ASSESSMENT AND MANAGEMENT OF ACUTE PAIN IN THE NEWBORN

WEB CONTINUING EDUCATION RESOURCE

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ASSESSMENT AND MANAGEMENT OF ACUTE PAIN IN THE NEWBORN

This continuing education resource was developed for AWHONN by Robin Koeppel, MS, RNC, CPNP.

INTRODUCTION

Despite a growing body of knowledge about the physiology of neonatal pain, the evolution of neonatal pain assessment tools, and pain management guidelines, there persists a wide variety of opinions among health care providers about how to treat pain in our most vulnerable patients. Newborns feel pain and require the same level of pain assessment and management as adults. Untreated pain in neonates may result in increased morbidity and length of stay in the neonatal intensive care-unit (NICU), exaggerated responses to pain in later life, and altered psychosocial development. Even the healthiest of newborns may suffer the consequences of untreated pain. The purpose of this on-line education resource is to provide registered and advanced practice nurses practicing in low risk, high risk, and NICU settings evidence-based information necessary to

- Identify common sources of pain in healthy and sick neonates.
- Understand the physiologic and developmental consequences of untreated pain.
- Select pain assessment tools appropriate for their patient population.
- Implement a variety of pharmacologic and nonpharmacologic pain management strategies.

BACKGROUND

Twenty years ago it was not uncommon for preterm infants to undergo a surgical procedure such as a patent ductus arteriosus (PDA) ligation without anesthesia. Withholding anesthesia was commonplace during this period because health care practitioners believed that newborns did not feel pain, or if they did, that the pain was not significant and had no long-lasting consequences. Additionally, many clinicians avoided using narcotics to treat pain in the newborn because of potentially dangerous side effects, such as respiratory depression and hypotension. The traditional view that newborns do not feel pain was supported by the belief that pain transmission required complete nerve myelinization and a mature cerebral cortex to interpret the pain signal. However, although the newborn's peripheral nerves are unmyelinated, complete myelinization is not a prerequisite to pain transmission. A detailed discussion about this point is provided in the section titled Physiology of Neonatal Pain.

Consequently, many health care practitioners concluded that the cerebral cortex of newborns was not well enough developed to register pain impulses or permit memory of painful experiences. Evidence has emerged over the last 20 years however, that supports the functional maturity of the newborn cerebral cortex through scientific evaluation of electroencephalograph (EEG) patterns and localized cerebral glucose utilization during early postnatal development (Chugani & Phelps, 1986; Fisch, 1991). For example, fetal EEG patterns have been documented as early as 20 weeks gestation, with sustained signals evident by 22 weeks gestation (Fisch, 1991). One study of term neonates revealed that cerebral glucose utilization was highest in the sensory areas of the brain, suggesting functional maturity in this area (Chugani & Phelps, 1986). Additional evidence indicated that newborns, including the most immature, have the anatomical,

biochemical, and physiological capability to perceive and respond to pain (Anand & Hickey, 1987).

Fearful of the side effects of narcotics, many clinicians practicing in the late 1970s and early 1980s determined that the risks of using narcotics outweighed their benefits in treating pain. Side effects, including respiratory depression and hypotension, are potentially life-threatening to the fragile preterm infant. Although side effects to narcotics can occur, there is now a better general understanding of the pharmacodynamics of narcotics in the newborn**.** This knowledge has resulted in improved dosing regimens and enhanced management of side effects.

Newborn Vulnerability to Pain

The belief that the infant's experience of pain is not associated with long-term adverse effects is now under scrutiny and intensive scientific study. Preterm infants appear to be most vulnerable to the negative effects of pain because they are typically exposed to repeated and prolonged painful procedures in the NICU. To determine whether previous pain exposure would result in subsequent altered pain reactions, Grunau and colleagues (2001) studied 136 preterm infants born at 23-32 weeks gestational age to identify their pain reactivity at 32 weeks postconceptional age (PCA). The infants were observed after a heel stick procedure, and their pain reactions, state of illness, and heart rate variability were analyzed. The researchers observed higher resting heart rates among infants who had lower birth weights and gestational age, more days on the ventilator, and higher illness severity scores. Of these infants, the youngest (at birth) and those exposed to at least 20 invasive procedures (as defined by the research protocol) demonstrated a diminished behavioral and autonomic pain response at 32 weeks PCA. The authors concluded that early and frequent pain exposure in the youngest infants was associated with the development of a perpetual state of stress and suggested that judicious use of analgesia might be effective in modulating this effect.

Results of other studies indicated that exposure to painful procedures may provoke a memory of those experiences, although the nature and quality of that memory is not fully understood. Taddio and colleagues (1995) found there was an exaggerated response to the pain associated with routine immunization in term newborn males previously exposed to circumcision without analgesia. Beginning research in rat pups exposed to painful stimuli early in development resulted in abnormal brain organization and increased susceptibility to anxiety disorders later in life (Anand et al., 1999). Evidence is mounting that there is a physiological memory of pain in the newborn. The important implication is that painful experiences early in life when the brain is developing may have long-term physiological and developmental effects.

Emerging research supports the premise that newborns, both preterm and term, feel pain. Researchers have focused on refining pain assessment tools that objectively measure newborn pain and identify the best pain treatment strategies and determining how adequate pain management may improve long-term outcomes.

Nurses play a key role in identifying sources of pain, minimizing exposure to painful procedures, and proactively assessing and treating neonatal pain. The challenges are numerous, but the opportunity to maximize the comfort and health of the newborn is great.

SOURCES OF NEONATAL PAIN

Major Surgery and Invasive Procedures in the NICU

Infants in the NICU experience multiple painful procedures. Some infants require major surgery, such as cardiac or bowel surgery, that are accompanied by intense pain. Other infants may experience painful invasive procedures such as peripheral arterial line placement or chest tube placement.

Most infants in the NICU are subjected to multiple and repeated minor painful procedures such as heel sticks, venipuncture, and endotracheal tube suctioning. Barker and Rutter (1995) reported on the frequencies of procedures performed in 54 infants admitted to an NICU. Of the 3,000 procedures recorded, 74% were in infants of less than 31 weeks gestation. During one hospitalization, an infant born at 23 weeks gestation experienced almost 500 procedures. Similarly, Stevens and colleagues (1999) reported that approximately 10% of the youngest infants with the most complications underwent more than 300 painful procedures. Because these repeated painful experiences occur during a period of rapid cortical development, they might negatively alter subsequent nervous system development. The extent of such alteration in central nervous system development and its long-term implications require further study.

Circumcision and Routine Nursery Procedures

Although the pain experience in the NICU of preterm infants and term infants who are at risk has been the focus of many studies, healthy newborns also experience painful procedures that are frequently undertreated. Until recently, the most common neonatal surgical procedure, circumcision, was performed without anesthesia.

What are the effects associated with circumcision without anesthesia? In the short-term, infants undergoing circumcision without anesthesia may have altered sleep patterns, increased fussiness, and an increased heart rate (Marshall, Stratton, Moore & Boxerman 1980). In the long-term, Taddio and colleagues (1995) demonstrated that infants exposed to circumcision without anesthesia may have an exaggerated response to pain in later infancy. This study found that infants may retain a memory of painful experiences which may cause increased sensitivity to pain later in life.

Within the past decade, the American Academy of Pediatrics (AAP) and other regulatory bodies have made clear and direct statements that the provision of anesthesia for circumcision procedures should be the standard of care (AAP, 1999; American College of Obstetricians and Gynecologists [ACOG], 2001). Based on recent research, a combination of a dorsal penile or ring block, eutectic mixture of local anesthetics (EMLA) cream (to minimize pain during the application of the local anesthetic), and oral sucrose administered via pacifier before the start of the procedure may be the preferred method for managing pain associated with circumcision (Anand & The International Evidence-Based Group for Neonatal Pain, 2001; Taddio, 2001; Taddio, Pollock, Gilbert-MacLeod, Ohlsson, & Koren, 2000).
The most effective method or a combination of methods of anesthesia for circumcision is still being studied. Application of EMLA cream alone is no longer considered the best anesthetic approach because recent studies demonstrated superior analgesia using the ring block or dorsal penile nerve block (Taddio, 2001; Taddio, et al, 2000). One study concluded that the administration of a ring block for circumcision anesthesia was more effective than other methods to maintain adequate anesthesia throughout the procedure. Dorsal penile nerve block was rated second, and EMLA cream was described as a poor

choice as the sole anesthetic agent for circumcision (Lander, Brady-Fryer, Metcalfe, Nazaralin, & Muttitt, 1997). Other studies identified a combination of dorsal penile nerve block, use of the Mogan clamp (associated with less procedure time and pain compared with the Gomco clamp), and administration of oral sucrose as an effective anesthetic method (Taddio, 2001; Stang et al., 1997).

Heel stick procedures and venipuncture, though considered to be minor painful procedures, are actual sources of pain in the newborn nursery. According to Haouari and colleagues (1995) healthy term newborns in the newborn nursery experienced at least one heel stick (for the newborn screen) and approximately 15% underwent an additional 2-4 heel stick procedures during the first week of life. Heel stick, venipuncture, and intramuscular (IM) injection are procedures for which newborn pain is not routinely treated.

The use of oral sucrose, discussed in-depth later in the section titled Treatment of Newborn Pain, is considered an inexpensive and safe method for treating pain from the minor procedures described above. Research trials have demonstrated that obtaining laboratory samples via venipuncture can be less painful than the heel stick method for healthy term infants (Shah, Taddio, Bennett & Speidel, 1997; Larsson, Lagercrantz, & Olsson, 1998). Other pain treatment interventions such as heel warming, Paracetamol (Tylenol) and EMLA cream have had little impact in modulating pain from a heel stick (Shah, Taddio, & Ohlsson, 1998; Taddio, Ohlsson, Einarson, Stevens, & Koren, 1998; Barker, Willetts, Cappendijk, & Rutter, 1996).

Birth Events

Although they are rare occurrences, scalp lacerations, severe head molding, and clavicular fractures are sources of newborn pain. There is a paucity of information about the pain experience or pain treatment options surrounding these clinical conditions. One research trial compared the effects of rectal paracetamol (Tylenol) with a placebo for neonatal pain experienced after vacuum extraction (van Lingen et al., 2001). The researchers proposed that neonatal pain after vacuum extraction was the result of the suction and traction applied to the scalp and that Tylenol might provide relief. The investigators recruited 122 infants, randomized them into two treatment groups, and evaluated pain scores and clinical condition scores (clinical condition was reported by nurses and included parameters such as pain with handling and poor feeding). The study group received rectal Tylenol, and the control group received a placebo. Although there was no difference in pain scores between the two groups, the study group demonstrated significantly improved clinical condition scores. Several limitations to the study were cited that may have resulted in the lack of pain score differences, most significantly that rectal Tylenol doses may have been too low to produce analgesia. Further research is needed to clarify the efficacy of Tylenol for this type of pain management.

In summary, intensive care in the NICU is usually accompanied by repeated invasive and painful procedures. Healthy term infants and convalescing preterm infants are exposed to multiple painful procedures that are frequently under- or untreated. Nurses and other health care providers should consider the following important points when evaluating the need for neonatal pain manangement:

- Newborns, even the most immature feel pain.
- Newborns in the NICU are subjected to multiple painful procedures then may result in an altered pain response later in infancy.

- Circumcision, the most common surgical procedure during the newborn period, should be performed with anesthesia; the best anesthetic approach often involves a combination methods.

(PRACTICE EXERCISE #1)

1. Preterm infants are especially vulnerable to the effects of procedural pain because

a. Frequent painful procedures occur during an important period of brain development

b. Exposure to multiple painful invasive procedures can result in a diminished autonomic pain response

c. Exposure to heel stick procedures can result in higher illness severity scores

d. All of the above

Answer: d

2. Circumcision should be performed using a combined anesthetic and analgesia approach that ideally includes:

a. EMLA cream and oral sucrose

b. Ring block or dorsal penile nerve block, EMLA cream, and oral sucrose

c. Ring block and Tylenol

d. Ring block and dorsal penile nerve block

Answer: b

REVIEW OF ACUTE PAIN PHYSIOLOGY

Pain, a sensory experience, begins with the transmission of an impulse by the sensory receptors in the skin and other body tissue. Pain impulses are transmitted from the sensory receptors in the skin or other organs via C- and A-delta fibers in the peripheral nerves to the dorsal horn in the spinal cord, then to the brain stem, the thalamus, and finally to the cerebral cortex. Ultimately, a process known as descending modulation assists to dampen specific pain impulses, presumably as a protective mechanism to modulate or moderate severe pain (Melzack, 1990).

When pain impulses are relayed to the spinal cord, the ascending neurons originating in the dorsal horn of the spinal cord send the pain impulse to different areas of the cerebral cortex. Ronald Melzack, a well-known researcher responsible for the Gate Control Theory of pain, described two distinct ascending pathways for pain: the lateral and medial pathways. The lateral pathway is responsible for transmitting phasic pain impulses to the cerebral cortex (Melzack, 1990). Phasic pain is that which is first felt after an injury and is brief, with an intensity that rapidly rises and then falls, similar to pain felt during the initial lance for a heel stick procedure.

The medial ascending pathway is responsible for transmitting tonic pain. Tonic pain usually follows phasic pain and is prolonged and persistent, often described by adults as diffuse in nature (Melzack, 1990). Unlike the lateral pathway, the medial pathway conducts the sensory information to the limbic area of the cerebral cortex that provides the psychological response to pain and makes the pain experience unique for each person.

Pain impulses are transmitted through unmyelinated C-fibers and thinly myelinated A-delta-fibers in the adult (Melzack,1990). Researchers studying fetal and newborn

neuroanatomy and physiology confirmed that newborns, both term and preterm, have the peripheral structures needed to transmit pain that are similar to those of adults (Fitzgerald, 1995; Fitzgerald & Anand, 1993), but with the following important differences:

- Pain impulses are predominately transmitted through the nonmyelinated C-fibers (Fitzgerald, 1995; Fitzgerald & Anand, 1993).
- Signal transmission is less specific within the spinal cord (Fitzgerald, 1995; Fitzgerald & Anand, 1993).
- Sensory nerve cells in the spinal tract are more excitable leading to a greater and more prolonged reflex response (Fitzgerald, 1998).
- Descending modulation is immature and ineffective (Fitzgerald, 1995).

These differences may result in newborns perceiving pain in a more intense fashion than adults. Fitzgerald, Shaw and MacIntosh (1988) demonstrated that premature infants have a lower pain threshold than term infants, indicating a more intense transmission of painful stimuli via the spinal cord, which can be further intensified with repeated painful stimulation.
The heel stick procedure can be used as an example of the reaction and response to pain: An infant senses the lance and immediately withdraws the foot. In the preterm infant this withdraw reflex may be less dramatic because of less muscle strength compared with the term newborn. Following the withdraw reflex, the infant cries and responds with the classic cry face (squeezed eyes, marked nasolabial folds, gaping mouth). This response, commonly witnessed by health care providers in the NICU and illustrated in **Figure 1,** is an example of an intact sensory pathway that transmits painful stimuli.

The endocrine responses to pain originate in the cerebral cortex. The intact cerebral cortex of a newborn is functionally mature and able to mount an adequate response to pain and stress. Through a complex array of interactions, the cerebral cortex orchestrates the release of catecholamines, inflammatory markers, and other important enzymes that mobilize the body to respond to painful stimuli. In a landmark article, Anand and Hickey (1987) presented findings of the preterm infant's ability to mount an endocrine and hormonal response to pain that can be modulated with sufficient anesthesia during surgery.

CONSEQUENCES OF UNTREATED PAIN

Untreated newborn pain can contribute significantly to neonatal morbidity and mortality. High postoperative mortality, poor growth related to prolonged protein catabolism, and increased time on mechanical ventilation have been attributed to untreated or poorly treated pain (Anand, Hansen, & Hickey, 1990; Anand, 1993; Fletcher, 1987). Additionally, there may be long-term consequences for the fragile infant exposed to multiple painful procedures during a critical time in brain development. Anand & The International Evidence-Based Group for Neonatal Pain (2001) describe a propensity toward anxiety disorders and an exaggerated response to pain in rat pups exposed repeatedly to painful procedures.

Generally, untreated or undertreated pain in the newborn includes the following physiologic and biochemical sequelae:

- hyperglycemia
- increased protein catabolism

- increased oxygen consumption
- decreased gut motility
- increased heart rate and blood pressure
- decreased transcutaneous oxygenation.

To address the need for guidelines on treating the neonatal pain and stress experienced in the NICU, the International Evidence-Based Group for Neonatal Pain published a consensus statement. This consensus statement detailed the need to proactively treat neonates undergoing procedures known to be painful and to consider background analgesia such as a low dose morphine drip for those infants requiring mechanical ventilation (Anand, & The International Evidence-Based Group for Neonatal Pain, 2001). Anand, Barton, and colleagues (1999) demonstrated in a pilot trial that low-dose analgesia (morphine) administered to infants at 24-32 weeks gestation who were ventilator dependent improved neurologic outcome, specifically a reduction in severe intraventricular hemorrhage (IVH). Sixty-seven preterm infants (24-32 weeks gestation) were randomized to receive either continuous infusions of morphine sulfate, midazolam or placebo. Infants who received the morphine continuous infusion had improved neurologic outcome when compared with the infants who received the midazolam and placebo infusions. The authors speculated that the background analgesia provided by morphine continuous infusion reduced the acute cardiovascular changes associated with common painful procedures (such as endotracheal suctioning) which can increase intracranial pressure and result in IVH.

Despite published guidelines, research findings and consensus statements, there is tremendous variation in the management of pain in the NICU and normal newborn nursery. Although most clinicians now believe that infants feel pain to at least the same degree as adults, consistent application of techniques to manage newborn pain is lacking (Porter, Wolf, Gold, Lotsoff, & Miller, 1997). Several nationwide and international surveys have revealed that analgesia is used infrequently before procedures in the NICU and that neonates who are awake frequently receive no sedation prior to endotracheal intubation (Bauchner, May, & Coates, 1992; Whyte, Birrell, & Wyllie 2000). Nurses should be aware of newborn pain management guidelines and implement treatment strategies consistently in their patient care settings to ensure appropriate pain management.

ASSESSMENT OF NEWBORN PAIN

Pain behaviors have been observed in the newborn for more than 20 years. The cry face, including brow bulge, gaping mouth and nasolabial folds (**Figure 1)** appears to be the most specific indicator of pain across all gestational ages (Stevens, Johnston, Petryshen, & Taddio, 1996) and is frequently included as a primary element in pain assessment tools. Term and near-term infants frequently exhibit pain by crying and increased body movement accompanied by tachycardia and elevated blood pressure. In contrast, preterm infants, especially the most immature, may become lethargic and unresponsive. This phenomenon has been explained not as a lack of pain, but as a failure of the central nervous system to mount a response to pain.

The International Association for the Study of Pain (IASP), recognizing the inability of the nonverbal and preverbal patient to clearly communicate their pain experience, revised their classic definition of pain to include this phenomenon:

"The inability to communicate in no way negates the possibility that an individual is experiencing pain, and is in need of appropriate pain-relieving treatment" (IASP, 2001, p.2).

Clearly, those who provide health care to newborns should recognize that a lack of pain response does not necessarily indicate absence of pain.

Neonatal pain assessment can be complex and challenging, but is vital to ensure appropriate pain management. The Joint Commission on the Accreditation of Healthcare Organizations (JCAHO) and other regulatory agencies require pain assessment at regular intervals throughout the hospital stay (JCAHO, 2002). In fact, some health care facilities now identify pain assessment as the 5th vital sign. To effectively assess pain, nurses must have the critical thinking skills necessary to differentiate pain behaviors from other behaviors that occur apart from painful situations. Moreover, effective pain assessment requires the use of the most reliable and valid multidimensional instruments (National Association of Neonatal Nurses [NANN] 1999; AAP/Canadian Pediatric Society, 2000). Assessment of newborn pain is challenging and complex for many reasons. Although many assessment tools are available for clinical use, few serve all populations or are applicable in all situations. Most tools do not distinguish pain from generalized distress nor measure the presence of chronic pain. Compounding this difficulty is that the responses vary from infants of differing gestational ages. For instance, a very preterm infant has a much less robust and variable response to pain compared with the term infant (Johnston, Stevens, Craig & Grunau, 1993). To address problems related to the complexities of pain assessment, nurses should use pain assessment tools that are multidimensional (scoring behavioral as well as physiological parameters), reliable and valid, as well as clinically useful and appropriate for gestational age.

Validity and Reliability of Pain Assessment Tools

Validity, reliability and clinical utility are all important considerations when choosing a pain assessment tool. Validity refers to the ability of the pain tool to measure pain as an isolated condition differentiated from other conditions, such as distress and agitation. A valid tool measures the condition for which it is intended. Reliability refers to the tool's ability to consistently score pain each time the tool is used (test-retest reliability) and when different people use the tool (interrater reliability). However, a tool that is highly valid or reliable in measuring pain in the newborn may be difficult or too cumbersome to use in the clinical setting. Therefore, when selecting a pain assessment tool, nurses should review the validity and reliability of various tools and determine the clinical utility relative to their own practice setting. Until more precise tools that are easy to use in the clinical setting are identified, existing pain assessment tools provide the best available mechanism to compare behaviors before, during, and after a painful procedure.
Using a pain assessment tool that is multidimensional provides the clinician with the most information. Whichever tool is used, however, the measurement of infant pain is just one aspect of comprehensive pain assessment. The nurse should take a holisitic view of the patient, understanding that one score on a pain tool is not necessarily representative of the extent of that infant's pain.

Newborn Pain Assessment Tools

A summary of selected pain assessment tools is presented in **Appendix A**. The Premature Infant Pain Profile (PIPP) is a pain assessment tool used frequently in research. The PIPP combines behavioral, physiological, and gestational age data to

arrive at a pain score or profile and is considered a reliable and valid instrument in a large data set, (Stevens et al., 1996). Components of the PIPP include gestational age, heart rate, oxygen saturation, behavioral state, and three components of the cry face (brow bulge, eye squeeze, nasolabial furrow). Taking gestational age into account, the PIPP accommodates the recognition that the youngest and smallest infants may not be able to mount or sustain a response to pain in the same fashion as an older infant. Therefore, these infants are given points toward their overall profile based on their gestational age. This seven-item, four-point profile contains the components that appear to correlate with pain, but may not be specific or sensitive to pain. In addition, this tool can be challenging to use in the clinical setting because it requires observation before, during and after handling the infant and mathematical calculations regarding heart rate and oxygen saturation changes.

The CRIES (Krechel & Bildner, 1995), developed for use with preterm and term infants undergoing postoperative pain, was initially tested on 24 infants who ranged in age from 32 to 60 weeks gestation. The CRIES is multidimensional and measures crying, oxygen requirements, increased vital signs, expression, and sleeplessness.

The Neonatal Infant Pain Scale (NIPS) is widely used for research purposes (Lawrence et al., 1993). This tool measures behavioral signs of pain, including facial expression, cry, breathing patterns, movement of arms and legs, and state of arousal. Measurement of physiological pain indices is not included in the NIPS tool.

The FLACC (Face, Legs, Activity, Cry, Consolability) Pain Assessment Tool has been shown to have high interrater reliability and evidence of validity in infants 2 months to 7 years of age (Merkel, Voepel-Lewis, Shayevitz, & Malviya, 1997). Because the healthy term newborn is not generally observed continuously using pulse oximetry or cardiorespiratory information, this tool may be useful in the normal newborn nursery because its emphasis is on behavioral responses associated with pain and does not include physiological responses.

Although not an exclusive list, **Appendix B** includes additional descriptions of pain assessment tools that may serve as a resource for nurses and other health care providers.

Selecting and Using Pain Assessment Tools

The following points should be considered to ensure appropriate and comprehensive pain assessment:

- Pain measurement is only one piece of a comprehensive pain assessment that should occur within the context of each infant's condition and environment.
- The lack of a response to pain in the preterm infant does not necessarily indicate of lack of pain.
- A multidimensional tool, (that is, a pain assessment tool that measures behavioral and physiological indicators of pain and ideally, one that has been tested for reliability and validity in the target population) should be selected.
- Neonatal care providers should receive education about the use and scoring guidelines for the chosen tool prior to implementation.
- Pain assessment should be performed at regular intervals, according to facility protocols.

- No pain assessment tool is perfectly suited to all circumstances; a tool should be chosen, used, and evaluated for its appropriateness and effectiveness in the individual clinical setting.

PRACTICE EXERCISE # 2

1. Phasic pain is pain associated with:

a. the initial injury and is usually intense but brief
b. chronic long term exposure to pain
c. persistent dull, throbbing pain
d. the prolonged discomfort of endotracheal intubation

Answer: a

2. The VERY preterm infant may respond to pain by exhibiting

a. an exaggerated cry face
b. lethargy
c. a robust withdrawal from the painful stimulus
d. signs of diffuse pain

Answer: b

NEWBORN PAIN TREATMENT

Despite the growing evidence that untreated pain is costly to the premature infant, a survey of pain management practices demonstrated that clinicians lack commitment to institute consistent pain management techniques (Porter et al., 1997). This may be due in part to the side effects experienced with the use of narcotics, the most common pharmacologic intervention used to treat pain.

Prevention of pain whenever possible is the best approach to pain management in the NICU and normal newborn nursery. When prevention is not possible, painful procedures can be minimized by limiting the number of blood draws required to safely monitor the infant, suctioning the infant on an as needed basis versus a routine protocol, and utilizing the most skilled person to perform painful procedures (NANN, 2001). The method by which the nurse performs specific procedures also can limit the pain experienced by the newborn. For example, venipuncture is usually more expeditious and less painful than blood sampling via heel stick in healthy full term infants (Larsson et al., 1998; Shah et al., 1997).

Despite the best prevention approaches, however, painful procedures occur in the NICU. Treating newborn pain involves both pharmacologic and nonpharmacologic methods. Acute pain, such as that following major surgery, is most commonly treated with narcotics, including morphine and fentanyl. Sedatives, such as benzodiazepines, do not treat pain but are often used as adjuvant therapy to treat distress and agitation in combination with the narcotics used specifically to treat pain. Topical medications such as EMLA cream also have been used for minor procedures such as venipuncture and lumbar puncture. Oral sucrose, typically defined as a food supplement, is another option for pain management in brief, intermittent, painful procedures.

Narcotics

Morphine, an extract of opium is commonly used to treat severe pain not only in newborns but also in patients of all ages. The prototype opioid, morphine works to

relieve pain by stimulating the Mu-opioid receptors in the spinal cord. Side effects may include respiratory depression, apnea, hypotension, and urinary retention. Fentanyl, also used to treat moderate to severe pain, is a synthetic opioid much more potent than morphine. Because of its high lipid solubility, fentanyl is widely distributed into body tissues. Reported side effects during a bolus administration of fentanyl include bradycardia, hypotension, and chest-wall rigidity. These effects can be minimized with slow administration time and close observation. Use of Fentanyl is more likely to result in rapid drug tolerance and withdrawal when compared with Morphine (Franck, Vilardi, Durand & Powers, 1998).

There is sparse research to suggest that one narcotic is preferred over another for pain management. Anand , Barton et al., (1999) reported improved neurologic outcomes with continuous morphine infusions for infants on mechanical ventilation when compared with midazolam and placebo infusions. However, Saarenmaa and others (1999) compared the effects of fentanyl and morphine during the first 2 days of life in newborns on mechanical ventilation and concluded that fentanyl had fewer side effects and may be superior short-term analgesia. This is an area that requires further research.

Sedatives

Many clinicians have used benzodiazepines as an adjunct to narcotic administration for the treatment of both pain and agitation in critically ill infants on ventilatory support. Benzodiazepines such as diazepam and midazolam are used to treat agitation, but do not treat pain. Diazepam is a potent sedative with a long half-life (20-80 hours). Disadvantages of using diazepam include the development of tolerance and potential displacement of bilirubin from binding sites. Another example, midazolam, may be a preferred by some clinicians because its half-life is only 1-3 hours, with potent sedative effects. Disadvantages to using midazolam include apnea, hypotension, and abnormal movements.

Although benzodiazepines provide sedation and amnesia, they also can mask the common behavioral signs of pain and therefore should not be used alone for the treatment of pain (Anand & The International Evidence-Based Group for Neonatal Pain, 2001). A recent collaborative review concluded that midazolam is not recommended for use as a sedative in preterm infants because adequate scientific evidence is lacking (Ng, Taddio, & Ohlsson, 2000). Although used frequently, benzodiazepines have not been widely studied and their effects on the newborn may be unknown.

Eutetic Mixture of Local Anesthetics (EMLA)

Eutetic ixture of local anesthetics (EMLA) is a cream-based ointment with lidocaine and prilocaine, which, when applied to skin provides numbing and pain relief. EMLA has been used to treat pain from circumcision, lumbar puncture, heel stick, and venipuncture. EMLA reduces pain during circumcision as evidenced by a slight decrease in heart rate and a higher oxygenation saturation when compared to placebo (Taddio, Ohlsson, & Ohlsson, 2002). Although EMLA and dorsal penile nerve block have been accepted by NANN and the AAP as neonatal anesthetic agents, a more recent systematic review article identified that the subcutaneous ring block is likely a superior method for anesthesia during circumcision (Taddio et al., 2002). Although no longer considered the superior sole anesthetic agent for circumcision, EMLA is recommended to treat the pain from the application of the dorsal penile nerve block or ring block (Anand, & The International Evidence-Based Group for Neonatal Pain, 2001).

EMLA cream has been evaluated for use during lumbar puncture, heel sticks, and venipuncture. Its use for lumbar puncture includes the application of EMLA at least 30-60 minutes prior to the procedure. Pain from heel stick procedures does not appear to be modulated by EMLA cream and therefore, is not recommended for this use (Taddio et al., 1998). EMLA has been shown to be effective in reducing pain from venipuncture in newborns (Lindh, Wiklund, & Hakansson, 2000).

Although previously not approved for use in infants less than one month old, EMLA cream is now approved by the U.S. Food and Drug Administration (FDA) for infants younger than 1 month of age who have a gestational age (at birth) of 37 weeks or greater (AstraZeneca, 1999). Use of EMLA cream in the low birth weight infant continues to be of concern because of potential toxicities from excessive absorption (through thin skin) and repeated exposures.

Oral Sucrose

The use of oral sucrose for the treatment of brief, mild, procedural pain has been described for over 10 years. Although the ideal dose, concentration, and administration method of oral sucrose are unclear, its effectiveness in treating pain from heel sticks and venipunctures is compelling. In fact, NANN, the AAP and Canadian Pediatric Society recommend the use of oral sucrose to manage procedural pain during heel stick, venipuncture, and IM injection (AAP, 2000; NANN 2001). A 1999 meta-analysis revealed that a dose of 1 to 2 ml of a 24% sucrose solution administered approximately 2 minutes before a minor procedure is effective in treating pain from mild, brief procedures (Stevens & Ohlsson, A. 1999). Oral sucrose also has been studied extensively for use as analgesia during circumcision. Herschel and colleagues (1998) demonstrated that sucrose on a pacifier may be an effective method of analgesia for circumcision when the dorsal penile nerve block is not desirable.

Oral sucrose and other sweet-tasting substances appear to work by way of an endogenous opioid-mediated pathway via the sweet taste buds located on the anterior portion of the tongue. For example, Blass, Fitzgerald, and Kehoe (1987) demonstrated that rat pups given oral sucrose prolonged withdrawal of their paw from a hot plate surface. This pain relief effect is reversed by administration of Narcan (naloxone hydrochloride), a narcotic antagonist, affirming that the pain effect may be modulated by endogenous endorphin release (Blass et al., 1987). Blass and Hoffmeyer (1991) furthered this research with oral sucrose by testing its effects in human infants exposed to heel lance and circumcision and found that oral sucrose decreased crying time by more than 50%. Additionally, a pacifier dipped in the oral sucrose solution appears to promote nonnutritive sucking, which provides and additional calming effect.

Administration of oral sucrose via the anterior portion of the tongue is an important component of its effectiveness. For example, one study showed that administration via nasogastric tube had no effect (Ramenghi, Evans, & Levene, 1999). Although, the evidence is not complete for sick, preterm infants (especially in relation to multiple doses), the use of oral sucrose for mild procedural pain (heel stick, venipuncture and IM injection) is evidence-based.

To date, there are no known short term side effects to the use of oral sucrose (Stevens, Yamanda, & Ohlsson, 2001) with appropriate administration. One small study of 15

healthy preterm infants with a gestational age of 32 to 34 weeks showed analgesic effects of oral sucrose for pain from a heel stick without immediate adverse effects (Ramenghi, Wood, Griffith, & Levene, 1996). However, the participants in these studies were healthy term infants or healthy preterm infants during their convalescence phase of illness.

Administration of multiple doses of oral sucrose in the preterm infant during an acute phase of illness has not been studied extensively. A recent study reports that administration of multiple doses of oral sucrose to infants of less than 31 weeks PCA during the first week of life is effective at relieving pain from brief painful procedures. However, its use is associated with negative neurobehavioral and physiological outcomes at 36 weeks and 40 weeks PCA (Johnston, et al., 2002). The authors conclude that additional studies are needed to confirm their results and to further delineate the most appropriate age and duration of oral sucrose use in the infant younger than 31 weeks PCA. This is the first study looking at multiple administrations of oral sucrose and the potential long-term effects on the preterm infant. More randomized controlled studies are required before definite conclusions can be made.

Oral sucrose is hypertonic, which may present an additional concern when used in the very preterm infant. Oral hypertonic solutions might be linked to the development of necrotizing enterocolitis (NEC). In an older study, Willis and colleagues (1977) reported a possible relationship between 20% oral sucrose solution mixed with calcium lactate given via nasogastric tube and an increased incidence of NEC. It is unclear whether the association was due to the calcium lactate or the oral sucrose, as both solutions are hypertonic. More studies are required before multiple administration of oral sucrose can be recommended in the sick, very preterm, low birth weight infant.

Nonpharmacologic Treatments

A developmentally supportive approach to caregiving is essential in the NICU and is an important adjunct to effective pain management. Described in the literature for over 20 years, developmentally supportive care is relational, taking into account the infant's response to handling, with the nurse altering her actions accordingly. Developmentally supportive care involves behavioral and environmental components including, but not limited to

- facilitated tucking (holding the infant's extremities close to the body, promoting flexion), swaddling, nesting, use of nonnutritive sucking
- minimal handling protocols
- lowering noise levels in the NICU
- avoiding exposure to bright lights
- promoting of day/night light cycles.

Integrating this approach to caregiving reduces noxious stimuli from the environment while promoting the infant's own coping abilities, thereby possibly reducing pain and stress. This approach should be applied consistently throughout the infant's stay in the NICU and is complementary to other pain treatment techniques. A developmentally supportive approach to caregiving can improve overall morbidity in the NICU by decreasing length of stay and improving weight gain and overall neurodevelopmental outcomes (Als et. al., 1994). Further research is needed to clearly link developmental care strategies to prevention and management of pain in the NICU.

Other nonpharmacologic approaches to pain management include use of nonnutritive sucking, music, and holding and rocking. Nonnutritive sucking as a pain-relieving technique has been studied extensively and shown to be helpful in reducing crying time and heart rate during painful procedures such as circumcision and heel stick (Shiao, Chang, Lannon & Yarandi, 1997). Studies evaluating the effectiveness of oral sucrose as a pain management strategy also used pacifiers as either the method of administration or as an adjunct (Blass & Watt, 1999; Carbajal, Chauvet, Couderc, & Olivier-Martin, 1999). Blass (1994) found that use of a pacifier provides some analgesia, but is not as effective as oral sucrose administration combined with sucking on a pacifier. Use of a pacifier is an effective adjunct to pain management strategies and is easy to implement.

In comparison to nonnutritive sucking as a nonpharmacologic intervention for pain management, music therapy (MT) to modulate pain during invasive procedures has been less studied. Butt and Kisilevsky (2000) demonstrated MT as an effective noninvasive intervention to treat pain during a heel stick procedure in 14 preterm infants. Although this was a small study, the researchers demonstrated that infants of more than 31 weeks PCA responded best to MT, with a rapid return of heart rate, behavioral state, and facial expressions to baseline levels as compared with infants less than 31 weeks PCA. Another small study by Bo and Callaghan (2000) demonstrated an effective reduction in pain behaviors and improvement in transcutaneous oxygenation levels in infants receiving MT and nonnutritive sucking during a heel stick procedure.

Finally, Joyce, Keck, and Gerkensmeyer (2001) studied the use of EMLA and MT as both a combined and a single treatment on pain responses in 23 neonates undergoing circumcision. Results of this randomized controlled trial revealed that EMLA and MT combined may contribute to pain relief during circumcision. In summary, larger studies are required before MT can be routinely applied in the clinical setting as a pain treatment modality.

Holding, rocking, and skin-to-skin contact have been shown to effectively modulate the pain responses of newborns during a heel stick procedure. One study demonstrated that the holding of term newborns skin-to-skin by their mothers during a heel stick procedure markedly reduced crying and grimacing (Gray, Watt, & Blass., 2000). Another recent study revealed that infants held by their mothers or breastfed before, during, and after a heel stick procedure had lower pain scores when compared with those who were not (Gray, Miller, Phillip & Blass, 2002). The researchers could not determine which intervention, suckling or skin-to-skin contact, was responsible for the reduced pain expression.

In summary, some nonpharmacologic approaches to pain management in the newborn, such as holding and rocking or offering the pacifier, are adjuncts to the administration of medications to treat moderate to severe pain. Other approaches, such as developmentally supportive care, are foundational to the nursing care of the newborn and are applied at all times to assist in management of mild pain and distress. Whether in the NICU or newborn nursery, the nurse is instrumental in providing the most appropriate nonpharmacologic technique to treat and prevent pain. **Appendix C** provides a selected summary of painful procedures, along with the recommended treatment approaches, as outlined in the consensus statement by The International Evidence-Based Group for Neonatal Pain (Anand, & The International Evidence-Based Group for Neonatal Pain,

2001). **Appendix C** may be used to assist the nurse in developing and implementing a consistent approach to pain management in the newborn.

Nurses and other health care providers should consider the following principles that are important to treating newborn pain:

- The prevention of pain (whenever possible) and treatment of pain are nursing priorities to reduce morbidity and improve outcomes.
- When it is impossible to prevent pain, methods/procedures that have been shown to be less painful should be used.
- Nurses are instrumental in the development and implementation of effective pain reducing strategies.
- Narcotics are the mainstay for treatment of acute pain, such as that following major surgery.
- Sedatives (benzodiazepines) are used as an adjunct to manage agitation. Their use in preterm infants however, has not been studied extensively.
- Nurses can prevent and/or manage pain associated with procedures through the use of nonpharmacologic strategies and the use of oral sucrose.
- To minimize the time it takes or minimize stress in the infant, the most skilled person should perform painful procedures
- Aggressive interventions should be used to pre-empt pain during known painful procedures whenever possible.

(PRACTICE EXERCISE #3)

1. Benzodiazepines

a. have not been shown to produce adverse effects in the newborn
b. are used primarily to treat pain
c. should be used cautiously in the newborn because its effects are not clearly understood
d. do not mask the behavioral signs of pain

Answer: c

2. EMLA crème is <u>MOST</u> effective in treating pain associated with

a. Lumbar punctures
b. heel sticks
c. circumcision
d. gastric reflux

Answer: a

SUMMARY

This on-line resource provides an overview of pain in the newborn, including sources of pain experienced during the newborn period and in the NICU, a review of pain physiology, pain assessment challenges, and pain treatment options. Although the attitudes of clinicians regarding the ability of the newborn to feel and respond to pain have improved, treating infant pain in a consistent fashion remains a somewhat elusive but nonetheless achievable goal. Nurses can be instrumental in changing attitudes about the causes and consequences of neonatal pain and improving pain management in the newborn by

- implementing useful pain assessment tools and utilizing these tools consistently.
- consistently discussing pain and pain management during their shift reports, multidisciplinary rounds, and with families.
- working collaboratively with all members of the multidisciplinary team to adopt pain treatment protocols.
- reading research articles and educating others about infant pain and effective pain management strategies.
- adopting a developmentally supportive approach to newborn care and consistently applying these techniques.

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APPENDIX A
PAIN ASSESSMENT TOOLS SUMMARY

PAIN TOOL	PATIENT POPULATION	RELIABILITY	VALIDITY
PIPP (Premature Infant Pain Profile)	Preterm infants 28 weeks to 40 weeks gestational age	Interrater reliability, ICC: .93-0.96 Intrarater reliability: .94 -.98	Content validity, construct validity: • in preterm neonates p =.0001 • in term neonates p < .02 Construct validity in clinical setting , p < .0001
CRIES (Crying, Requires O2, Increased VS, Expression and Sleepless)	Postoperative pain in preterm and full-term infants (32-56 weeks)	Interrater reliability: .72 (p<0.0001)	Content validity; concurrent validity: 0.73 (p<.0001) Discriminate validity: p <.0001
NIPS (Neonatal Infant Pain Scale)	Preterm and full-term infants requiring capillary, venous or arterial punctures. 28-38 weeks gestation	Interrater reliability: .92-0.97 Internal consistency, alpha: r = .95, .87 and .88 for before, during and after the procedure, respectively	Construct validity: p <.001 Concurrent validity: r =.53-.84
FLACC (Face, Legs, Activity, Cry, Consolability)	Children 2 months to 7 years of age	Interrater reliability: r = 0.87 (p<0.001)	Early construct validity: p < .001

ICC = Inter-class Correlation Coefficient.

APPENDIX B
ADDITIONAL PAIN ASSESSMENT TOOLS

NAME	PATIENT POPULATION	METHOD OF MEASUREMENT	REFERENCE
Riley Infant Pain Scale	Preverbal infants	Behavioral	Joyce et al. (1994). Reliability and validity of preverbal pain assessment tools. Issues in Comprehensive Pediatric Nursing, 17, 121-135.
POPS Postoperative Pain Score for Infants	Preverbal infants	Behavioral	Barrier, et al. (1989). Measurement of post-operative pain and narcotic administration in infants using a new clinical scoring system. Intensive Care Medicine, 15, S37-39. Schade et al. (1996). Comparison of three preverbal scales for postoperative pain assessment in a diverse pediatric setting. Journal of Pain Symptom Management, 12, 348-39.
BPS Behavioral Pain Scale	Infants and toddlers	Behavioral	Robieux et al. (1991). Assessing pain and analgesia with a lidocaine-prilocaine emulsion in infants and toddlers during venipuncture. Journal of Pediatrics, 118, 971-973.
EDIN Scale Echelle Douleur Inconfort Nouveau-Ne, neonatal pain and discomfort scale)	Preterm infants 25-36 weeks gestation	Behavioral	Debillon et al. (2001). Development and initial validation of the EDIN scale, a new tool for assessing prolonged pain in preterm infants. Archives of Disease in Childhood Fetal Neonatal Ed., 85: F36-41.
CDSVN Clinical Distress Scale for Ventilated Newborns	Preterm and Full Term infants	Multidimensional (Physiological changes are not scored)	Sparshott, M. (1996). The development of a clinical distress scale for ventilated newborn infants: Identification of pain and distress based on validated behavioural scores. Journal of Neonatal Nursing, 2(2), 5-11.
NFCS Neonatal Facial Coding System	Preterm (32 weeks), full term and infants 2-4 months of age.	Behavioral	Grunau, R. & Craig, K. (1987). Pain expression in neonates: facial action and cry. Pain, 28(3), 395-410. Grunau, et al. (1998). Bedside application of the Neonatal Facial Coding System in pain assessment of premature neonates. Pain, 76(3), 277-286.
PAIN Pain Assessment in Neonates)	Preterm and Full term infants 26-47 weeks	Multidimensional	Hudson-Barr et al (2002). Validation of the Pain Assessment in Neonates (PAIN) Scale with the Neonatal Infant Pain Scale. Neonatal Network, 21(6), 15-21.

APPENDIX C
SUGGESTED GUIDELINES FOR MANAGEMENT OF PROCEDURAL PAIN

THE TABLE BELOW IDENTIFIES A VARIETY OF CHOICES FOR MANAGEMENT OF PROCEDURAL PAIN. COLLABORATION WITH OTHER HEALTH CARE PROVIDERS IS USUALLY NECESSARY TO DETERMINE THE MOST APPROPRIATE PROCEDURAL PAIN MANAGEMENT METHODS.

PROCEDURE	DEVELOPMENTALLY SUPPORTIVE CARE	EMLA	ORAL SUCROSE WITH PACIFIER	OPIOIDS	SKIN-TO-SKIN CONTACT, BREASTFEEDING, ROCKING, HOLDING	LOCAL ANESTHESIA (LIDOCAINE INFILTRATION)	GENERAL ANESTHESIA
Heel stick	√		√		√ (if possible)		
Venipuncture	√	√	√				
IM/SQ injections	√		√				
Percutaneous venous catheter Insertion/Venipuncture	√	√	√	√			
Peripheral Arterial Line Placement/Arterial Puncture	√	√	√			√	
Central Venous Line Placement	√	√	√	√		√	√
Umbilical Catheter Placement	√		√				
Lumbar Puncture	√	√	√			√	
Peripheral Arterial or Venous Cutdown	√	√	√	√*		√	
Peripherally Inserted Central Catheter	√	√	√	√*			

Consider opioid administration if IV access available

Containment not possible; utilize careful handling.

Note: Adapted from (Anand, et al. (2001). Consensus statement for the prevention and management of pain in the newborn. Archives Pediatric Adolsescent Medicine, 155(2), 173-80)