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Assessment of neonatal pain: uni- and multidimensional evaluation scales

Review

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Abstract: Neonatal pain is a problem that is easily overlooked. According to the status quo of neonatal pain management, commonly 9 scales are used for evaluation of neonatal pain; details of the specific indicators, such as the applicable neonatal gestational age range, score, and the type of pain, for the domestic references are provided so as to provide reference for the proper evaluation and standardized management of neonatal pain, as well as to promote the management level of neonatal pain.

Keywords: *neonatal care • neonatal pain • neonatal pain assessment scales • pain assessment tools • pain management • review*

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1. Introduction

In modern medical science, clinical workers pay more attention to the patients' pain management. However, there are few research and practical experience in neonatal pain management; therefore, this study focuses on the question of how to assess neonatal pain and summarizes various types of neonatal pain assessment scales for evaluating different types of pain.

1.1. Adverse consequences of neonatal pain

Neonatal pain is a problem that need to be mentioned and studied. Newborns can feel and respond to painful stimuli. Preterm infants are even more hypersensitive to pain, which may lead to long-term structural and functional changes in pain pathways.[1] Previous studies have shown that newborns during their stay in the hospital need to experience pain stimulus-related operations ranging from dozens to hundreds of times.[2–4] Moreover, infants' brains showed the same level of response as adults' brain in functional magnetic resonance imaging (fMRI).[5]

Uncontrolled repeated pain episodes may have a negative effect on neonates: in the short term, it may cause physiological and behavioral changes, and in the long term, it may affect the normal development of the brain, leading to problems of emotion, behavior, and learning disabilities at later stages.[1,6–10] Therefore, timely assessment and intervention are very important for neonatal pain management. However, unlike children, newborns do not have the ability to actively express

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pain, so we can only judge the presence and degree of pain by observing the corresponding pain assessment indicators.

1.2. Classification of neonatal pain

Clinically, neonatal pain is generally divided into the following types: acute pain, procedural pain (refers to the pain caused by invasive procedures, which are commonly observed in heel stick, vein puncture, subcutaneous injection, etc.), and prolonged pain (refers to the pain that lasts for a few hours or a few days, caused by pulmonary hyaline membrane disease with assisted ventilation, early stage of necrotizing enterocolitis, arterioductal atresia, etc. , which are often neglected in long-term treatment,[11] especially for neonatal patients who cannot express their real feelings). Postoperative pain, that is, pain that lasts for a long time after surgery. These types of pain may be co-existing, especially for premature infants, who are more susceptible to various pain factors, leading to frequent pain. Therefore, how to distinguish and intervene pain in time is very important.

2. Dimensions of pain assessment

Because an important characteristic of newborns is their inability to communicate, medical professionals can only assess pain through observation. Dimensions of pain assessment mainly include physiological indicators, such as heart rate (HR), blood pressure (BP), respiratory rate (RR), oxygen saturation fluctuation, vagal tone changes, palm sweating, plasma cortisol and catecholamine, and concentration changes; behavioral indicators such as facial expression changes, physical activity, and crying[12]; and auxiliary evaluation indicators, such as gestational age at birth, health status, neonatal maturity degree, and behavioral status.[13–15]

The purpose of neonatal pain assessment is to accurately identify pain occurring in neonates under various conditions and also to evaluate the effectiveness of analgesic measures. Therefore, a scale is necessary for the accuracy of assessment. At the same time, it is better for the scale to have a defined threshold value to distinguish whether pain is present or not, as well as to identify the pain level, mild, moderate, and severe pain, which is more convenience in clinical use.

3. Several common neonatal pain assessment scales

Some pain assessment tools (PAT) have been developed for neonatal pain assessment. Points of the assessment scales may differ because characteristics of different types of pain are different in clinical manifestations, for instance, acute or procedural pain may show changes in breathing, HR, and facial expression significantly, but the physical manifestation of prolonged pain may show a tendency of inhibition in all major organ systems,[16] such as apathetic facial expression, decreased HR, slower breathing, and the assessment is more likely confounded by other factors, resulting in inaccurate assessment. The clinical manifestations of different types of pain are not consistent, so the evaluation indexes selected for the corresponding pain scales are also different. In clinical practice, we need to understand the evaluation criteria and applicable scope of different scales and flexibly choose appropriate scales to use. Several common clinically available neonatal pain assessment scales are listed in Table 1.

3.1. Premature Infant Pain Profile Scale/ Premature Infant Pain Profile-revised Scale (PIPP/PIPP-R)

The PIPP/PIPP-R scale is suitable for the evaluation of procedural pain and postoperative pain, and its total score is between 0 and 18 points for term infants and between 0 and 21 points for premature infants <28 weeks of gestational age. For all gestational age neonates, ≤6 suggests no or mild pain, a score of ≥7 indicates pain, a total score > 12 indicates middle or severe pain because there are some other factors that may affect the newborn's response to pain, such as more mature babies, with higher gestational age, and are more active in responding to pain after birth, so gestational age at birth is also included for assessment in the scale. During the evaluation, the status of the baby will also affect the score. When the baby is awake and active, it has the strongest response to pain, so the status of the baby is also included in the score as an influencing factor.[17,18] In the evaluation of this scale, the difference in pain response between premature infants and full-term infants is taken into account, so the range of scores is not consistent, and there are differences in the degree of pain assessment, including no or slight pain, mild pain, moderate pain, and severe pain, which is more clinically practical.

3.2. Neonatal Pain, Agitation, and Sedation Scale (N-PASS Scale)

The N-PASS scale is used to assess acute and prolonged pain and sedation. It has 5 assessment dimensions and 2 assessment components: pain/agitation and sedation. The pain/agitation score was between 0 and 10,

Assessment tool	Physiological indications	Behavioral indications	Gestational age tested	Threshold value	Types of pain tested
PIPP/PIPP-R Scale	HR and oxygen saturation	Brow bulge, eye squeeze, and nasolabial furrow	PIPP is suitable for 28–40 weeks of gestational age; PIPP-R is suitable for gestational age for 25–41 weeks	Score: 0–18 (full-term); 0–21 (preterm). ≥7 points indicate pain; >12 points indicate moderate to severe pain	Procedural pain Postoperative pain
N-PASS Scale	HR, RR, BP, and SaO_2	Crying/irritability, behavior state, facial expression, and extremity tone	Preterm and term infants	Score: 0–10. >3 points indicate pain; -10 to -5 indicate deep sedation; -5 to -2 denote mild sedation	Acute pain, prolonged pain, and sedation
NFCS	None	Brow bulge, eye squeeze, nasolabial furrow, open lips, stretch mouth (vertical), stretch mouth (horizontal), lip purse, taut tongue, and chin quiver	Preterm and term infants	Score: 0–9 (full-term); 0–10 (preterm). >3 points indicate pain	Procedural pain
EDIN Scale	None	Facial activity, body movements, quality of sleep, quality of contact with nurses, and consolability	Preterm infants of gestational age 25–36 weeks	Score: 0–15. ≥7 points indicate pain	Prolonged pain
CRIES Scale	Increased Vital Signs (HR and BP), oxygen saturation	Crying, facial expression, sleeplessness	Term infants and preterm infants of gestational age ≥32 weeks	Score: 0–10. ≥4 points indicate pain	Postoperative pain
COMFORT neo Scale	None	Alertness, calmness/ agitation, respiratory response (in mechanically ventilated children), crying (in spontaneously breathing children), body movement, facial tension, and (body) muscle tone (observation only)	Preterm infants	Score: 6–30. ≥14 indicate pain; ≤8 indicates the risk of excessive sedation	Prolonged pain
COVERS Scale	HR, BP, respiration, and oxygen requirement	Crying, expression, resting, and signaling distress	Preterm and term infants	Scale: 0–12. ≥7 points indicate pain	Procedural pain
PAIN Scale	O_2 required for Sat >95%, HR, and breathing pattern	Facial expression, cry, extremity movement, and state of arousal	Preterm and term infants (gestational age with 26–47 weeks)	Score: 0–10. ≥4 points indicate pain	Postoperative pain and procedural pain
NIPS Scale	Breathing patterns	Facial expression, cry, arms, legs, and state of arousal	Preterm and term infants (gestational age with 26–47 weeks)	Score: 0–7. ≥4 points indicate pain	Procedural pain

Notes: HR, heart rate; BP, blood pressure; CRIES scale, crying, requires increased oxygen administration, increased vital signs, Expression, Sleeplessness Scale; EDIN scale, Echelledela Douleur Inconfort Nouveau-ne' (Neonatal Pain and Discomfort Scale); NIPS scale, Neonatal Infant Pain Scale; NFCS, Neonatal Facial Coding System; N-PASS Scale, Neonatal Pain, Agitation, and Sedation Scale; PAIN Scale, PAIN Assessment in Neonates Scale; PIPP/PIPP-R Scale, Premature Infant Pain Profile Scale/Premature Infant Pain Profile-revised Scale; RR, respiratory rate.

Table 1. Summary of neonatal pain assessment scales.

and the sedation score was between –10 and 0. When scoring, the scale also included the gestational age of the newborn, and the younger the gestational age, the higher the score. As newborns with small gestational age have less obvious response to pain, this factor is used to adjust the score. Some neonates will use sedatives, such as newborns with mechanical ventilation as the appropriate level of sedation can promote oxygen supply and reduce complications of ventilation. The evaluation of sedation is helpful for us to know whether there is excessive sedation in neonates. A score of –5 to –2 is mild sedation, and a score of –10 to –5 is deep sedation. This score can help us determine whether the newborn has a problem with excessive sedation and, if so, may indicate the need for adjustment of treatment. For special situations, such as infants with ventilatory

support, deep sedation may be permitted. There may be a negative score for analgesic/sedative use, but a negative score without these medicines may be due to the preterm infant's response to prolonged pain, or the effects of neural inhibition, sepsis, or other medical conditions. For the assessment of pain/agitation, a score of >3 indicates obvious pain and requires intervention, and the intervention goal is ≤3, but it should be noted that if a procedure is known to cause pain, intervention measures can be taken in advance to prevent or relieve pain.[19] The scale takes into account pain/agitation and sedation, and the degree of sedation is classified as mild and deep sedation. If the score is >3, there may be obvious pain. If the score is negative, it may be sedation or prolonged pain. Therefore, it needs to be identified according to the actual situation in clinical application.

3.3. Neonatal Facial Coding System (NFCS) Scale

The NFCS is a unidimensional scale used to assess procedural pain, that is, specific changes in facial expression, such as brow bulge, eye squeeze, and open lips, are judged to be stress responses to painful stimuli. However, there are some limitations in the evaluation of this scale because the facial coding system requires a long period of professional training, so it is not convenient for clinical use. It was also mentioned in the study that there was a difference in pain response between neonates in different states, that is, whether they were asleep or awake, but this was not included in the scale. The total score of the NFCS was 0–9 for term infants and 0–10 for preterm infants, and >3 indicated pain.[20] This scale involves a single dimension, and it is subjective in the judgment of facial expression changes and requires a long time of training, so it is not convenient to use.

3.4. Echelledela Douleur Inconfort Nouveau-ne' (Neonatal Pain and Discomfort Scale) (EDIN scale)

The EDIN scale is a tool designed to assess prolonged pain in premature infants. The EDIN scale requires a long observation time during the evaluation, and the comprehensive judgment and score should be calculated after 8 h of observation. There are 5 dimensions with behavioral indicators, 0–3 points for each, and 0–15 points for the total score, and ≥7 indicated pain. The reason why the scale does not include physiological indicators is that the change of physiological indicators is usually an acute stress response, which is not suitable for the assessment of prolonged pain. This scale has certain limitations. First, the evaluator must be a ward nurse who has frequent contact with the neonate and is familiar with the neonate, and it requires a long observation time. At the same time, the evaluator needs to interact with the neonate, which may lead to nonobjective assessment results, and the evaluator is limited, so it is not convenient to use. Another problem is that newborns with hypoxic brain injury cannot be evaluated because they do not interact well and affect the evaluation results. And prolonged pain is sometimes overlooked clinically, such as abdominal distension caused by enteral nutrition and nasal continuous positive airway pressure caused by nasal injury. If assessment is not routine, or may be ignored, neonates cannot get timely and effective treatment, so it is recommended that for neonates who may be at risk for prolonged pain, at least regular assessments 1–2 times a day is necessary.[11] The evaluation of this scale requires a long observation time, and there are limitations on evaluators and evaluation content. Nurses who are familiar with the neonates are required to evaluate and observe them for a long time, which makes it inconvenient to use the scale, and interaction may lead to less objective evaluation results. In addition, this is not applicable to neonates with poor interaction such as cerebral hypoxia.

3.5. Crying, requires increased oxygen administration, increased vital signs, Expression, Sleeplessness Scale (CRIES scale)

The CRIES scale is used to assess postoperative pain in neonates, but cannot be used for intubation or paralysis. Crying is one of the behavioral indicators, and infants with small gestational age may need intubation for mechanical ventilation after birth and cannot cry. Therefore, the scale is suitable for infants with a gestational age ≥32 weeks at birth. The scale contains 5 dimensions, 0–2 points for each dimension and 0–10 points for the total score. When pain was identified, the score averaged 4 points, suggesting interventions were needed when a score ≥4 points. The study was aimed at postoperative pain, so the recommended evaluation time was at least once every hour after surgery, depending on the duration of the disease lasting from 24 h to 72 h.[21] The limitation of this scale is that it cannot be used to evaluate intubated or paralyzed infants due to their inability to cry.

3.6. COMFORTneo scale

The COMFORTneo scale was used to assess prolonged pain in preterm infants and contained 7 dimensions with an overall score of 6–30. Studies have shown

that scores of 14 and above may require appropriate interventions. The gestational age, birth weight, and diseases at risk of nerve damage, such as perinatal asphyxia and intraventricular hemorrhage, should be considered in the specific operation, which may affect the response to pain or the implementation of analgesic measures. Prolonged pain may result from surgery, inflammation, skin burns, birth injuries, or prolonged mechanical ventilation. Interventions, especially medications, also need to be evaluated regularly to avoid excessive sedation. Considering that there may be excessive sedation during sedative use, NICU use of the COMFORTneo scale indicates that dosage reduction may be considered when the score is ≤8, but a low score during quiet sleep at night generally does not require dosage change.[22] However, if the deep sleep exceeds 12 h, gradual reduction of medication dose should be considered.[23] It takes 2 h of training to proficiently use the scale for evaluation. Neonates need to be observed 2 min before the evaluation and evaluated regularly after the intervention. The scale takes into account the differences between intubation and spontaneous breathing in neonates, and the risk of excessive sedation when the score is too low, which requires nursing staff to timely identify and cooperate with doctors to intervene. The scale can be skillfully used within 2 h of training, which is relatively convenient.

3.7. COVERS Neonatal Pain Scale

The COVERS scale is a multidimensional scale used to assess procedural pain in premature and term infants. It contains 6 dimensions, including physiological indicators and behavioral indicators, with a total score of 0–12. When the painful procedure was performed, the mean score for all neonates is about 7, and ≥7 indicates pain for all gestational age. It has a wider range of evaluation objects. For example, it can assess the pain of patients who are intubated because they cannot cry. For these neonates, crying is judged by recognizable crying expressions, which has good clinical practicability. In general, the COVERS scale can be used to evaluate premature infants, very low–birth weight infants, intubated neonates, and neonates in the postoperative recovery period, with a wide range of application.[24] The scale can be used to assess pain in intubated infants and is more widely used than the CRIES scale.

3.8. PAIN Assessment in Neonates Scale (PAIN Scale)

The PAIN scale is used to measure postoperative pain and procedural pain for preterm and full-term newborns, which includes 7 dimensions, including physiological and behavioral indicators, with a score of 0–10 points, where a score of 4 points or higher indicates pain. During evaluation, the nurse was required to observe the neonate for 2 min before evaluation, but whether the observation time was too short needs further discussion. In addition, attention should also be paid to when pain assessment should be carried out. Assessment should be performed before 30–60 min of pain events for the neonates, but in the actual process, the assessment time may be delayed, which will affect the accuracy of the assessment results.[25] For this scale, the nurse is required to observe the neonate for 2 min before the evaluation, and the infant is evaluated within 30–60 min after experiencing pain events. However, there may be problems of short observation time and timely evaluation. Therefore, appropriate extension of observation time and standardized evaluation time can be considered, such as evaluation twice a day after surgery or evaluation immediately after pain-causing operation.

3.9. Neonatal Infant Pain Scale (NIPS scale)

The NIPS scale is used to measure pain in premature and full-term neonates. It is a single-dimension scale, excluding physiological indicators, with 6 dimensions and a total score of 0–7. When the total score is ≥4, pain is indicated. It can also be used for neonates on mechanical ventilation. Like the COVERS scale, crying expressions will be scored.[26] The evaluation index of this scale is a single dimension and does not include physiological indicators, which may have some limitations. However, like the COVERS scale, it can also be used for infants with mechanical ventilation.

4. Discussion

4.1. Characteristics of different types of scales

In this article, 9 different neonatal pain assessment scales were summarized. The pain types applicable for the assessment included acute pain, procedural pain, prolonged pain, and postoperative pain. The assessment includes preterm and term neonates. The evaluation indexes include physiological indications and behavioral indications. Many of these scales have the threshold value of pain score, which has practical significance. The PIPP/PIPP-R scale and N-PASS scale included the adjustment items. The PIPP/PIPP-R scale took into account the gestational age and the status of the newborn at the time

of evaluation, such as small gestational age and in the sleep state during evaluation of the newborn with higher scores. The N-PASS scale also took gestational age into account. These factors will affect the pain response of neonates, resulting in deviation of evaluation results; therefore, it needs to be appropriately adjusted.

According to the table, some scales contain only behavioral indications For example, the physiological manifestations of prolonged pain may show a tendency of inhibition, such as expressionless face, decreased HR, and weakened respiratory changes, which are not suitable for direct correlation with pain. Therefore, some prolonged pain assessment scales do not include physiological indicators. It is debatable whether multidimensional or unidimensional items are better included in the scale when assessing neonatal pain. One study has shown that in an evaluation of procedural pain caused by vitamin K injection in newborns, 2 unidimensional scales (NFCS and behavioral indicators of infant pain [BIIP] scale,[27] which only contained behavioral indicators) and a multidimensional scale (PIPP scale) were used simultaneously to evaluate the pain response to vitamin K injection in newborns, and the results showed that in 80% of the neonates, the pain response could be detected using the NFCS, while only 70% of the neonates' pain response could be detected using the PIPP scale.[28] Therefore, further consideration and evaluation are needed when choosing a suitable scale.

4.2. Other neonatal PAT

In addition to using scales for neonatal pain assessment, there are many other methods, such as HR variability analysis,[29] electroencephalogram (EEG) detection,[30] functional magnetic resonance imaging,[31] near-infrared spectroscopy,[32] and other new assessment methods. These methods have the advantage of automation and labor-saving and also limitations. For example, it is difficult to take into account other factors that influence neonatal pain response. In future, it can be considered to combine with the scale to find a better way to evaluate neonatal clinical pain. Furthermore, there are many other neonatal pain assessment scales, including Pain Assessment Tool (PAT) scale,[33] Scale for Use in Newborns (SUN),[34] and Bernese Pain Scale for Neonates (BPSN).[35] They can also be used to measure neonatal pain, and more neonatal pain assessment scales can be better interpreted in future studies.

4.3. Suggestion

This article summarized the progress of 9 common neonatal pain assessment scales, and they can be used to evaluate acute pain, postoperative pain, procedural pain, persistent pain, etc. They are applicable for premature or term infants. In clinical use, nurses should understand the applicable scope of the common pain assessment scales, to form a set of suitable pain assessment programs, such as for different pain types, and choose one of the most suitable scales. In the process of assessment, appropriate improvement should be made, such as the timing of assessment, and assessment methods should be adjusted to form a set of neonatal pain assessment systems suitable for their own departments. At present, there have been relevant research in China, such as LAN's Neonatal Pain Assessment Scale for the assessment of acute pain in neonates on mechanical ventilation,[36] the development and research of neonatal facial expression pain scale,[37] and the localization and reliability and validity evaluation of the N-PASS scale,[38] but they are far from enough. Researchers can also adapt and apply more locally applicable pain assessment scales to gradually promote the development of neonatal pain management in China.

5. Conclusions

At present, the existing pain assessment scales have both advantages and disadvantages. We can carry out clinical research and actively adapt them to our department when using different scales in Chinese. On the other hand, we also need to actively carry out training on neonatal pain-related assessment scale for clinical pediatric medical staff so as to promote the development of neonatal pain management.

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Ethical approval

Ethical approval are not needed for this study.

Conflicts of interest

There is no conflicts of interest.

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