Infant Pain Management

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Abstract

Emphasis on infant pain management has recently become prominent in the medical field. Though it was once thought that infants do not feel pain or remember pain, this thinking has changed due to recent research on the subject. This research has found that infants' underdeveloped nervous systems actually leads to increased pain rather than decreased pain as previously thought. Research has also found that there are long-term developmental risks associated with prolonged or unmanaged pain in infancy. However, this has not been applied to clinical practice. Studies show that infants are still being under-medicated, if medicated at all, for painful or invasive procedures. Infants in the neonatal intensive care unit are at a high-risk for complications related to unmanaged pain because of the frequency and abundance of invasive procedures performed on this unit. Reasons for this include lack of physician education on this subject, risk for adverse effects with opioid administration, and lack of adequate pain assessment tools for infants. There are some interventions that can be implemented to improve pain management in infants, which include non-pharmacological methods and educating medical staff on this subject.

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Infant Pain Management

Pain management for infants is a much debated topic in the medical field. New research has recently brought about a change in how infants' perception of pain is viewed. In the past, it was thought that infants had an underdeveloped nervous system and, therefore, did not feel pain as acutely as adults. It was also thought that infants did not remember pain, so it did not have an effect on them. However, recent research has shown the contrary. Infants do feel pain as adults do and may actually feel it more acutely. Also, some research has shown that prolonged pain in infants can affect their development. Though this research is well documented and accessible, a change in clinical practice has not occured. Studies have shown that infants are still under-medicated for invasive procedures. The most susceptible population is infants in the neonatal intensive care unit. There are numerous amounts of invasive procedures that these infants must undergo daily. Unfortunately, many of them are not properly medicated, and, therefore, are at a high risk for developmental complications associated with prolonged pain. There are many reasons for this, including ineffective pain assessment. Because infants are nonverbal, pain assessment and management is not as easy as it is with adults. Infants cannot verbalize when they are in pain, so healthcare professionals must be proactive about watching the infant for signs of pain. Another reason has to do with a lack of knowledge or research on this subject. Because infant pain is a recent concept, little research has been conducted in this area. There is still much to learn about infant pain management and more research needs to be conducted on this subject. However, the rapid development of infants makes it challenging to gather a control group that is the same gestational age in order to conduct a reliable study. Also, the lack of knowledge in the area of how infants exhibit pain has led to inadequate pain assessment tools that are not congruent with each other. This further complicates the research process, since there are several

different ways of evaluating pain and therapeutic interventions, making comparing results with other research findings a challenge (Walker & Howard, 2002). Lack of research has led to a lack in the education of healthcare professionals. This combined with other complications such as ineffective pain assessment tools and adverse effects of pain medications have led to a deficit in the area of infant pain management.

Pathophysiology of Pain

Pain arises from the stimulation of sensory nerves in the tissues. The mode of transmission for pain is through the central nervous system. There are two divisions within this system, which are the parasympathetic and sympathetic nervous systems. The parasympathetic nervous system is responsible for resting and digesting, while the sympathetic is responsible for the fight or flight response. When tissue damage occurs, a transmission is sent through these nerves, to nerves in the spinal cord, and then to nerves in the brain that interpret the sensation as painful.

The brain then stimulates the sympathetic nervous system resulting in physiological responses such an increased heart rate and respirations, epinephrine release, and other systemic responses. Pressure and extreme heat or cold can also stimulate the transmission through these nerves and the sympathetic nervous system. However, each individual is different regarding how much stimulation is needed before the transmission is sent. This is called the pain threshold. In the past, it was thought that this system was not yet developed in infants and, therefore, they could not experience pain acutely. It was believed that infants did not feel pain the same way adults do, nor did they remember the pain. Because of this, many physicians did not see the need to medicate infants before procedures or manage their pain in the same way they would for an adult patient. However, recent research has shown that this is not the case. In fact, the thalamus, which is the part of the brain responsible for the perception of pain, is developed

by 20 to 24-weeks gestation, and researchers can now see that at 24-weeks gestation, infants physically respond to painful stimuli (Hatfield, 2008). There are several different types of pain an infant can experience. These include acute pain caused by invasive procedures such as heel sticks, established pain caused by inflammation, or prolonged pain caused by nerve damage, osteomyelitis, or necrotizing enterocolitis (Anand, 2007). Because there are many different types and causes of pain that have different effects developmentally, it is important that it is evaluated thoroughly and treated individually.

Effects of Pain on the Central Nervous System

Much research has been conducted on infants' pain, and it is found that they not only feel pain acutely, but that prolonged pain may have an impact on their development. When pain occurs, it stimulates the sympathetic nervous system. This causes an increase in heart rate and respirations, bronchodilation, and a shunting of blood away from the gastrointestinal system to the core of the body. It also causes a release of hormones such as epinephrine, cortisol and aldosterone. These hormones cause an increase in blood pressure and blood glucose levels, vasoconstriction, and decrease the function of the immune system. Any of these symptoms if experienced for long periods of time can cause damage to the body and its systems. Because cortisol suppresses the immune system, prolonged pain and, therefore, prolonged high levels of cortisol can predispose the infant to infections and delay healing in the body (Ponder, 2002).

Also, in order for a stimulus to be transmitted from nerve to nerve, there needs to be enough action potential or energy for the information to be passed on. In order to speed up the transmission of information, nerves develop a coat of protein called a myelin sheath. Also, sensory nerves are surrounded by myelin, which increases the speed of transmission. In infants, these nerves have not developed the myelin sheath, which causes transmission through the

nerves to be slower and actually leads to their feeling pain more intensely than adults (Sayed, 2007).

Other sensory systems such as sight or hearing develop as they are stimulated; however, the pain system develops normally when it is not stimulated. Prolonged, excessive stimulation can lead to abnormal development of the structure of the system and can cause increased sensitivity (Anand, 2007). A study performed during the first week of life of rat babies revealed that the organization of the nerves can actually be altered by prolonged inflammation during this time. Nerves are connected to the spinal cord in a specific way that correlate with each part of the body; however, based on this research, nerve damage or constant inflammation can alter this organization (Walker & Howard, 2002). An alteration in this organization can lead to a plethora of chronic problems including hyperalgesia. The neonatal intensive care unit has a lot of sensory stimulation. There are lots of lights, assessments, and procedures conducted. The infant is constantly being touched and handled, which stimulates the nervous system. Because the nervous system is already stimulated, when the infant then experiences pain or true discomfort, the nervous system responds hyperactively (Cignacco et al., 2008). This is evidenced by an increased withdrawal of the limbs seen in infants who have had repeated heel sticks. Repeated pain causes hyperalgesia, which is oversensitivity to pain. Hyperalgesia causes a decrease in the threshold of pain, which causes the infant to withdraw its limb (Walker & Howard, 2002).

During the neonatal period, the inhibitory pathways of the sensory system are still developing. Because of this, prolonged pain or inflammation can have developmental effects that are not seen in adults. People who experience prolonged, unmanaged pain as infants perceive pain more acutely as adults. For example, infant males who underwent circumcision without any pain interventions responded more acutely to the pain of immunizations compared

with those who had received analgesia or who did not undergo circumcision (Walker & Howard, 2002). This increased sensitivity to pain is due to the disruption of the development of the inhibitory pathways caused by pain during their infancy (Ponder, 2002). Descending inhibitory fibers are nerves that descend from the brain stem through the nervous system. They develop with age and function to inhibit the pain stimulus from transmitting up through the nerves to the brain. Because these nerve fibers develop with age, the younger the infant, the lower the pain threshold. This is due to the fact that the descending fibers have not fully developed. For example, a term infant would have a higher pain threshold in the hand compared to the foot. This is because the descending inhibitory pathways have developed in the upper part of the body and as a result function to dampen or decrease the stimulus sent to the brain. Conversely, in the lower part of the body, they are not as developed. The infant would have a lower pain threshold in the foot because there would be no inhibitory pathways to stop or dampen the stimulus (Anand, 2007). This is revealed in a study done on 40 infants who came in for their monthly immunizations at 2 months and again at 4 months of age. This study revealed that when the infants came in for their immunizations at 4 months of age, their pain scores were lower than at 2 months of age and they had less of a behavioral responses to the pain. The descending neural pathway that inhibits the transmission of the ascending pain sensation has not completely developed in these younger infants causing an increased perception and behavioral exhibition of pain (Hatfield, 2008).

Effects of Pain on the Brain

During infancy the brain is rapidly developing. It is making synaptic connections, producing white matter, which is responsible for the transmission of messages, and increasing in capillaries that carry blood to the brain. Because chronic pain can inhibit this development this

means that there is less capillary blood flow to the brain, less white matter to transmit messages and less synaptic connections are made. There have also been other differences in the brain structure when comparing preterm infants to full term infants. This includes a smaller hippocampal region and smaller cortical and subcortical regions. Children who were born preterm were shown to have an overall smaller brain volume at age seven than children who were born full term. The reasons for these changes have not been directly linked to pain; yet other factors such as perinatal risk factors or sociodemographics did not cause these abnormalities. This leads to speculation that it could very well arise from the abundance of procedures and pain that preterm infants experience. Repeated pain can not only affect the development of the organization of the sensory nerve system but can also affect the infant's ability to regulate stress related hormones. Two of these hormones are cortisol and adrenocorticotropic hormone. Both of these hormones are released in accordance with stress in the body. Premature infants who were born before 28 weeks gestation were found to release decreased amounts of cortisol and adrenocorticotropic hormones in response to stressors in the body caused by procedures and nursing care in the neonatal intensive care unit or NICU. Conversely, they were found to have elevated base levels of cortisol after they were discharged from the NICU. Premature infants are the majority of the population in the NICU and receive a higher number of painful, invasive procedures. Because the development of the brain is affected by hormones and more specifically by stress hormones, an increase in these, which occurs with pain, can cause an alteration in this development (Grunau, Holsti, & Peters, 2006). Also, infants are smaller in size and, therefore, there is less distance for the transmission of pain to travel. This too supports the belief that infants feel pain more acutely than adults (Melhuish & Payne, 2006). The body has several acute reactions to pain that occur because of the sympathetic

nervous system stimulation. One reaction to pain that occurs in infants and adults alike is an increased heart rate and increased respirations (Saniski, 2005). The invasiveness of the procedure directly correlates with an infant's heart rate, oxygen saturation, mean arterial pressure, and behavior; the more painful the procedure, the higher these values go (Porter, Wolf, & Miller, 1999). Increased respirations cause a decrease is oxygen saturation because shallow rapid breaths do not oxygenate the blood as well, and increased heart rate leads to increased mean arterial blood pressure. Therefore, one can infer that infants are, in fact, feeling pain during these procedures.

Ineffective Pain Management

Despite these facts, effective pain management is not always manifest in clinical practice. Recent surveys show that infants are still being under-medicated for invasive procedures. Several studies have been conducted comparing nurses' and physicians' views on infant pain to their actual assessments and interventions for infants' pain. These studies have all found a discourse between the two (Reyes, 2003). Most nurses and physicians say that they believe infant's feel pain as adults do or even more so than adults do, but they also believe that infants are often under-medicated for procedures and are often inadequately assessed for pain. This belief holds true when charting is reviewed. Assessments of pain are not consistent or frequent. Many nurses do not document many pain assessments throughout the shift, nor do they document follow up pain assessments after analgesic administration. This implies that the nurses are not routinely assessing for infant pain, and they are also not assessing the efficacy of their pain management interventions (Reyes). Interestingly, nurses stated that they often disagree with the physician's assessment of infant pain. They believe that physicians tend to underestimate the amount of pain the infant is feeling, and when compared, nurses consistently rate certain

procedures as more painful than the physicians do. Nurses also express that there is difficulty in obtaining orders for pharmacological interventions for pain in infants from physicians. This could be due to the fact that physicians underestimate infant pain or to the physician's fear of the adverse effects of analgesics in infants (Reyes). This reveals the need for educating healthcare professionals, especially physicians who are not constantly at the bed side, about the manifestations of pain in infants.

Inadequate pain assessment leads to inadequate pain management, which has also been revealed in recent research. A study conducted in 102 neonatal intensive care units revealed that of infants who receive endotracheal intubation in the neonatal intensive care unit, only 43% are premedicated before intubation (Sarker, Schumacher, Baumgart, & Donn, 2006). Only 58% of infants received analgesia before a lumbar puncture and only 44% receive it before a heel lancing (Lago et al, 2005). However, in the adult or even pediatric population, adequate analgesia is given before these procedures (Rouzan, 2001). On average in the NICU, neonatal intensive care unit, infants undergo about 12-15 invasive, painful procedures per day. However, it is estimated that infants are only premedicated for about 31% of these procedures, despite that fact that most procedures were rated at moderate to severe pain (Anand, 2007). Therefore, many factors contribute to the lack of pain management in infants, including lack of education of healthcare workers about how infants express pain, fear of adverse effects of pharmacological pain management, and inability to adequately assess infant's pain.

Lack of Education

There are many reasons why infants are still under-medicated despite research findings indicating their need for pain management. First, many older physicians were not educated on infant pain management when they were going through school. Because only recently has the

thinking changed about how infants perceive pain, many physicians have a lack of understanding about this issue. This lack of a good understanding of the development and pathophysiology of pain in infants has led physicians to under-estimate infants' pain and under- medicate them during procedures (Anand, 2007). Also, infants react very similarly to pain, distress and stimuli that make them uncomfortable. Because of this, many healthcare providers attribute their behavior to the distress or discomfort of the procedure rather than to the pain (Melhuish & Payne, 2006).

Physicians that do understand the necessity of infant pain management, however, do not always implement it in clinical practice. Research shows that there is a gap between the beliefs of doctors and nurses about pain management and their actual clinical practice. Though nurses say that they believe infants experience pain acutely, they are often inconsistent with their pain assessments. As gestational age increases, however, the frequency and consistency of pain assessments by nurses also increases (Reyes, 2003). Most physicians and nurses will agree that infants feel pain as adults do and that a need for analgesics is present, yet when questioned about how often analgesics are used, the answer is minimally (Porter, Wolf, Gold, Lotsoff, & Miller, 1997). Getting the procedure over with quickly is not a substitute for pain relief yet one study revealed that this is the motivation behind not giving analgesics. Topical analgesics are used more with older toddlers and children and much less with infants unless ordered by the anesthetist or doctor. This implies that nurses believe that infants do not feel as much pain as older children (Melhuish & Payne). Because infants are nonverbal and exhibit pain in non-specific ways, educating healthcare providers about different signs of pain is critical. Pain assessment is not the only category where more education is needed. Interventions for pain is another category where much research has been conducted and revealed new data. Education

about pharmacological as well as non-pharmacological interventions for pain and their adverse effects in infants is another area where healthcare professionals need to be educated. Because of this, there is a need for seminars and improved training to healthcare professionals about infant pain and new ways to manage it.

Inadequate Pain Assessment Tools

Another reason that infants are often under-medicated has to do with inadequate pain assessment tools. Because infants cannot verbalize their pain, it is often hard to judge the intensity of it. Adults have a parallel relationship between the intensity of their pain and the physiological response in their body. This means that the more intense the pain, the more the sympathetic nervous system is stimulated. This leads to an increased physiological response such as an increased heart rate, respiratory rate, restlessness, urinary retention, and others. Because infants respond physiologically to discomfort and other stimuli, they do not necessarily have a clear parallel relationship with pain. Infants may have a physiological response such as crying or restlessness because they are hungry or have a wet diaper. Also, very young infants actually have an opposite physiological response to pain and become flaccid. Coupled with the fact that they cannot verbalize their pain, this makes evaluation of pain difficult (Porter, Wolf, & Miller, 2009). No single tool can be used across the board for evaluating pain in infants, and many of the assessment tools used vary based on the observers' interpretation (Melhuish & Payne, 2006). For example, a tool often used is the PIPP, which stands for "premature infant pain profile".

Table V – Premature Infant Pain Profile (PIPP)

Indicators	0	1	2	3
GA in weeks	≥ 36 weeks	32 to 35 weeks and 6 days	28 to 31 weeks and 6 days	< 28 weeks
Observe the NB for 15sec				
Alertness	Active Awake Opened eyes Facial movements present	Quiet Awake Opened eyes No facial movements	Active Sleep Closed eyes Facial movements present	Quiet Sleeping Closed eyes No facial movements
Record HR and SpO_2				
Maximal HR	↑ 0 to 4 bpm	↑ 5 to 14 bpm	↑ 15 to 24 bpm	↑ ≥ 25 bpm
Minimal Saturation	↓ 0 to 2.4%	↓ 2.5 to 4.9%	↓ 5 to 7.4%	↓ ≥ 7.5%
Observe NB for 30 sec				
Frowned forehead	Absent	Minimal	Moderate	Maximal
Eyes squeezed	Absent	Minimal	Moderate	Maximal
Nasolabial furrow	Absent	Minimal	Moderate	Maximal

Absent is defined as 0 to 9% of the observation time; minimal, 10% to 39% of the time; moderate, 40% to 69% of the time; and maximal as 70% or more of the observation time. In this scale, scores vary from zero to 21 points. Scores equal or lower than 6 indicate absence of pain or minimal pain; scores above 12 indicate the presence of moderate to severe pain.
GA – Gestational Age. NB – Newborn.

(Stevens et. al, 1996)

This tool evaluates pain based on seven variables: gestational age, eye squeeze, behavior state, nasolabial furrow, heart rate, oxygen saturation, and brow bulge (Hockenberry, 2009). Each of these categories is rated on a scale of 0-3, depending on the intensity of the symptoms the infant exhibited. Yet, this tool has been shown to underestimate the severity of pain. One study compared pain assessment using the PIPP to pain assessment using cortical hemodynamic activity. Heel pricks were performed on twelve infants, and their pain was assessed using these two different methods. It was found that the measurement of pain intensity using the PIPP and the more accurate measurement of cortical hemodynamic activity varied significantly. Corticol hemodynamic activity refers to the blood flow in the cortical portion of the brain. When this portion is more active, pressure and blood flow increase in this area. Comparing the pain scale to this activity revealed a conflict. The pain scale was lower than the hemodynamic activity in the brain, implying that this scale underestimates the amount of pain. Therefore, it can be concluded that the PIPP is not the most reliable tool for estimating pain. It does not accurately measure the intensity of the pain and may be preventing infants from receiving adequate pain

management (Stretton, 2009). Another pain assessment tool is the CRIES, which rates pain based on crying, oxygen requirement, increased vital signs, expressions, and sleeplessness.

DATE/TIME						
Crying - Characteristic cry of pain is high pitched. 0 – No cry or cry that is not high-pitched 1 - Cry high pitched but baby is easily consolable 2 - Cry high pitched but baby is inconsolable						
Requires O_2 for SaO_2 < 95% - Babies experiencing pain manifest decreased oxygenation. Consider other causes of hypoxemia, e.g., oversedation, atelectasis, pneumothorax) 0 – No oxygen required 1 – < 30% oxygen required 2 – > 30% oxygen required						
Increased vital signs (BP* and HR*) - Take BP last as this may awaken child making other assessments difficult **0** – Both HR and BP unchanged or less than baseline **1** – HR or BP increased but increase in < 20% of baseline **2** – HR or BP is increased > 20% over baseline.						
Expression - The facial expression most often associated with pain is a grimace. A grimace may be characterized by brow lowering, eyes squeezed shut, deepening naso-labial furrow, or open lips and mouth. **0** – No grimace present **1** – Grimace alone is present **2** – Grimace and non-cry vocalization grunt is present						
Sleepless - Scored based upon the infant's state during the hour preceding this recorded score. 0 – Child has been continuously asleep 1 – Child has awakened at frequent intervals **2** – Child has been awake constantly						
TOTAL SCORE						

(Krechel et.al, 1995).

Yet, this scale may not be as accurate because of compensation in the body. Especially with prolonged pain, the body will adjust and vital signs may return to normal even though the patient is still in pain (Saniski, 2005). With prolonged pain, a decrease in behavioral response to pain occurs. This means that the infant can be in pain, but its heart rate and respirations may not increase (Anand, 2007). Also, infants' hemodynamic activity can change with activity, crying, and awaking from sleep, so one cannot rely solely on these numbers to judge pain in an infant (Leef, 2006). No current tool has been validated for use in evaluating long-term pain. Also, many tools fail to factor in development and gestational age, which play a major role in determining how in an infant responds to pain (Fellman, 2007). For example, an older infant will respond to pain with crying, thrashing around, and grimacing; however, a premature infant

may respond to pain by becoming limp (Walker & Howard, 2002). Premature infants often have underdeveloped motor responses that attribute to their flaccid response to pain and lack of behavioral responses to pain, such as crying or grimacing (Stretton). The FLACC pain scale evaluates pain based on the appearance of the baby such as crying, grimacing, or jerky movements.

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	Scoring		
Categories	**0**	**1**	**2**
Face	No particular expression or smile	Occasional grimace or frown, withdrawn, disinterested	Frequent to constant frown, quivering chin, clenched jaw
Legs	Normal position or relaxed	Uneasy, restless, tense	Kicking or legs drawn up
Activity	Lying quietly, normal position, moves easily	Squirming, shifting back and forth, tense	Arched, rigid, or jerking
Cry	No cry (awake or asleep)	Moans or whimpers; occasional complaint	Crying steadily, screams or sobs, frequent complaints
Consolability	Content, relaxed	Reassured by occasional touching, hugging, or being talked to; distractible	Difficult to console or comfort

Note: Each of the five categories Face (F), Legs (L), Activity (A), Cry (C), and Consolability (C) is scored from 0-2, which results in a total score between 0 and 10.

From Merkel, Voepel-Lewis, Shayevitz, & Malviya (1997). The FLACC: A behavioral scale for scoring postoperative pain in young children. *Pediatric Nursing, 23*(3) 293-297.

Source: Pediatr Nurs © 2003 Jannetti Publications, Inc.

However, these manifestations not only change with gestational age, but do not always occur because the infant is in pain. They may just be associated with increased distress or stimulation. Infants cry when they are uncomfortable, hungry, have wet their diaper or have reasons other than pain. Infants who are experiencing no pain to mild pain may actually cry at a higher pitch and more intensely than those who are in moderate to severe pain (Fuller, 2001).

Overcoming the weaknesses in infant pain assessment is very difficult because the assessment tools are affected by the subjectivity of the nurse and the surrounding environment and stimuli (Davidson, London, & Ladwig, 2008). Because of this, one pain assessment tool is not sufficient for estimating an infant's pain, but it must be combined with other assessment tools

and clinical information (Fuller, 2001). Fuller suggests a new way of appraising pain based on the likelihood of pain rather than waiting until signs of distress are manifested. This tool takes into account clinical data as well as the infant's response to the interventions. There are six steps to this model. The first step is assessing the infant for signs of distress. In order to do this, the nurse must be knowledgeable about how infants express pain and must conduct frequent pain assessments. The second step is thinking about what could be causing the distress. To do this the nurse must look at clinical data found in the infant's chart, which is also the third step. The nurse must apply the clinical data relating to the infant to the infant behavior in order to judge the cause accurately. The fourth step is implementing comfort interventions. These could be pharmacological or non-pharmacological, depending on the physician's orders and resources available to the nurse. The fifth step involves evaluating how easily the infant is consoled and, finally, assessing the infants' pain (Reyes, 2003). These last two steps are important in determining the efficacy of certain interventions and learning more about pain manifestation in infants. According to this model, the nurse would still assess for signs of distress in the infant, but the nurse should also be looking at the clinical data to determine the likelihood of this infant to experience pain. For example, the nurse would look at the infant's chart for factors such as the diagnosis, any surgeries or procedures the infant has undergone, when the infant was last fed, or medications prescribed, etc. If the infant has just undergone surgery, the nurse would determine that any abnormal activity by the infant would arise from pain and administer pain medication. However, if the infant has not been fed recently or has not undergone any procedures that would increase the likelihood of pain, then the nurse may try other interventions before administering pain medications. The nurse also evaluates the effectiveness of any interventions to determine how easy the infant was to console and whether the intervention was

successful at doing this. Because infants cannot verbalize their pain, consolability can be key in determining whether an intervention was successful. One particular study conducted revealed that nurses consistently rated an infant's pain lower when they did not have access to clinical data than when they had access to this information (Fuller). Therefore, this is an important piece to an adequate pain assessment tool. The tool must look at the entire clinical picture in order to assess the cause of an infant's behavioral responses accurately.

Opioid Use

In addition to lack of education and inadequate assessment tools, the third reason infants are often under medicated is that many physicians are reluctant to use pain medications or opoids such as morphine because of their adverse effects on infants. Physicians often use a risks/benefits assessment to decide what treatment is best for the patient. With every procedure there are going to be risks; however, if the benefit of the treatment outweighs the risks involved, the physicians will recommend that treatment or procedure. If the risks outweigh the benefits, the physician will often refrain from recommending or implementing that treatment despite the fact that it could help or benefit the patient. Because such a small margin of error exists with infants, often times the physicians believe that the risks of opioid administration outweigh the benefits. Due to infants' low body weights and underdeveloped body systems, the side effects of opiods, such as hypotension and decreased respirations, can quickly become a problem (Anand, 2007).

Determining what a safe dosage would be for an infant can be difficult because changes in metabolism and fluid shifts occur early on in infancy. An infant's body fat composition, protein plasma, renal function, and hepatic function all change quite rapidly during the first couple weeks of an infant's life. These are all factors that interfere with the metabolism of a

drug, which is how much of the drug stays in the infant's body and how strong of an effect the drug has. This makes dosing drugs for infants a challenging and tedious process (Walker & Howard, 2002).

Dosing for morphine is based on tolerance rather than a ceiling dose. A ceiling dose is the maximum dose of a drug that can be given without the risk for harmful effects outweighing its benefits. Because morphine does not have a ceiling dose, administration is based on the tolerance of the patient. The more tolerance a patient has to morphine, the higher the dose that must be administered to get the same analgesic effects. This also leads to an increase in the risk of withdrawal symptoms. This is why long-term treatment with morphine is not recommended. The longer a patient is on morphine, the more tolerance the patient will build up to this drug. Balancing the amount of morphine needed to obtain an analgesic effect with the risk for increased tolerance and withdrawal is challenging with infants due to their changing body composition and small, less developed systems. Because of this, many physicians fear legal issues that could arise from opoid administration to infants (Belleini & Buonocore, 2008). However, a study conducted on infants who had mechanical ventilation showed that although morphine prolonged an infant's time on the ventilator, it did not have significant effects on the infant's blood pressure or respiratory rate (Sayed, 2007). Another study called the NEOPAIN or neurologic outcomes and pre-emptive analgesia in neonates trial compared the amount of negative neurological side effects of two groups of infants on ventilators (Anand, 2007). One group received morphine while on the ventilator, but the other did not. No significant differences were found in the amount of negative neurological outcomes between the two groups. Still, the infants who received the morphine did exhibit respiratory depression that kept them on a ventilator for one day longer than those who do not receive morphine. Also, the

morphine slowed gastrointestinal activity, causing a decrease in the amount of feedings the infants were able to tolerate (Anand, 2007).

Fentanyl is another opioid that can be used for pain management. Yet, the current problem with Fentanyl is that the lowest dose that is able to be administered is 12.5 micrograms per hour. This is quite a large dose for infants, especially because it is more potent than morphine, and there is an increased risk for withdrawal and tolerance with Fentanyl as compared to morphine (Anand, 2007).

There are a few drugs, however, that do not have the same risks for tolerance and withdrawal but still provide analgesia. These drugs can actually be given with morphine and other analgesics to block the body from developing a tolerance to them. Ketamine is an example of this kind of drug. Ketamine is not only an analgesic, but it is a sedative that results in amnesia as well. An analgesic inhibits the perception of pain in the body, but a sedative decreases the level of consciousness by decreasing the functioning of the central nervous system. Because of its method of action the body does not develop a tolerance to Ketamine, and it does not cause respiratory depression or hypotension. Ketamine actually causes muscle tone to increase, thereby steadying the body's blood pressure and respiratory function (Anand, 2007).

There are also some topical analgesics such as EMLA, which can be applied to the area before a procedure. This cream has very few side effects; however, it is more often used in older children than infants. In some facilities EMLA is contraindicated for infants under ten months, though research shows that the cream is safe for infants (Melhuish & Payne, 2006). A study conducted with infants revealed that infants who were circumcised without anesthesia exhibited increased pain behaviors when receiving their immunizations at four and six months of age. However, when EMLA cream was applied, the pain behaviors exhibited were decreased

(Grunau, Holsti, & Peters, 2006). Pharmacological intervention can not only greatly decrease pain in infants, but it can also decrease the harmful effects that repeated or prolonged pain can cause.

Non-Pharmacological Methods of Pain Management

Because the adverse effects of pain medications are more prominent in infants, non-pharmacological methods are preferred to manage pain if possible. These methods are also preferable because a physician's order is not needed to implement them. This means that nurses can intervene with these measures any time they think that the infant is in pain or before they are going to do a procedure that could cause pain (Kashininia, Sajedi, Rahgozar, & Noghabi, 2008). Non-pharmacological interventions would include methods such as giving an infant a pacifier with sugar on the tip or using distraction techniques during a procedure.

Giving a 24% oral sucrose solution to infants pre-procedurally reduces their response to pain and shortens the time it takes their sympathetic nervous system, which is stimulated by pain, to return to normal. Oral sucrose works by stimulating the release of endogenous opioids in the infant's brain. In addition to stimulating endogenous opioids, the use of a pacifier stimulates the moro reflex or the sucking reflex. This type of sucking, which does not occur during breastfeeding or in the presence of a bottle, is called non-nutritive sucking. Non-nutritive sucking is a comfort measure for infants and helps to calm them (Hatfield, 2008). A study conducted on infants undergoing circumcision revealed that oral sucrose is a satisfactory substitute for a dorsal penile nerve block (Leef, 2006). The study assessed the difference in heart rate and oxygen saturation between a group of infants that received a dorsal penile nerve block and a group of infants that received oral sucrose during the procedure. This study revealed that the only significant difference in heart rate occurred during the clamping of the foreskin. During

this time, the group that received a dorsal penile nerve block had a lower heart rate and higher oxygen saturation that the group that received the oral sucrose. However, in every other part of the procedure, there were no significant differences in the two groups. Because of this, oral sucrose could be used as a non-pharmacological intervention for pain management in circumcision. In fact, infants who receive oral sucrose before a heel stick cried 50% less than those who do not. Nevertheless, oral sucrose did not have a significant effect on infants receiving three injections. This reveals that oral sucrose is successful for mild acute pain but it is not strong enough to overcome moderate or repeated acute pain. Also, especially in preterm infants, giving repeated doses of oral sucrose can actually be more harmful than helpful. The risk exists of causing the infant's blood sugar to increase significantly resulting in hyperglycemia and a shift in fluid in the body. A study conducted evaluating the development of infants for their gestational age revealed that infants who received repeated doses of oral sucrose were behind in development of motor skills and alertness (Leef). Because of this, pharmacological methods of pain management are necessary as well (Hatfield).

Also, topical analgesics such as EMLA are available that can be applied to the area before a procedure. This cream has a few side effects including blistering of the skin or a burning sensation, but these symptoms are rare. Still, it is more often used in older children than infants. In some facilities is contraindicated for infants less than 10 months, though research shows that the cream is safe for infants (Melhuish & Payne, 2006).

Another method of non-pharmacological interventions for pain is kangaroo care. Kangaroo care consists of holding the infant against the mothers' bare chest with her clothes wrapped around the infant during an invasive procedure. A study was done on healthy infants to find out the effect of kangaroo care on infants response to the pain of an intramuscular vitamin K

injection. This study revealed that infants who are held in the kangaroo position for ten minutes before they received the injection and while the injection was being given had less pain than those who received no intervention. This was determined by observing around an eighty percent decrease in the amount of behavioral responses to pain, such as grimacing or crying (Kashininia et al., 2008).

Other non-pharmacological interventions include swaddling the infant in a blanket and distracting the infant by stimulating the infant's other sensory systems with music or a visual distractor. These interventions, however, are only effective for mild pain and discomfort. Simple interventions such as these have been shown to decrease pain perception in infants (Hockenberry, 2009). They do not carry with them the risk for adverse effects that pharmacological interventions have, yet they reduce the adverse effects that pain can have on an infant. These interventions are especially useful for mild pain such as heel sticks. Heel sticks are a frequent procedure that without pain intervention can negatively affect the infant simply due to the frequency of repeated pain. In this situation, non-pharmacological interventions can be very effective in diminishing these negative consequences. As with any pain interventions, however, assessment is an important piece to its efficacy. Not every infant responds to kangaroo care or swaddling. The nurse must assess the infants after these interventions to determine whether it was effective and which interventions are preferable.

Conclusion

Much work needs to be done in order to improve the pain management of infants in the hospital. The problems that are causing ineffective pain management may not be able to be righted overnight; yet, there are ways that it can be improved in clinical practice. Because it has only recently been suggested that infants do, in fact, feel pain and maybe more acutely than

adults, education of physicians and nurses is necessary. Also, because infants are not able to express their pain verbally, educating healthcare professionals about the signs of pain in infants is important as well. Seminars focusing on these issues could be implemented to increase knowledge on this subject. Written guidelines that outline protocol for pain assessments and interventions can also be helpful in improving pain management in infants. Research has found that with written protocols for pain management, infants were twelve times more likely to receive adequate assessments and interventions. Also, written guidelines decrease the subjectivity that comes with pain assessments made by nurses and physicians (Lago et al., 2005). The problem with inadequate assessment tools is not an easy issue to fix. Because infants are non-verbal there is no way to know exactly what kind of pain they are feeling and when they are feeling it. Still, there are some interventions that can be implemented quickly, such as the many non-pharmacological methods that can be used to manage pain. These interventions can be used for minor to moderate pain that is repeated frequently, such as heel sticks. There are many other factors that contribute to the under-medication of infants, including the adverse effects of opioids. This argument, however, does not take into account the developmental and psychological effects that occur when pain is not managed in infants. These developmental effects, research is finding, may, in fact, be worse than the side effects of pain medications. The fear of adverse effects has led to nurses' expressing their difficulties in obtaining orders for pharmacological interventions for pain from physicians. This is even more motivation for education of nurses and physicians about infant pain and interventions. Nurses are to be an advocate for their patients and a liaison between the patient and the physician. The nurse that has a good understanding of infant pain and interventions will be more effective in obtaining orders for pain management in the infant as well as assessing and intervening for infant pain

(Reyes, 2003). Effective pain management in infants is not just a scientific issue, but it is an ethical issue. Effective pain assessment and management in infants directly correlates to the quality of care they are given, and healthcare professionals are committed to the welfare of their patients. They are entrusted to heal and not harm, so this issue of pain management is significant for those in this profession (Rouzan, 2001). The medical field has come a long way when it comes to pain management in infants; however, there is still much improvement to be done and infants are still not receiving the pain medication they need.

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