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Assessment of Acute Pediatric Pain

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Abstract

Accurate assessment of acute pediatric pain can help dispel myths that children's experience of pain is less severe than that of adults, aid medical staff and clinicians in accurately diagnosing and treating children's pain, and allow researchers to investigate pain and its correlates. A range of measures have been developed to quantify children's acute pain. In general, these assessment tools are either self-report, behavioral observation, or physiological. Although there are a number of psychometrically sound instruments in each of these areas, there continues to be room for improvement.

Assessment of Acute Pediatric Pain

Valid and reliable assessment is the lifeblood of science; research findings are dependent on the quality of the measures. Given the subjective and personal nature of pain, quantifying the experience is a challenge. Measuring children’s pain introduces a host of additional difficulties, such as immature language or cognitive abilities to clearly verbalize the experience. To properly assess pediatric pain, many factors must be considered. For example, the human pain system may react differently to similar types of tissue damage based on both physiological (e.g., location of tissue damage; Craig & Grunau, 1993) and psychological factors (McGrath & Gillespie, 2001) such as thoughts, emotions, attention, beliefs, and previous experiences (Cohen et al., 2008). Other potential factors that affect children’s pain reaction include sex, age, developmental level, contextual factors, and family background (McGrath & Gillespie). In short, the accurate assessment of pediatric pain is a complex endeavor.

Despite the barriers, an arsenal of instruments has been developed in pediatric acute pain assessment. These tools have allowed researchers and clinicians to demonstrate that children experience and remember acute pain, to accurately diagnose and treat painful conditions and situations, and to open up other lines of scientific inquiry (e.g., parent-child interactions during pediatric painful events). Pediatric acute pain assessment can be categorized by the respondent or method of measurement.

Self-report Scales

Visual Analogue Scales

Visual analogue scales (VAS’s) are a commonly used self-report measure of acute pediatric pain. VAS’s measure pain using a visual continuum. For example, patients might be presented with a VAS that consists of a 100 mm horizontal line anchored by the terms “extreme pain" and "no pain" on either end and they are instructed make a hash mark on the line that best represents their pain experience. In addition to VAS's, other visual assessment aids including vertical lines, numbers, and depictions of thermometers have been employed (for a review, see McGrath & Gillespie, 2001). Given the abstract nature of these scales, they are typically recommended for use with children at least eight years of age and older. Advantages of VAS's are that they are easily administered, inexpensive, and produce ratio data (Stinson, 2006). Research suggests that children's self-report VAS scores correlate with parents' reports (Luffy & Grove, 2003; Varni, Thompson, & Hanson, 1987) and medical staff's ratings (Gragg et al., 1996). VAS's have also correlated with a number of other pain scales including faces pain measures (Hunfeld, van der Wouden, den Deurwaarder, van Suijlekom-Smit, & Hazebroek-Kampshreur, 1997), the Oucher (Aradine, Beyer, & Thompson, 1988), the Eland Color Scale (Guariso et al., 1990), and the COMFORT Scale (van Dijk et al., 2000). Positive associations have also been found between disease status indices and VAS ratings in children with arthritis (Schanberg, Keefe, Lefebvre, Kredich, & Gill, 1998; Scott, Ansell, & Huskinsson, 1977) and also between VAS ratings and children with post-operative pain (Beyer & Aradine, 1987). Another benefit of VAS, is that scores have been found to fluctuate following the use of analgesics (Romsing, Moller-Sonnergaard, Hertel, & Rasmussen, 1996) and behavioral pain management interventions (Powers, Blount, Bachanas, Cotter, & Swan, 1993), supporting its ability to detect variations in pain.

Faces Scales

Another category of pediatric pain self-report measures that is specifically geared to younger children is faces scales. With these scales, the pediatric patient is presented with a series of faces varying in the expressions of pain. The child is instructed to select the face that best represents the experience of pain. Faces scales are considered developmentally suitable for children as young as 3 years of age (Beyer, 1984; Wong & Baker, 1988), in part because they lack abstract numerical values and sophisticated wording (Cohen et al., 2008). Analyses have revealed a positive relation between children's pain ratings and that of parents and medical staff, such that as children choose faces representing more intense levels of pain, parent and staff observer-ratings increase (Chambers, Giesbrecht, Craig, Bennett, & Huntsman, 1999). Additionally, a similar association between children's pain faces ratings and other self-report measures (Spafford, von Baeyer, & Hicks, 2002) and behavioral pain measures (Maclaren & Cohen, 2006) has been observed. Also, these scales are responsive to changes in pain associated with both analgesia use and behavioral interventions (Gold, Hyeon Kim, Kant, Joseph, & Rizzo, 2006; Spafford et al.). One potential drawback associated with these measures includes their potential to influence children based on subtle differences (e.g., having a smiling versus neutral "no pain" face; Chambers et al.). Differences such as the inclusion of tears on the faces can influence children's ratings of their own pain. Another drawback is that they yield ordinal data. Three commonly used faces scales include the Oucher (Beyer, 1984), the Wong-Baker Faces Scale (Wong & Baker, 1988), and the Faces Pain Scale-Revised (FPS-R; Hicks, von Baeyer, Spafford, van Korlaar, & Goodenough, 2001). The Oucher uses photographs of Caucasian, Black, and Hispanic children. Both the Wong-Baker Faces Scale and the FPS-R provide ethnically ambiguous line drawings. Although the Wong-Baker Faces Scale and the Oucher assign numerical values to each face, McGrath (1987) reported that faces scales containing numerical values may be confusing due to the simultaneous use of both facial expressions and numbers in describing pain intensity.

Concrete Scales

Another form of child-pain assessment involves counting of simple objects (e.g., poker chips, marbles) in quantities that correspond to either greater pain (e.g., more chips) or less pain (e.g., fewer chips). Benefits of these measures include ease of use and multicultural applicability (Gharaibeh & Abu-Saad, 2002; Suraseranivongse et al., 2005). These measures are recommended as assessment tools for children three to four years old (Stinson et al., 2006). One example of such a measure is the Poker Chip Tool (Hester, 1979; Hester, Foster, & Kristensen, 1990), comprised of four red chips representing “pieces of hurt.” One chip indicates “a little hurt” and all four chips indicate “the most hurt a child could have.” This measure exhibits positive correlations with self-report, word descriptor, and faces scales measures as well as behavioral observations (Gharaibeh & Abu-Saad). Pain rating correlations between children and parents and children and medical staff have been moderately significant (for a review, see Cohen et al., 2008).

Interviews

Structured and semistructured interviews provide an excellent addition to any battery of pain assessment measures because they can provide information on a variety of dimensions of pain including severity, location, frequency, and persistence as well as provide information on contextual issues by which pain may be indirectly impacted (McGrath & Gillespie, 2001). Another benefit of interviews is their flexibility; the examiner has the opportunity to design questions based on specific patient variables and then modify those questions as necessary. Two examples of pain assessment interviews are the Abu-Saad Pediatric Pain Assessment Tool (PPAT; Abu-Saad et al., 1990) and the Adolescent Pediatric Pain Tool (APPT; Savedra et al., 1989; Tesler et al., 1991).

The PPAT is used to evaluate pain among school-age children. It is comprised of thirty word descriptors including emotional expressiveness, sensory, and assessment properties of pain. This measure utilizes a 10 cm scale to record current pain intensity. The PPAT has been used effectively across different cultures (Abu-Saad, 1984; Gharaibeh & Abu-Saad, 2002) and has yielded satisfactory reliability scores. This measure has been shown to be a valid tool in assessing variations in pain levels among children receiving pre- and post-analgesia (Abu-Saad, Pool, & Tulkens, 1994). Also, pain rating correlations among child, parent, and medical staff have been shown to be significant (Abu-Saad, 1994). However, scores of pain intensity appear to vary according to specific pain populations (e.g., cancer, post-operative).

Similarly, the APPT is used to assess post-operative pain in children 8–17 years old. It contains three parts: a body outline including an overlay grid of 43 areas, a 100-mm line serving as a word-graphic intensity scale with pain intensity increasing from left to right, and a list of 67 pain descriptive adjectives. Psychometric qualities of this measure include adequate validity (Savedra, Tesler, Holzemer, & Ward, 1989), test-retest reliability (Wilkie et al., 1990), as well as construct validity between child report and medical chart (Savedra, Tesler, Holzemer, Wilkie, & Ward, 1990; Savedra et al.). Also, the three components of this measure have been translated into Spanish (Van Cleve, Muñoz, Bossert, & Savedra, 2001).

Observational scales

Child pain may also be assessed using behavior observation scales. Observation scales focus on pain by observing its concomitants, such as emotional expressions of pain (e.g., fear, anxiety). Typically, these scales are constructed by identifying, operationally defining, and coding relevant behaviors of interest. A coder can subsequently watch a pediatric procedure and indicate the presence or absence of the behavioral codes, which can later be quantified. One benefit of behavioral scales is that they include coding of adult (e.g., parent, nurse) behaviors that might be related to children's acute pain. Behavioral observation measures are especially useful for measuring pain in young preverbal children and children with cognitive impairments (von Baeyer & Spagrud, 2007). Although it is arguably best to create observational scales depending on the particular questions of interest (Cohen, Bernard, Greco, & McClellan, 2002), some scales have been used across populations and procedures and will be discussed.

Observational Measures of Pediatric Procedural Pain and Distress

Existing behavioral observation measures have been developed for specific environments. Three example measures created to assess acute pediatric pain and distress during medical procedures are the Observational Scale of Behavioral Distress (OSBD; Jay, Ozolins, Elliott, & Caldwell, 1983), the Child-Adult Medical Procedure Interaction Scale (CAMPIS; Blount et al., 1989) and the COMFORT Scale (Ambuel, Hamlett, Marx, & Blumer, 1992).

The Observational Scale of Behavioral Distress (OSBD; Jay et al. 1983) originally included eleven behaviors but was eventually reduced to eight (i.e., cry, scream, physical restraint, verbal resistance, seeks emotional support, information seeking, verbal pain, and flail) in the revised version (OSBD-R; Elliot, Jay, & Woody, 1987). The OSBD/OSBD-R employs 1-4 point distress weighting scales for each behavior (e.g., cry). The OSBD and OSBD-R typically rely on coding via intervals (e.g., 15-second) in which a behavior is marked as either present or absent during each interval over the phases of the medical procedure. Once completed, a total score is produced by summing the number of occurring behaviors in each phase. This measure has exhibited good internal consistency scores (Elliot et al., 1987).

Similar to the OSBD, the Child-Adult Medical Procedure Interaction Scale (CAMPIS Blount et al., 1989; CAMPIS-R Blount et al., 1997) was developed to code specific behavioral indicats of child distress. In addition, the CAMPIS included codes reflecting child coping and parent and staff behavior. Based on conceptual and correlational findings, the behavioral codes were grouped into larger categories: Child Coping, Child Distress, Adult Coping Promoting, Adult Distress Promoting, and Neutral for each participant. Significant correlational data has been used to corroborate the concurrent validity of the CAMPIS-R (Blount et al., 1997). These include parent report, medical staff report, child self-report, and observational measures gathered prior to, during, and following the procedures.

The COMFORT Scale (Ambuel et al. 1992) has been used in pediatric intensive care units for children and young adults up to eighteen years old (Carnevale & Razack, 2002; Ista, van Dijk, Tibboel, & de Hoog, 2005). It includes eight areas of behavior that receive 1-5 intensity scores. These behavior areas are alertness, calmness/agitation, respiratory response, physical movement, mean arterial blood pressure, heart rate, muscle tone, and facial tension. Both inter-rater reliability (Ambuel et al., 1992) and validity for this measure have been substantiated (van Dijk et al., 2000).

Observational Measures of Pediatric Post-Operative Pain

Three examples of scales designed to assess pediatric post-operative pain are the Children's Hospital of Eastern Ontario Pain Scale (CHEOPS; McGrath et al., 1985), the Parent's Post-operative Pain Measure (PPPM; Chambers et al., 1996), and the Nursing Assessment of Pain Intensity (NAPI; Stevens, 1990. CHEOPS was originally developed to assess pediatric post-operative pain but has also been used with acute pain procedures. It is comprised of six behavioral domains including cry, facial, child, verbal, torso, touch, legs, and a scale of 0-3 to be used to gauge domain intensity. This measure has exhibited strong inter-rater reliability among post-operative children between one and five years old (McGrath, de Veber, & Hearn, 1985).

CHEOPS is also correlated with child self-report of needle injection pain and appears responsive to pain fluctuation in patients receiving pharmacological interventions.

Another post-operative pain measure designed specifically to obtain observational data from parents is the Parent's Post-operative Pain Measure (PPPM; Chambers, Reid, MCGrath, & Finley, 1996) which contains 15 behavioral items such as "Whine or complain more than usual," "Groan or moan less than usual," "Eat less than usual," and "Hold the sore part of his or her body." This measure is ideal for use with post-operative children 2-12 years old and includes specific time-of-day information gathering guidelines. A study by Chambers, Finley, McGrath, and Walsh (2003) supported the use of the PPPM as a reliable and valid measure of pediatric post-operative pain.

A pediatric post-operative pain measure created particularly for nurses' pain ratings of children is the Nursing Assessment of Pain Intensity (NAPI; Stevens, 1990). This scale contains scores from 0 to 3 used to rate observed body movement, facial expression, vocal/verbal behavior, and touching of the wound site. Interrater agreements and discriminate validity for this measure have been supported (Joyce et al., 1994).

Physiological Measures of Pediatric Pain

Assessment of pediatric pain via physiological measures is a burgeoning area. As with behavioral observation measures, these measures are especially helpful when working with nonverbal individuals (e.g., infants, cognitively impaired). These measures can also provide important and complex information regarding children's levels of pain and distress not captured by behavioral and self-report measures. Physiological measures include heart rate, respiratory rate, skin blood flow, palmar sweating, blood pressure, intracranial pressure, vagal tone, oxygen saturation, transcutaneous oxygen and carbon dioxide tension, cortisol levels and concentration of endorphins (Anders, Sachar, Kream, Roffwarg, & Hellman, 1971; Campos, 1991; Finley & McGrath, 1998; Gunner, Isensee, & Fust, 1987; Harpin & Rutter, 1982, 1983; Jay et al., 1983; Johnston & Strada, 1986; Katz et al., 1982; Owens & Todt, 1984; Porter & Porges, 1991; Szfelbein, Osgood, Atchison, & Carr, 1987). To date there appears to be no conclusive evidence that any one of these measures is superior to the others. One limitation of physiological measures is that they may be affected by other stimuli in the environment (e.g., temperature, emotional stress). Another complaint of this category of measures is that they are not well-established measures of pain assessment and lack specificity and sensitivity (van Dijk et al., 2001; von Baeyer & Spagrud, 2007). The examples of physiological measures discussed here are categorized according to their method of pain assessment: simple, complex, and biochemical.

Simple Physiological Measures

Physiological measures that are readily assessed by simple monitoring include heart and respiration rate. Heart rate is defined as the rate of heart beats per minute and can be measured at various pulse points over the body (e.g., palpation method) and respiratory rate can be measured by the number of inhalations within a specified amount of time. Numerous studies indicate that heart often increases as pain is experienced (Craig & Grunau, 1993; Megel, Houser, & Gleaves, 1998; Owens & Todt, 1984; Rawlings, Miller, & Engel, 1980; van Dijk et al., 2001) In a study by van Dijk et al. (2001) evaluating the relation between the COMFORT scale and physiological measures including heart rate, heart rate variability, mean arterial pressure, and mean arterial pressure variability, correlations among the COMFORT and all four physiological measures were significant. However, findings on respiratory rate have been equivocal. Craig and Grunau (1993) concluded that respiratory rate decreased in association to pain whereas Howard, Howard, and Weitzman (1994) found that it increased.

Complex Physiological Measures

Alternative physiological measures of pain may be optimal when more simplistic measures are potentially affected by variables such as illness, medication, or extreme distress. Some of these measures include skin blood flow, palmar sweating, blood pressure, intracranial pressure, vagal tone, oxygen saturation and transcutaneous oxygen and carbon dioxide tension. Some of these measures involve equipment requiring specialized training before use.

Skin blood flow is assessed using a laser Doppler technique which involves a probe attached to the abdomen (Sweet & McGrath, 1998). A study by McCulloch, Ji, and Raju (1995) found that skin blood flow increased as pain was experienced. The authors also concluded that skin blood flow exhibited greater changes than heart rate, respiratory rate, and oxygen saturation. Skin blood flow also appears to be sensitive to analgesics (McCulloch,1995; Moustogiannis Raju, Roohey, &McCullough, 1996). In more recent research, skin blood flow measures were used to assess blood flow impairment in adults suffering from diabetic neuropathy (Fromy et al., 2002).

Another physiological occurrence related to pain is palmar sweating. This involves excessive sweating of the hands and can be measured using an evaporimeter. Various studies have indicated an increase in palmar sweating associated with increases pain (Harpin and Rutter, 1982; Stevens, Johnston, & Grunau, 1995). Harpin and Rutter (1982) investigated the development of sweating due to heel pricks in infants and found that newborns older than 36 weeks exhibited palmar sweating in association with pain. Also, Schwartz and Jeffries (1990) discovered a positive association between variations in palmar sweating and heart rate and a negative association with respiratory rate and oxygen saturation.

Blood pressure is also used to gauge pain in children. Blood pressure describes the force with which blood presses against the artery walls. It can be measured a number of ways but is most often assessed using a sphygmomanometer. Research indicates that systolic and diastolic blood pressures increase when pain is experienced (Durand, Sangha, Cabal, Hoppenbrouwers, & Hodgman, 1989; Megel et al. 1998; Stevens et al., 1995). Specifically, a study by Megel, Houser, and Gleaves (1998), which investigated the effects of audiotaped lullabies on physiological and behavioral distress associated with pain during routine immunizations, found that regardless of whether the children were exposed to the music, they exhibited a significant rise in blood pressure following the immunizations. Although this study did not support the researchers' initial hypothesis, it was successful in illustrating the correlation between procedure pain in infants and increased blood pressure.

Another type of physiological measure, intracranial pressure, is more difficult to measure than blood pressure, in that it involves specialized equipment and training. Pressure is assessed using a Ladd monitor and that pressure appears to increase as pain occurs (Durand et al., 1989; Stevens et al., 1995). A study by Johnston, Stevens, Yang, & Horton (1995) investigated differential reactions to either actual or sham heel sticks and reported significant correlations among maximum heart rate, heart rate standard deviation, oxygen saturation, and intracranial pressure. This corroborates the use of intracranial pressure as a measure of infant pain.

Another physiological measure used to assess pain in children is vagal tone which results from the vagus nerve causing inhibition on the heartbeat. Vagal tone is measured using respiratory sinus arrhythmia, defined as the fluctuation in heart rate during a respiratory cycle. When under stress, vagal tone will typically decrease, meaning there is less variablity in heart rate during a respiratory cycle. An electrocardiogram may be used to assess vagal tone. Gunnar, Porter, Wolf, Rigatuso, and Larson (1995) found that neonates vagal tone decreased as a reaction to a heel stick and Arditi, Feldman, and Eidelman (2006) reported a significant drop in vagal tone during infants' heel pricks, which coincided with increased heart rate.

Measurements of oxygen saturation provide the percentage of hemoglobin containing oxygen at a specific time and may also be used to gauge pediatric pain (Maxwell, Yaster, Wetzel, & Niebyl, 1987). This information is easily obtained using a pulse oximeter. Previous research indicates that decreases in oxygen saturation typically occurs during a painful experience (Bennini, Johnston, Faucher, & Aranda, 1993; Holsti, Grunau, Oberlander, Whitfeld, & Weinberg, 2005; Maxwell et al.). Specifically, a study by Holsti, Grunau, Oberlander, Whitfeld, and Weinberg investigating body movements associated with pain among preterm infants found that infants' oxygen saturation diminished as brow bulge and heart rate intensified during a heel lance/squeeze. Also, a study by Johnston et al. (1995) found significant correlations among decreased oxygen saturation, maximum heart rate, heart rate standard deviation, and intracranial pressure.

Two physiological pain assessment techniques requiring measurement using a transcutaneous oxygen electrode include the measurement of transcutaneous oxygen ($tcPO_2$) and of carbon dioxide ($tcPCO_2$) tensions. First, an electrode is placed on the body. After placement, it increases in heat to heighten the flow of blood at which time gases pass through the electrode. Findings suggest that $tcPO_2$ decreases during painful experiences (Porter, Miller, Cole, & Marshall, 1991; Rawlings, Miller, & Engel, 1980). In their study investigating the possible advantages of using lidocaine to decrease physiological problems associated with acute illness in neonates undergoing medical procedures, Porter et al. discovered that $tcPO_2$ decreased during the lumbar puncture phase when compared to the preparation phase suggesting that tcPO may be an accurate marker of procedureal pain in infants. In contrast, another study by Beaudoin, Janes, and McAllister (1991) found no significant changes in $tcPO_2$ during a heel stick of preterm infants.

Biochemical Responses to Pain

Aside from simple monitoring and the use of technical equipment, blood samples of children may be examined to detect chemical differences in reaction to pain. Both cortisol and endorphins have been found to fluctuate among infants experiencing painful stimuli (Anand, Phil, & Hickey, 1987; Franck, & Miaskowski, 1997; Gunnar, Connors, Isensee, & Wall, 1988; Gunnar, Porter, Wolf, Rigatuso, & Larson, 1995). A study investigating the relationship between behavioral distress and adrenocortical activity found that circumcision and blood sampling induced elevated cortisol levels in newborns, however weighing, measuring, and the discharge examination mimicked these results (Gunnar et al.) Another study examining the association between temperament and measures of neonatal stress concluded that higher cortisol levels, decreased vagal tone, increased crying, and quickened heart periods occurred during heel sticks (Gunnar et al.). A study by Pokela (1994) investigating the efficacy of opioid use to reduce problems associated with routine medical procedures among neonates in respiratory distress found that 19 of 34 (56%) neonates in the control (saline) group showed an increase in beta-endorphins one to two hours after treatment compared to 10 out of 36 (28%) neonates in the experimental (meperidine) group, suggesting beta-endorphins may be useful as a measure of pain.

Future Directions

There are a variety of courses for future research in the assessment of pediatric acute pain. First, as von Baeyer and Spagrud (2007) point out, contextual factors (e.g., situational, cultural, emotional) should play a greater role in gauging the client's pain condition. As an example, it might be helpful to consider factors such as being in a strange environment, which might increase children's pain experience and, in turn, affect their pain experience at home. Generating pain scales that include contextual factors would increase medical staff's ability to accurately assess child pain thereby improving their ability to alleviate discomfort. Considerations of temperament, cognitive development, maturational effects, and medical pain history would also enhance pain assessment instruments potentially aiding the assessor in determining how much of the pain response is due to physiological versus psychological factors. Furthermore, ways in which pain is measured among various pain scales require additional investigation. Specifically, current scales may be too simplistic to account for the full range of pain experienced by children (e.g., instead of focusing on pain intensity only, questions regarding pain type might also be developed; pulsating versus constant).

Regarding the burgeoning field of physiological assessment measures for pain, much work is still to be done. Many of these measures are impractical and costly, requiring special skills. Frequently it is unclear whether physiological arousal is due to pain or the emotional state associated with it. Also, these measures often introduce other distress variables that may affect the assessment (e.g., handling an infant following a heel stick may exacerbate pain response, thereby affecting physiological response).

The effect of race/ethnicity on the perception of pain among children also requires additional research. Currently, the generalizabiltiy of pain assessment measures to racially/ethnically diverse populations is limited. Only a handful of measures have been tested across cultures. Because cultural components may affect the way in which children experience and express pain, these factors deserve more attention.

Finally, as pointed out by Finley and McGrath (1998), proper pediatric pain assessment continues to require greater acceptance at the organizational levels of health care. Medical care professionals need appropriate training to use, understand, interpret, and relay data to children, families, and other health care professionals. This can only be accomplished if issues of child pain are taken seriously on administrative levels. Considering that issues of pain are the most prevalent among health care complaints and that the cost of alleviating pain is high (Stewart, Ricci, Chee, Morganstein, & Lipton, 2003), the need for efficient pain assessment within and among health care institutes is great.

Conclusion

The accurate assessment of pain is important in both evaluation and management of child pain. To optimally assess acute pediatric pain, it is important to consider situational factors such as thoughts, emotions, attention, beliefs, and previous experiences (Cohen et al., 2008). Also, sex, age, race/ethnicity, developmental level, contextual factors, and family background should be considered when estimating a child's pain (McGrath & Gillespie, 2001). When choosing between self-report, behavioral observation, and physiological pain assessment measures, it is important to consider that a battery of different tests is optimal in creating a well rounded, child-specific evaluation.

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