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# An Extensive Literature Review on Neonatal Pain Assessment & Management

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**Introduction:**

Newborns born premature, ill, compromised, with congenital abnormalities, or with intrauterine adverse events typically spend the very beginning of their lives in the neonatal intensive care unit. With odds already stacked up against them, from low birth weight and difficulty thermoregulating, to immature respiratory and renal systems; pain management can come in low on the priority list for these infants. However, this does not negate the fact that neonates experience pain just like adults and children. In fact, studies show that the pain preterm infants experience is heightened compared to full-term infants. Obviously, newborns cannot verbally express their pain; and with preterm infants in the NICU, common procedures such as ventilation and restraints, cause distress symptoms to be diminished, and thus, caregivers are not adequately treating the pain caused from their distress. Neonates with unmanaged pain are more likely to develop physiological consequences on development, maladaptive behaviors, and hormonal responses due to their diminished behavioral responses to pain and stress, and thus, decreased caregiver awareness and intervention for pain. (Lavanga et al., 2020).

The history of neonatal pain management consists of beliefs that neonates have blunted and immature responses to pain, which has since been disproven. Studies have found that both premature and mature infants have the neuroanatomic pathways that communicate nociception. (Maxwell et al., 2019). By the 24th week of gestation, infants are able to respond to stress and pain as evidenced by physiologic, hormonal, and metabolic markers that are associated with the stress response. It is possible that pain perception and the stress response can be heightened in premature infants due to the immaturity of their nociceptive communicatory response through their descending inhibitory pathways. This creates a problem in managing preterm infants pain as although they perceive pain to possibly a higher degree, they cannot exhibit the full spectrum of

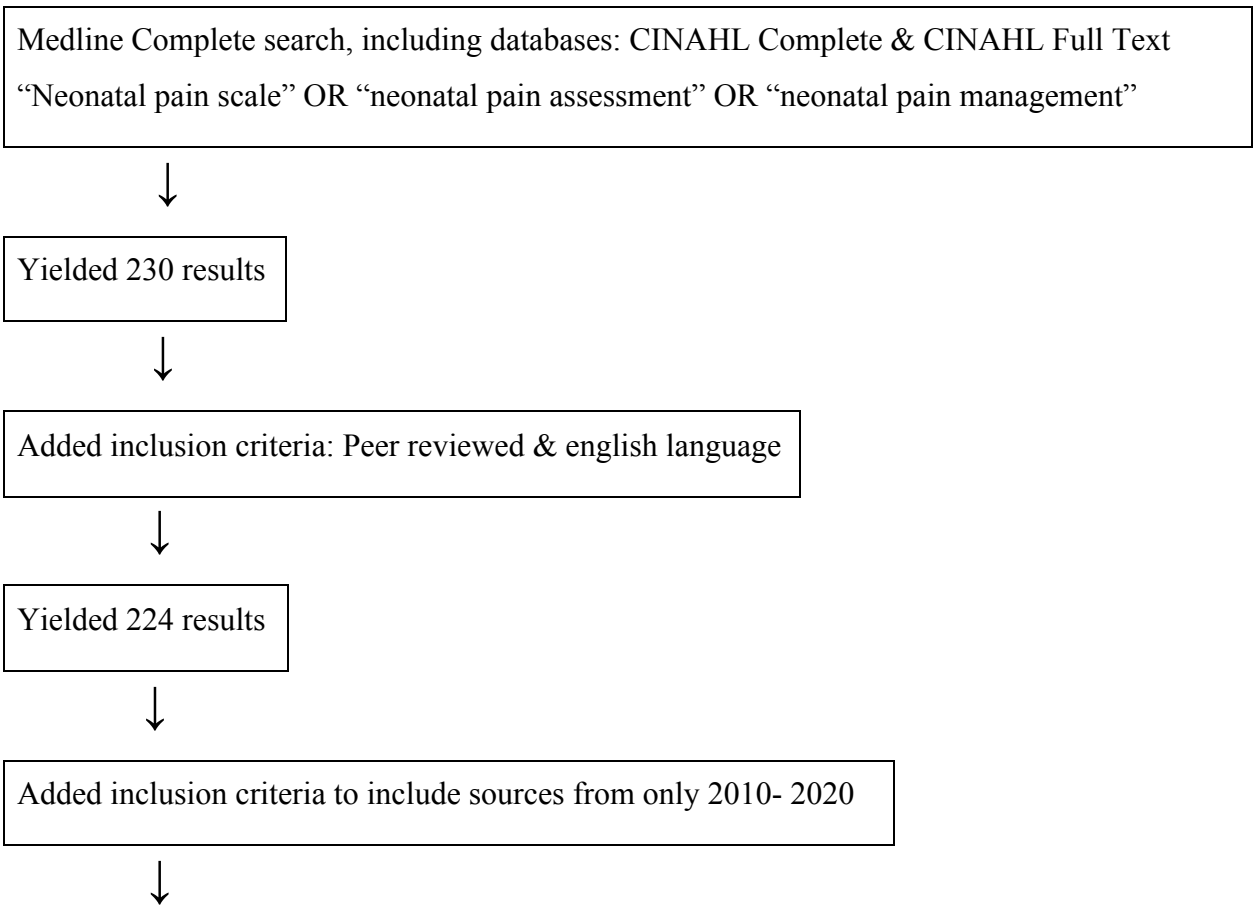
distress responses seen by pain compared to full-term infants; this requires an altered pain assessment strategy than what can be used for full-term infants. According to (SOURCE 13), neonates experience two different types of pain, procedural and postoperative. Studies have been conducted to determine which pain assessment tool has better reliability, validity, and clinical utility based on the type of pain a neonate is experiencing, in order to best manage their pain with pharmacologic and nonpharmacologic interventions alike. (Xie et al., 2020). Despite studies conducted to determine the best pain assessment scales and pain management strategies for neonates, gaps in the literature still exist, and thus more research in this field is needed. Some studies in the literature mentioned an inability of researchers to agree on the best scale to assess neonatal pain, indicating that a "gold standard" of assessing neonates' pain has yet to be confirmed. (Gimenez et al., 2020). In addition, the *Role of OPRM1, clinical and anthropometric variants in neonatal pain reduction*, illustrates the benefit of nonpharmacologic pain management interventions for neonates such as breast milk, swaddling, and holding, and suggests the possibility of personalized analgesia for newborns; However, there are gaps in the literature to support this new type of pain management for neonates as this is a new idea in the field. Other pain management strategies for infants include sucrose water solution, and acetaminophen, at times. Opioids are generally to be avoided in this population, but are considered during more painful procedures, such as circumcisions.

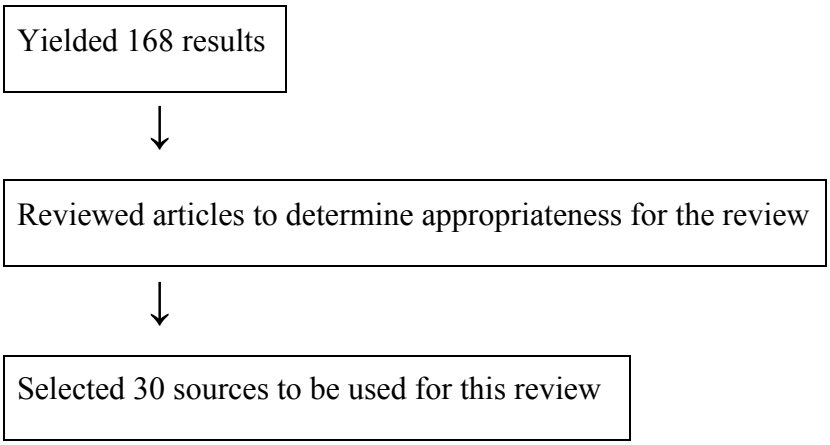
This review will highlight the current problems with managing neonatal pain including my own personal experience in NICU environments with no standard pain assessment scale, ideas suggesting that premature neonates perceive pain less than their mature counterparts, and the consequences of unmanaged neonatal pain; as well as current best practice for assessing and treating neonatal pain, and implications for the future in this field.

**Methods:**

For this review, sources have been recovered from two databases, Medline Complete and CINAHL Complete. The search strategy consisted of 3 keyword searches of "neonatal pain scale" or "neonatal pain assessment" or "neonatal pain management;" using the "OR" feature, I was able to find sources that had information on either neonatal pain scales, assessment, or management. This allowed me to find sources featuring current neonatal pain assessment scales and methods of assessing, as well as current management. The inclusion criteria included peer reviewed articles and the english language, and the majority are primary sources. I went on to exclude sources from more than 10 years ago to have the most recent data on the subject.

*Search method flow chart illustrating the process to my literature search.* *(Figure 1).*






**Results:**

A Bradycardia- Based Stress Calculator for the Neonatal Intensive Care Unit: A Multisystem Approach by Lavagna et al., discusses the vitality of managing neonatal pain by illustrating the consequences of unmanaged neonatal pain. This multi system approach collected data as part of the Resilience Study in the Neonatal Intensive Care Unit (NICU) at the University Hospitals Leuven, Belgium. Infants that were considered for this study were required to have the following characteristics: prematurity before 34 weeks gestational age and/or birth weight less than 1500 g, and being 3 or less days old. Exclusion criteria included parents less than 18 years of age, limited proficiency in the Dutch or English language, condition of the parent(s) that hindered participation, and the presence of a major congenital malformation in the newborn, namely, grades 3 or 4 intraventricular hemorrhage or periventricular leukomalacia. This allowed for a total of 136 patients for this cohort of the study. Data was obtained utilizing the daily assessment of pain with the multidimensional scale, the Leuven Pain Scale (LPS). This measures pain by concluding a numerical value on a pain scale based on various categories, such as crying, grimace, heart rate, EEG, HRV, and SpO2. Perinatal stress is defined as an "accumulation of pain and noxious stimuli." For a baseline, perinatal stress has been defined as an LPS score of 0 the day before the recording; which means that an LPS score of anything greater than 0 indicates

that the newborn experienced pain the day before the recording. (Lavagna et al., 2020). A total of 245 recordings had associated LPS scores and were able to be analyzed. This study validated the theory that hands on care and clinical handling can induce apneic spells and thus, desaturations in neonates. Perhaps the most noteworthy conclusion of this study is the theory that, "neonates with unmanaged pain are more likely to develop physiological consequences, behavioral and hormonal responses." (Lavagna et al., 2020). University Hospitals in Leuven, Belgium developed a bradycardia- based classification to determine whether a bradycardic spell occurred in a neonate with or without a stress burden. In addition to measuring bradycardic events, desaturation and length of apneic periods were measured. As stated previously, routine handling has been proven to elicit pain and a stress response in neonates, which this study has shown as, "routine contact in the NICU could induce respiratory events, such as apneas and hypopneas, and long oxygen desaturations. This result has been confirmed by the classification performance and desaturation charts." (Levy 2017). Perhaps the most profound conclusion reached by this study is the proven consequences of unmanaged neonatal pain. Infants with prolonged contact in the NICU face many setbacks; hypopneas, apneas, and desaturations usually follow handling, and if these are not monitored and managed, low oxygenation, especially to the brain, can cause delayed or impaired development. In fact, "higher apnea burden is associated with worsening cognitive and motor outcome." (Lavagna et al., 2020). Therefore, it is reasonable to conclude that these stress responses have a negative effect on cerebral oxygenation. In addition, procedural pain can affect the structural connectivity of subcortical areas in the brain, further disrupting neurodevelopment. (Lavagna et al., 2020).

*Assessment of four pain scales for evaluating procedural pain in premature infants undergoing heel blood collection* by Xie et al., is an observational clinical research study that

evaluates and compares the reliability, validity, and clinical utility of 4 different neonatal pain assessment scales in infants undergoing heel blood collection. Pain assessments were performed on 111 premature infants using the following four scales: Neonatal Facial Coding System (NCFS), Douleur Aiguë Nouveau-né Scale (DAN), Neonatal Infant Pain scale (NIPS), and Premature Infant Pain Profile (PIPP). Of the 111 premature infants, 60 were females and 51 were males. Gestational ages ranged from 28 to 36 weeks, and age ranged from 8- 10 days. Average APGAR score at 1, 5 and 10 minutes was 9, 9, and 10. The NCFS scale was developed by Grunau in 1987, and assesses preterm and mature infants' pain solely based on facial movements; brow bulge, eyes squeezed shut, deepening of nasolabial furrow, open lips, vertical mouth stretch, horizontal mouth stretch, taut tongue, chin quiver, pursed lips, and tongue protrusion (for preterm infants only). This scale was shown to have good inter rate reliability, meaning that different professionals assessing the same infant at the same time would likely obtain the same pain score. NIPS assessment tool measures procedural pain through assessment of facial expression, cry, breathing pattern, arms movement, legs movement, and state of arousal. Each item is rated as 0 (relaxed) or 1 (behaviorally defined), except for cry, which can be rated from 0- 2 (no cry, whimper, vigorous). Total score can range from 0-7, with 4 being considered a critical value. The DAN scale measures three behavioral factors such as facial responses (0- 4), limb movements (0- 3), and vocal expression (0- 3). The DAN scale, like NCFS, was shown to have strong inter rate reliability. Lastly, the PIPP scale determines pain through three behavioral items (facial actions: brow bulge, eye squeeze, nasolabial furrow), two physiological items (heart rate and oxygen saturation), and two patient specific items (gestational age and behavioral state). Physiologic and behavioral factors are scored from 0- 4, and contextual factors are reverse scored 3- 0. The maximum score for preterm infants is 21 and is 18 for full-term infants. A total

score of 6 or below reflects minimal to no pain, while a score above 12 indicates moderate to severe pain. Internal consistency was only satisfactory for this scale, but convergent validity and inter rate reliability were stronger. Clinical utility was tested among the four scales by evaluation of those utilizing the scales by responding to a questionnaire with categories of ease of use, ease of score, time required, ease of understanding, feasibility in clinical setting, and ease of identifying pain. This evaluation is measured using a 1- 5 Likert scale. This study concluded that each of the four scales were highly reliable and had strong internal consistency. However, in terms of clinical utility and what is better for evaluating procedural pain, PIPP and NIPS had the strongest scores across validity, reliability, and clinical utility; Therefore, the evidence suggests that these are the best to use to measure pain in premature infants undergoing heel blood collection. (Xie et al., 2020).

Assessment of Pain in the Newborn: An Update, by Maxwell, Fraga, and Malavolta is an update of an article that originally appeared in the Clinics of Perinatology, Volume 40, Issue 3, September 2013. This piece of literature outlines the neurodevelopmental considerations, parental involvement, methodology, and best practice for neonatal pain assessment and management, as well as the long-term developmental implications of unresolved pain and stress during the neonatal period. According to this article, hospitalized infants with a gestational age of 25 to 42 weeks experience an average of 14 painful procedures per day for the first 2 weeks of life. In addition to the procedural pain, NICU infants often have surgical procedures which causes postoperative pain in combination with their procedural pain. As mentioned briefly earlier in this review, neonates were formerly perceived to have blunted pain responses. This has since been disproven as research suggests that premature and full-term infants both have the neuroanatomic pathways from their periphery to the cortex which is required for nociception. By

the 24th week of gestation, nociception is acquired as evidenced by physiologic, hormonal, and metabolic markers of the stress response. (Maxwell et al., 2019). Therefore, infants are capable of perceiving pain as early as 24 weeks, and in preterm infants with immature descending inhibitory pathways, that perception of pain could be more severe. In addition, the still developing nervous system that preterm infants are born with confirms that autonomic and neuroendocrine systems that modulate sensory experience may be immature in preterm babies, causing preterm infants to be more vulnerable to the effects of pain and stress. Studies have shown that preterm infants are especially affected long term by early physical pain, with effects ranging from permanent changes in brain processing and development to altered pain sensitivity and maladaptive behavior in later life. (Maxwell et al., 2019). Studies have also shown that any infant that experienced more physical pain as a neonate has a higher pain response later in life. For example, infants who were born at full-term but underwent a circumcision procedure without analgesia had a higher pain response to vaccinations at 3 and 6 months than full-term infants who underwent a circumcision with analgesia. (Maxwell et al., 2019). This demonstrates how the healthy full-term infants do not have the history and experiences that can alter pain perception and development like that seen in premature infants; proving pain management in NICU infants is of the utmost importance because early physical pain has lasting negative effects on their nervous system, something that they would not experience had they not been preterm, compromised, or ill when born. In addition to this revelation, this article also mentions the difficulty in managing neonates' pain which can cause a diminished stress response due to the pharmacologic interventions, mechanical ventilation, and restraints that are necessary in the NICU environment. Physiologic measures that are typically useful in assessing a neonate's pain can be unreliable in the NICU setting due to confounding variables such as medications to

control their heart rate, blood pressure, etc. It is important to assess the infant at their baseline in order to be able to determine whether a medication is working therapeutically or if they are experiencing pain. Though the methodology for measuring neonatal pain is difficult and varies depending on a preterm versus full-term infant, the best practices for assessing and managing pain in the NICU population include: a specific pain assessment tool for preterm versus full-term and procedural versus postoperative pain. This allows for a more specialized and applicable pain assessment tool for healthcare professionals to use in order to most accurately describe and treat their patient's pain. Something that this article mentions which most others fail to is the importance of parental involvement in pain management. Parents know the behaviors of their infant better than any healthcare provider can, and they are often overlooked in contributing to pain management. Despite being overlooked, parents often face barriers in the NICU to managing their baby's pain such as the high technology environment, inability to get close to their baby, shame that their baby is sick, and unexpected or traumatic birth can all make parents feel unqualified to care for their baby and contribute to their care. It is important to educate parents on the importance of their involvement, as their contributions to their baby's care can aid in the attachment process and have been proven to improve neonatal health outcomes.

| Study | Subjects | Pain Assessment Tools | Type of Pain Investigated | Findings |
|---|---|---|---|---|
| A Bradycardia-Based Stress Calculator for the Neonatal Intensive Care Unit: A Multisystem Approach | 136 premature infants before 34 weeks GA and/or birth weight of <1,500g | Bradycardia Based Stress Calculator (HR), HRV, SpO2, EEG, crying, grimace | Procedural | "Larger desaturation levels are associated to stress experience; larger brain-heart asynchrony and EEG |

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| | | | | regularity are observed during hypoxic events linked to procedural pain” |
| Assessment of Four Pain Scales for Evaluating Procedural Pain in Premature Infants Undergoing Heel Blood Collection | 111 premature infants undergoing heel blood collection | NCFS, DAN, NIPS, PIPP | Procedural | Validity, Reliability (convergent and inter- rate) similar among all<br>NIPS & PIPP best clinical utility |
| Effects on Three Different Methods used during Heel Lance Procedures on Pain Level in Term Neonates | Prospective, randomized controlled trial. Sample of newborns= 160. | NIPS | Procedural | Swaddling, holding, and breastfeeding best nonpharmacologic intervention for pain during heel lance procedure |
| Assessment of Pain in the Newborn: An Update | N/A | PIPP-R, CRIES, NIPS, COMFORT, COMFORTneo, NFCS, N-PASS, EDIN, BPSN | Procedural & Postoperative | Best Practices; “Currently, there is no combination of physiologic and/or behavioral indicators that mark the presence of pain in preterm neonates as reliably and specifically as those validated in full-term infants.” |

**Discussion:**

The findings across the literature reviewed were consistent; almost all highlighted the importance of treating neonatal pain in order to prevent the negative physiological, hormonal, and behavioral consequences, and many provided interventions to prevent these consequences. (Lavanga et al., 2020). While some sources emphasized this more than others, the neurodevelopmental problems that occur from unmanaged pain during the neonatal period was a frequent theme in almost every source. The stress response in neonates that occurs from pain almost always includes a period of bradycardia, apnea, and desaturation; in a prolonged NICU stay, these repeated episodes have a negative impact on cerebral oxygenation which adversely affects the infant's neurodevelopment. In addition, the difficulty of assessing neonatal pain was noted in many sources, as infants in the NICU environment often have a diminished stress response, meaning that caregivers are less likely to notice when the infant is in distress as premature infants do not exhibit the same symptoms and stress markers as full-term infants. This validates the need for a neonatal pain assessment tool specific to preterm infants, as assessing and managing their pain is a different battle than managing their full-term counterparts.

The literature reviews various pain assessment scales, and the most frequently cited, as well as the one I have seen most in my practice, is NIPS. As a future and hopeful NICU nurse, I plan to implement the NIPS pain scale into my hourly assessments, as I believe all nurses should do the same. From my experience as a student nurse in the NICU, when asked what pain assessment scale the hospital uses, nurses either said, "vital signs", or "nothing." This is what inspired me to research this topic because as the literature clearly states, unmanaged pain in neonates has serious consequences that can affect them later in life. Assessing only vital signs to indicate pain is not sufficient because A) there are behavioral factors such as crying, grimace, etc

that indicate pain; and B) interpreting pain from medically managed vital signs is misleading; NICU infants are on medications to control their heart rate and blood pressure, meaning the vital signs these nurses are assessing are not the infant's baseline. Refusing to complete a full pain assessment utilizing a specific pain scale is negligence, and I believe all charting in the NICU should have a pain scale embedded into it. This would remind nurses to assess pain, and allow healthcare professionals to refer back to see the infant's baseline and previous response(s) to procedural or postoperative pain. Integrating pain assessment into the head to toe assessments via the charting system would be a tremendous step in the right direction to assessing neonatal pain to make sure it is not ignored. In addition, this could pave the way for provider specific orders for analgesia based on the pain assessment score and other parameters. This would help nurses manage their infants pain as they have specific guidelines for analgesia dosage based on the pain score and vital signs, which would better standardize the pain management specific to that infant from nurse to nurse. Having objective data with analgesia orders is more safe and efficient than having the sedation and analgesia be up to the nurse caring for the infant that day. Utilizing neonatal pain scales is vital to preventing long-term repercussions of unmanaged pain such as altered pain sensitivity, maladaptive behavioral responses to pain, and neurodevelopmental delays.

Infants in the NICU have frequent handling from healthcare professionals, all of which likely induce pain and thus, the stress response. This stress response is diminished in premature infants due to elements necessary to their care in the NICU, such as pharmacological sedatives and restraints. These impair infants from responding to pain in the typical way we expect, such as crying, grimacing, moving, and withdrawing the affected body part from the pain. This can be misleading to healthcare professionals because if the infant isn't exhibiting normal responses to

pain, they can assume the infant isn't experiencing pain. This is far from the truth as premature infants can experience pain as early as 24 weeks gestational age. Regardless if a preterm neonate is displaying the symptoms of pain that are expected of a full-term neonate, they experience pain the same, or likely to a higher degree than full-term infants. However, the majority of neonatal pain scales found in the literature are developed for full-term neonates. This serves as a disservice to the premature neonatal population as they experience a heightened sense of pain due to the immaturity of their nervous system and the inability to demonstrate symptoms of pain; and there is no assessment tool to account for this. As the literature states, unmanaged neonatal pain can cause delays and problems with neurodevelopment, and in a premature infant who is already battling low birth weight, poor thermoregulation, and immature body systems, this infant does not stand a strong chance at recovery.

The implications for this field remain interminable as long as neonates continue to face the adverse effects of unmanaged pain. From reviewing the literature, the biggest problem and gap that I see in this practice is the lack of understanding and interpreting NICU infants' pain. Whether they are premature, have a congenital abnormality, experienced a traumatic birth, or whatever it may be, the inability of NICU infants to exhibit the symptoms of pain like non NICU infants do puts them at the highest risk for unmanaged pain. Therefore, a pain assessment tool for premature and/or mechanically ventilated infants is crucial to giving this population a chance to achieve health and wellness.

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