "intravenous cannulation," "IV insertion," "venipuncture pain." Data from selected articles were extracted, including study design, participant characteristics (gestational age, postnatal age), dextrose concentration and volume, timing of administration, type of pain assessment tool, and key pain outcomes (e.g., pain scores, crying duration, physiological parameters like heart rate and oxygen saturation). The extracted data were then qualitatively synthesized to identify patterns in efficacy and safety across the different dextrose strengths.

Inclusion Criteria:

- Studies published in English peer-reviewed journals.
- Randomized controlled trials (RCTs), quasi-experimental studies, and systematic reviews/meta-analyses.
- Studies specifically investigating the use of oral 5%, 10%, or 25% dextrose solutions.
- Studies that assessed pain levels during intravenous cannulation or venipuncture (as IV cannulation often involves initial venipuncture) in neonates (term and preterm).
- Studies that utilized validated neonatal pain assessment tools (e.g., PIPP, NIPS, CRIES, NFCS) for outcome measurement.

Exclusion Criteria:

- Studies focusing solely on sucrose or other sweet solutions without direct comparison to dextrose.
- Studies on major surgical pain or chronic pain.
- Case reports, editorials, or opinion pieces.
- Studies not clearly specifying dextrose concentration or administration method.
- Studies where IV cannulation was not the primary painful procedure evaluated.

3. Results

The literature search revealed that while venipuncture is a commonly studied painful procedure in neonates, studies specifically isolating the pain of intravenous cannulation and directly comparing the efficacy of 5%, 10%, and 25% dextrose in this context are fewer. Often, IV cannulation is grouped under "minor invasive procedures" alongside heel pricks and venipuncture.

3.1. Dextrose 5%

Evidence supporting the analgesic efficacy of 5% dextrose for any procedural pain in neonates, including IV cannulation, is largely absent. In the context of IV administration, 5% dextrose is primarily used as a diluent or for fluid and calorie provision [7]. Its low concentration of glucose

is generally not considered sufficient to stimulate the sweet taste receptors to elicit a clinically significant analgesic effect when administered orally. No direct studies were found that demonstrated 5% dextrose effectively reduces pain during IV cannulation when given orally.

3.2. Dextrose 10%

The efficacy of 10% dextrose for procedural pain in neonates, including venipuncture (often analogous to the initial part of IV cannulation), is inconsistent and generally less robust compared to higher concentrations. Some studies, particularly those focused on mild procedures or comparing to placebo, have reported a modest reduction in pain with 10% dextrose [8]. However, these effects are often statistically less significant or clinically less impactful than those observed with 25% dextrose or sucrose. A study that compared 10%, 20%, and 40% dextrose for pain control during intramuscular vaccination (a procedure that, like IV cannulation, involves needle insertion), found that 10% dextrose did not significantly reduce pain scores (NFCS and PIPP) compared to sterile water [9]. This suggests that for procedures involving a distinct painful stimulus like needle insertion, 10% dextrose may be insufficient. While 10% dextrose is commonly used in neonatal units for IV fluid maintenance, its oral administration for analgesia during IV cannulation specifically lacks strong, consistent evidence of superior efficacy over placebo [10].

3.3. Dextrose 25%

25% dextrose is the most commonly studied concentration among these three for its analgesic properties in neonates undergoing minor invasive procedures, including venipuncture, which shares key painful components with IV cannulation.

- **Venipuncture Analogy:** Numerous randomized controlled trials have consistently demonstrated that oral administration of 25% dextrose significantly reduces pain scores (e.g., CRIES, PIPP, NIPS) and crying duration during venipuncture in both term and preterm neonates [11, 12, 13]. Since IV cannulation involves the same initial needle stick and vein puncture as venipuncture, these findings are highly relevant and often extrapolated to support its use for IV cannulation.
- **Pain Score Reduction:** Studies show that neonates who receive 25% dextrose prior to venipuncture exhibit significantly lower pain scores compared to those receiving sterile water or no intervention [11, 13].
- **Behavioral and Physiological Indicators:** Improvements in behavioral pain indicators (e.g., less grimacing, shorter crying) and stabilization of physiological parameters (e.g., heart rate, oxygen saturation) have been reported with 25% dextrose during venipuncture [12, 14].
- **Safety:** When administered orally in single, appropriate volumes (typically 0.5-1 mL), 25% dextrose is generally considered safe for neonates. Reports of hyperglycemia or other adverse events are rare in healthy term and stable preterm infants [11, 13].
- **Clinical Recommendation:** Due to its proven efficacy in venipuncture and similar procedures, 25% dextrose is widely recommended as a first-line non-pharmacological analgesic for minor procedures in neonates, often including IV cannulation [5, 15].

4. Discussion

There is virtually no evidence to support the use of 5% dextrose as an effective analgesic for procedural pain in neonates. The data for 10% dextrose are ambiguous. While some studies suggest a minimal effect, it often falls short of demonstrating robust or consistent pain reduction, especially when compared to higher concentrations or for procedures involving a clear, acute painful stimulus like needle insertion. Clinicians should exercise caution when considering 10% dextrose as a sole analgesic for this procedure, as it may lead to under treatment of pain. Dextrose 25% concentration stands out as the most consistently effective among the reviewed strengths for alleviating pain during venipuncture, with strong implications for IV cannulation.

The mechanism of action, involving endogenous opioid release, is adequately stimulated by 25% dextrose, leading to measurable reductions in pain scores and distress. Its safety profile for oral administration in single doses is favorable, making it a practical and valuable tool in neonatal pain management. The review of the literature indicates a clear hierarchy in the perceived and proven efficacy of different dextrose concentrations for procedural pain in neonates, particularly in the context of IV cannulation. While direct comparative studies between 25% dextrose and higher concentrations (e.g., 30% or 40% dextrose, or 24% sucrose) specifically for IV cannulation are still needed, the current body of evidence strongly supports 25% dextrose as an effective option. Higher concentrations of sweet solutions are generally reserved for more intensely painful or prolonged procedures, or when 25% dextrose proves insufficient. It is crucial that the dextrose solution is administered orally (on the anterior tongue), approximately 1-2 minutes prior to the anticipated painful stimulus, to allow for optimal absorption and onset of analgesic effect [11, 15]. One limitation in the existing literature is the interchangeable use of "venipuncture" and "IV cannulation" in many study descriptions. While overlapping, IV cannulation can be more prolonged and involve multiple attempts, potentially requiring a sustained or more potent analgesic effect. Future research could specifically differentiate these procedures and evaluate the dynamic pain response to various dextrose concentrations. A study by Amitabh et al (2020) also revealed significantly effective in decline the pain among neonates during venipuncture. Furthermore, integrating non-pharmacological interventions like non-nutritive sucking (pacifier use) and facilitated tucking alongside dextrose administration can offer synergistic pain relief [17].

5. Conclusion

Oral administration of 25% dextrose is a well-supported and effective non-pharmacological intervention for reducing pain during intravenous cannulation in neonates. The evidence, largely extrapolated from venipuncture studies, consistently demonstrates its ability to lower pain scores and reduce distress. In contrast, 10% dextrose offers inconsistent and often insufficient analgesia, while 5% dextrose shows virtually no evidence of pain-relieving effects. For optimal pain management during IV cannulation in neonates, clinicians should routinely administer 25% dextrose orally, approximately 1-2 minutes before the procedure. This practice, combined with other comforting measures like non-nutritive sucking, forms a crucial component of evidence-based neonatal pain care. Further research directly comparing different dextrose concentrations specifically for IV cannulation, accounting for multiple attempts and prolonged distress, would further strengthen the evidence base and help refine standardized protocols.

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6. References

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