Pediatric Procedural Pain

Kelly D. Young, MD, MS

From the David Geffen School of Medicine at University of California–Los Angeles, Los Angeles, CA; and the Department of Emergency Medicine, Harbor-UCLA Medical Center, Torrance, CA.

Pain is subjective. The pain response is individual and is learned through social learning and experience. Early pain experiences may play a particularly important role in shaping an individual's pain responses. Painful medical procedures such as immunizations, venipunctures and dental care, and minor emergency department procedures such as laceration repair, compose a significant portion of the average child's experience with painful events. Inadequate relief of pain and distress during childhood painful medical procedures may have long-term negative effects on future pain tolerance and pain responses. This article reviews the evidence for long-term negative effects of inadequately treated procedural pain, the determinants of an individual's pain response, tools to assess pain in children, and interventions to reduce procedural pain and distress. Future research directions and a model for conceptualizing and studying pediatric procedural pain are proposed. [Ann Emerg Med. 2005;45:160-171.]

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INTRODUCTION

According to the International Association for the Study of Pain definition, ''Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage.''[1] The International Association for the Study of Pain further states that, ''Pain is always subjective. Each individual learns the application of the word through experiences related to injury in early life.'' This definition emphasizes the individuality of each person's pain response and the importance of pain experiences, especially those in early life, in shaping that response. Common routine and emergency childhood painful medical procedures, such as immunizations, blood tests, circumcision, dental care, and laceration repair, along with minor everyday pain experiences, such as falls, bumps, and cuts, compose the majority of the typical child's pain events. Thus, a child's experience during painful medical procedures likely plays a significant role in shaping that individual's pain response to future events.

Understanding and study of the pediatric pain experience has increased exponentially during the past 2 decades. Besides the negative experience of pain itself, growing evidence supports the occurrence of long-term negative effects from inadequately treated pediatric pain, especially in infants.[2,3] Significant short-term adverse outcomes have also been demonstrated, including hypoxemia, altered metabolic stress responses, and even mortality.[4,5] Despite the exponential growth in knowledge of pediatric pain determinants, assessment, and treatments, standard clinical practice continues to inadequately address prevention and treatment of procedural pain in children.[6-9] Even minor medical procedures such as finger sticks and venipuncture cause significant pain and fear in children, yet interventions to reduce pain and distress are infrequently used.[10-12] Improved emergency department (ED) care is a key link in the chain of improved overall pediatric pain management.[13]

This article summarizes the evidence for long-term negative effects of procedural pain, briefly reviews the determinants of an individual child's pain response and methods to assess pain in children, and discusses useful interventions for reducing the pain and distress associated with ED medical procedures. Non-pharmacologic methods to reduce children's procedural pain and anxiety are emphasized because pharmacologic methods and procedural sedation have been well reviewed elsewhere.[14] Finally, a model for conceptualizing future research is proposed.

EXPERIENCES, MEMORY, AND LONG-TERM EFFECTS

Animal and human studies support the concept that detrimental long-term effects result from inadequately treated repeated painful procedures in neonates and young children.[2,3] Much of the clinical research in this area focuses on prematurely born neonatal intensive care unit (NICU) survivors. The developing brain's neuronal architecture may be permanently altered by repeated noxious stimuli such as painful procedures.[15] Infants who have undergone repeated painful procedures in the NICU compared with those who have not react to subsequent procedures with lower behavioral pain responses but higher autonomic cardiovascular responses.[16] Ex-NICU patients also were rated by their parents as less pain sensitive at 18 months of age[17] yet were found to be more pain sensitive as adolescents[18] and displayed more somatization at age 4.5 years,[19] and although few

differences remained between groups at 8 to 10 years of age in rating hypothetic pain events, ex-premature children rated medical events as more painful than psychosocial events, whereas ex–full-term children rated psychosocial events as more painful.[20] These data support residual long-lasting effects from the NICU experience; whether these effects are due primarily to repeated procedures and pain is unclear.

Studies outside the NICU also support the occurrence of long-term effects. Infant boys who were circumcised without analgesia as neonates displayed a greater pain response to immunizations at 4 to 6 months of age than uncircumcised boys.[21] Young children randomized to placebo in a trial of fentanyl for the treatment of procedural pain continued to rate their pain higher for subsequent procedures, even when given fentanyl for these subsequent procedures.[22] In a study of hospitalized children, increased quantity of invasive procedures was positively associated with more medical fears and more posttraumatic stress disorder symptoms 6 months after discharge.[23] A survey of young adults correlated high childhood pain and fear at medical procedures with high adult fear, pain, and avoidance of health care.[24]

Contrary to the findings in ex-premature infants, full-term infants of diabetic mothers subjected to repeated heel lances displayed increased behavioral pain response to a subsequent venipuncture compared with infants who underwent only the venipuncture.[25] Discrepancies between study findings may be due to variation in the ages studied. Age and brain development at the time of the insult are thought to determine the nature, severity, and permanence of detrimental long-term effects, with premature infants representing a particularly vulnerable developmental window. Discrepancies may also be due to differences in adequacy of pain treatment. No differences in pain response to immunizations at 14 and 45 months of age were found between infants who had undergone major surgery and infants who had not,[26] possibly attributable to the use of general anesthesia during surgery.

Memory for the painful event is another factor influencing the long-term effects. Children as young as 3 years have accurate memories for details of painful procedures and pain events.[27,28] Infants display increased distress at cues (eg, skin cleansing) to previous procedures.[25] Children, even those who display low distress, tend to have a distorted negative recall of the pain they experienced with procedures.[29] Recall is further distorted if children were distressed at the procedure.[27,30] These fragmented traumatic memories easily become exaggerated memories of the pain experienced, resulting in increased distress at subsequent procedures. Thus, inadequate treatment of a child's distress at an initial procedure produces a negative ongoing cycle of distress at subsequent procedures (Figure 1). Altering these distorted memories to more realistic ones through postevent suggestion and feedback may break this cycle.[31,32]

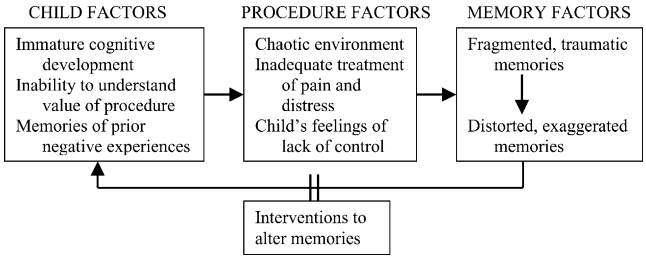

Figure 1. Factors unique to the young child combined with factors associated with the typical procedural environment produce fragmented, traumatic memories, which become distorted and exaggerated. These negative memories then affect the child's response to future procedures. Interventions to alter these memories may break this cycle.

DETERMINANTS OF AN INDIVIDUAL CHILD'S PAIN RESPONSE

The pain response is individual and learned. Evidence exists for genetically determined factors and environmental influences.[33,34] Many factors converge to produce an individual with a particular set of preprocedural pain beliefs, attitudes, and coping skills. Additional procedure-specific factors such as interactions with parents and health care workers, characteristics of the procedure and the environment, and use of pain- and distress-reducing interventions further modify an individual's unique pain response. Some pain response determinants are fixed (eg, sex, temperament), some may be modified over time (eg, anxiety, pain coping style), and some may be modified just before or during the procedure (eg, procedure environment, parental interactions, use of nonpharmacologic and pharmacologic interventions) (Table 1).

Preprocedural Nonmodifiable Determinants

Age. Younger children display more distress and rate their pain intensity higher than older children.[35,36] Only older children can differentiate "pain" from "unpleasantness" and "fear."[37,38] Older children may be more able to contain their behavior or may desire to appear stoic, resulting in lower pain ratings but not lower pain sensation.[33,39] Physiologic mechanisms for age differences such as differences in body surface area[39] and cortisol response[40,41] have been suggested.

Development. Developmental stage affects a child's ability to understand and cope with a painful event. Age is strongly correlated with development, but correlation is not perfect. Infants begin to demonstrate some memory for previous pain (eg, distress at cues for immunizations) at 6 months.[42] Toddlers have words to describe pain and can engage in noncognitive coping such as seeking comfort. Young school-aged children can begin to use cognitive coping skills. Only older adolescents are able to understand and describe such complex concepts as the value of pain.[42,43]

Sex. Adult studies have found that women report more recurrent pains and more severe pain to a given stimulus than men.[44] Findings in children are less consistent, although sex differences similar to those seen in adults appear in early adolescence.

Ethnicity. Adult studies have demonstrated interethnic differences in pain ratings.[45-47] Pain ratings are generally higher in blacks and Hispanics than in whites.[48-50] Research in ethnic

Table 1. Summary of current evidence for determinants of a child's pain response to painful medical procedures.

Determinant	Proposed Effect: Group With Greater Pain Response
Preprocedural, not modifiable	
Age	Younger
Developmental level of understanding	Less complex understanding
Sex	Female
Race/ethnicity/culture	Non-Caucasian
Temperament	Difficult (adaptable=lesser pain response)
Birth order	Unknown
Pain sensitivity	More sensitive
Symptom monitoring	Higher level of symptom monitoring
Pain expressivity	More expressive, more pain reporting
Locus of control	Internal locus of control
Anxiety level: trait (overall)	High anxiety
Experiences	Variable effect, no evidence for habituation or sensitization
Systolic blood pressure	Lower blood pressure
Preprocedural, modifiable over time	
Pain coping style	Internalizing, catastrophizing (distraction, problem-focused=lesser pain response)
Familial role models	Pain-sensitive family members
Social learning from peers, media, authority figures	Variable
Perceived secondary gains	Increased desirable secondary gains
Medical fears	Increased medical fears
Procedural, not modifiable	
Procedure invasiveness, noxiousness, duration	Increased noxious stimulus, invasiveness, duration
Sex and ethnicity of person performing procedure	Unknown
Procedural, modifiable	
Preparation and information given	Inadequate information and preparation
Appraisal of meaning of procedure, context of procedure	Less positive meaning (eg, medical procedure vs ear piercing)
Anxiety level: state (current)	More anxious
Sense of control	Decreased sense of control
Use of pain-coping skills	Not using pain-coping/promoting behavior
Parental presence	Mixed effects
Parent and staff behaviors	Reassurance, apology, criticism, giving general control to child (not specific choices); decreased pain response with distraction, direct commands to use coping skills, and praise
Environment	Chaotic, noisy environment
Child's physiologic state (eg, hunger, fatigue, nausea, baseline pain)	Variable
Use of nonpharmacologic and pharmacologic interventions	No or ineffective interventions

differences in children's pain response has been minimal.[51-54] Interethnic differences may be a result of cultural learning on pain expressivity, pain coping, and monitoring for pain symptoms. Differences seen may vary, depending on the ethnicity of the examiner, the patient's ability to communicate in the same language as the examiner, and the patient's and family's degree of acculturation.[47,55] There may also be physiologic differences in pain receptor density, blood pressure (higher systolic blood pressure has been correlated with lower pain sensation),[49] endogenous opioid or cortisol response, or another factor. Possible confounders include socioeconomic status, access to health care, and resultant experiences. The literature emphasizes that individual intraethnic differences are far greater than group interethnic differences.

Preprocedural Determinants Modifiable Over Time

Pain sensitivity, coping, and anxiety. Studies of temperament have shown some effect on children's pain responses, with children rated as "difficult" having greater pain responses and those rated as "adaptable" displaying less distress.[56,57] Evidence exists for an identifiable pain-sensitive profile[58] and for a familial predisposition to pain sensitivity.[59,60] High anxiety results in a greater pain response.[37] Pain coping style influences the pain response, with those using distraction reporting lower pain.[39,61] Parental prediction of the child's reaction, which is much more readily obtainable than the results of formal temperament, pain-coping style, or anxiety assessments, strongly correlates with children's pain responses.[56,62] Pain-sensitive children may benefit from behavioral anxiety-reduction techniques, formal teaching of adaptive coping skills, and education of their parents on modeling pain-coping techniques.

Procedural Determinants: Immediately Modifiable

Parental presence. Parental presence during their children's procedures is a well-researched factor.[63] The effect of parental presence on children's pain and distress response has been mixed and likely depends on the parent's own anxiety level, parent-child interactions, and the parent's ability to help the

Table 2. Selected pain assessment tools.

Tool	Validated Age Range (If Applicable)
Self-report	
Visual analog scale[81]	7 y to adult
Faces scales[82,128,129]	3 y to adult
Oucher[87]	3–12 y
Hester's Poker Chip Tool[130]	4–7 y, often used in children as young as 3 y
Colored Analog Scale[131]	5–16 y
Facial Affective Scale[131]	5–16 y
Word Descriptor Scales[132]	3 y to adult
Numeric rating scales[132]	7 y to adult
Adolescent Pediatric Pain Tool[133]	8–17 y
Behavioral	
Children's Hospital of Eastern Ontario Pain Scale (CHEOPS)[134]	1–7 y
Observational Scale of Behavioral Distress[135]	3–13 y
Procedure Behavior Checklist[136]	6–18 y
COMFORT score[137,138]	All ages
Child-Adult Medical Procedure Interaction Scale[94,95]	3–7 y
Brief Behavioral Distress Scale[139]	2–10 y
Groeningen Distress Scale[12]	≥2.5 y
Faces, Legs, Activity, Cry, Consolability (FLACC)[140,141]	0–7 y
For developmentally delayed children	
Noncommunicating children's pain checklist[91]	3–18 y
University of Wisconsin Children's Hospital Pain Scale for Preverbal and Nonverbal Children[92]	All ages
For neonates and infants	
Neonatal Facial Coding System (NCFS)[142]	Neonates
Neonatal Infant Pain Scale (NIPS)[143]	Neonates
Premature Infant Pain Profile (PIPP)[144]	Neonates
CRIES[145]	Neonates
Modified Behavioral Pain Scale[146]	0–6 mo
Scale for Use in Newborns (SUN)[147]	Neonates
Physiologic	
Pulse rate[148]	All ages
Mean arterial pressure or systolic blood pressure[148]	All ages
Pulse rate variability[149]	All ages
Cortisol (salivary)[150,151]	All ages

child cope effectively.[64] Parents and children overwhelmingly prefer to have parents remain present,[63,65] and parental presence does not decrease health care worker procedure performance.[66-68] Health care workers must be aware of nonverbal cues they may subconsciously use to exclude parents.[69] Parents who choose to remain present may benefit from training in effective methods to help their children cope.[70-72]

Adult behavior. Specific parental and health care worker behaviors associated with decreased child pain and distress include distraction, direct commands to use a coping strategy, and praise.[64,73] Adult behaviors associated with increased child distress include reassurance, criticism, apology, and giving control to the child (overall control of the procedure, not choices).[74,75] Reassurance is commonly used by parents and staff and, although meant to decrease children's distress, may actually increase it.[75,76]

Preparation. Preprocedural information given to the child by health care workers or parents, especially information on the sensations to be expected and information aimed toward enhancing realistic expectations, has been associated with reduced distress in children.[32,77,78]

Use of interventions. Although a body of literature supporting the efficacy of pharmacologic and nonpharmacologic interventions exists, there remains a gap between what we know works and how we actually practice.[79] Nonpharmacologic interventions and topical and local anesthesia are reviewed later in this article, and references to excellent reviews of procedural sedation and analgesia are given.

Using Knowledge of Determinants

Practitioners should expect higher levels of distress from young patients whose parents rate them as particularly pain sensitive. This awareness of increased likelihood of distress should prompt special efforts to adequately prepare the parent and child, to educate parents on how to coach their child in using adaptive coping skills, and to make use of available interventions to reduce pain and distress.

PEDIATRIC PAIN ASSESSMENT

The first step to adequate pain management is adequate pain assessment. Assessment instruments used must be practical, reliable, valid, and appropriate for the child's developmental stage. There are 3 dimensions typically assessed: self-report of pain intensity, behavioral reactions, and physiologic reactions (Table 2). Because pain is subjective, self-report is considered the criterion standard. Children are usually able to differentiate a few gross levels of pain intensity by the age of 3 years. Children using self-report scales should be able to complete simple seriation tasks, such as ordering blocks of various sizes. For younger or noncommunicating children, behavioral scales are used. Physiologic changes are inconsistent and should be used as corroborative data only. Multidimensional assessment gives the most complete picture of a child's pain response.[33] Consistency of scales used within a health care setting is essential.

Two commonly used methods of self-report are the visual analog scale and faces scales. The visual analog scale is a 10-cm line with the ends typically marked "no pain" and "worst pain possible." Scores range from 0 to 100 mm. The minimum clinically significant change in visual analog scale scores is 10 to 13 mm.[80,81] The visual analog scale can be used by children as young as 7 years.

Faces scales generally consist of 5 to 9 faces, ranging from happy or neutral (no pain) to sad or distressed. Scales vary in the number of faces, whether the no-pain anchor is smiling or neutral, and whether the faces are cartoon-like, realistic drawings, or actual photos.[82] The minimum clinically

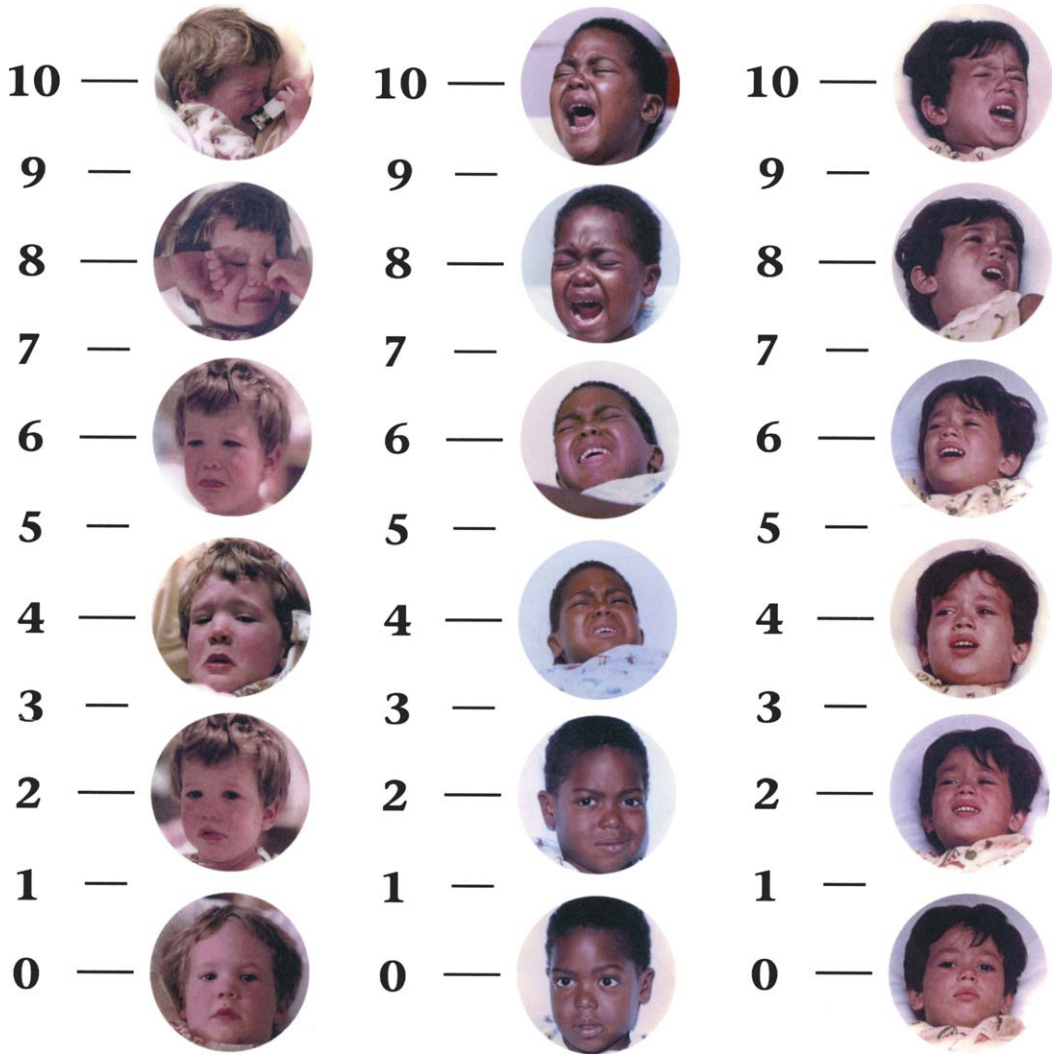

Figure 2. Oucher self-report pain scale, for use in children aged 3 to 12 years. Younger children use the faces portion, whereas older children use the numeric rating scale. Used with permission.

significant difference is 1 face.[83] Researchers have suggested that 6 faces is optimal because scores can be compared easily to visual analog scale scores, with the faces corresponding to 0, 2, 4, 6, 8, and 10 cm.[84] Neutral anchors are more valid for rating pain intensity; smiling and tearful anchors introduce an emotional component to the pain rating.[85] Young children's scores must be interpreted with caution because they are more likely to choose the extremes of scales.[86]

The Oucher combines 6 photographic faces for use with younger children, with a numeric rating scale ranging from 0 to 10 for older children (Figure 2).[87] The numeric portion may be used when the child is able to count to 100 by 10s.[88] The Oucher has undergone extensive psychometric testing, and alternate versions have been validated in black and Hispanic children.[89]

Behavioral rating scales score pain behaviors such as facial expression, crying, torso movements, kicking, verbal protest, and need for restraint. Some children may be able to control their behavior, however, resulting in poor correlation with self-reported pain.[90] Behavior rating scales are also used with developmentally delayed noncommunicating children.[91,92] An observer-rated visual analog scale (parent or health care worker), although commonly used and presumably based on the observer's assessment of the child's pain behaviors, often correlates poorly with children's self-report.[93] The Child-Adult Medical Procedure Interaction Scale rates the child's pain behaviors and parent and health care worker interactions with the child.[94,95]

A CHANGE IN THE ED "CULTURE"

Prevention and treatment of procedural pain should be multidimensional, including environmental methods, non-pharmacologic interventions, and pharmacologic interventions.[6] Given the evidence that even minor procedures result in significant pain and distress for children and that long-term negative effects result from inadequate treatment,

Provide information and prepare the parent and child.[97,152,153]
- Give step-by-step information of what will occur during the procedure.
- Give sensory information about what the child will see, hear, and feel.
- Use age-appropriate language and terminology and avoid medical jargon.
- Avoid high-anxiety words such as pain, hurt, cut, shot. Use words such as poking, freezing, squeezing instead.
- Do not insinuate that the procedure will definitely hurt.
- Be aware of possible misinterpretations of words and phrases such as ''dye'' or ''put to sleep.''
- Address children's concerns (eg, ''taking all my blood'').
- Consider using books describing the procedure the child can read with the parent.
- Give information before and during the procedure.
- Be honest.

Parental involvement[71,154]
- Ask the parents how much distress they expect from the child.
- Allow parents to remain present.
- Do not ask the parent to help restrain the child.
- Instruct the parent not to threaten the child (eg, with additional shots).
- Instruct the parent on coping-promoting behaviors (eg, distraction) and to avoid distress-promoting behaviors (eg, reassurance).

Health care worker behavior[6,74]
- Be calm, confident, and in control.
- Avoid reassurance, apology, criticism.
- Avoid conversation with other health care workers and parents that may be distressing (eg, describing possible adverse events) in front of the child.
- Teach students how to perform the procedure outside the room to minimize discussion in front of the child.

Health care setting[6]
- Maintain a quiet, calm environment.
- Avoid stressors such as beeping monitors.
- Avoid long delays between informing the child of the procedure and performing it.
- Avoid situations in which children can see or hear procedures performed on other children.

Procedural details[153]
- Allow comfort items such as favorite stuffed animals or blankets.
- For venipunctures and intravenous cannulation in thumb-sucking children, avoid the arm of the preferred thumb.
- Do not force the child to lie down if he or she does not want to and is not required to.
- Consider giving the child a ''job'' (eg, holding a gauze).
- Give the child choices to increase the perception of control (eg, right arm or left).
- For long procedures (eg, burn dressing changes), allow the child ''time outs'' of a predetermined number and duration (eg, three 20-second time outs).
- Allow the child to ''count down'' from 10 to 1 before a brief procedure.
- Use automatic lancets for finger sticks.
- Venipuncture, when feasible, may be less painful than heel lance.[155]

Hospitalized children[96]
- Use a treatment room; keep the patient's room/bed as a ''safe place.''
- Give hospitalized children a predictable ''safe'' time when procedures will not occur and a predictable time for procedures.
- Plan ahead and draw all blood samples at once if possible.
- Do not give pain medications by a painful route (intramuscular).

Figure 3. Environmental methods to decrease pain and distress with procedures.

pain-reduction methods should be used routinely for immunizations, finger sticks, venipunctures, and intravenous cannulation, as well as for more invasive procedures.

EDs are typically chaotic, noisy, and frightening for young children. Health care workers often feel rushed. They may justify holding the child down and quickly performing the procedure as the most compassionate alternative available. Because of the potential for long-term effects, however, this approach cannot be supported.

Creating a distress-lowering environment requires a change in the ''culture'' of the ED and the commitment of *all* staff, including physicians, nurses, technicians, and phlebotomists.[6,96] Multidisciplinary pain management teams that promote pain management education, formulate and implement protocols, identify and remove barriers to effective pain management, carry out quality improvement exercises, and work to keep prevention and treatment of pain a high priority should be created.[97,98] This approach will be much more successful than expecting individual health care providers to spontaneously learn new pain-management techniques and implement them on their own.

NONPHARMACOLOGIC INTERVENTIONS

Emphasis has been placed on pharmacologic procedural sedation and analgesia, but environmental and nonpharmacologic therapies contribute greatly to distress reduction. Environmental methods to reduce pain and distress include adequate preparation of the parent and child, a calm nonthreatening environment, anticipation of and planning for each individual child's expected distress, and training of staff in coping-promoting behaviors (Figure 3).[6] Room for improvement in the environment in which procedures are performed on children likely exists in most EDs.

Simple nonpharmacologic techniques (Table 3) can be taught to children as ''tricks'' to use and to parents for coaching their children. Children are more likely to use coping

Table 3. Nonpharmacologic interventions to reduce pain and distress with procedures.[104,106]

Technique	Description
Distraction[97]	Infant: pacifier, bubbles, toys Toddler: bubbles, songs, pop-up books, party blower, kaleidoscope, toys School-age: videos, video games, search for objects in pictures, stories, jokes, counting, nonprocedural conversation Adolescent: music by headphones, video games, nonprocedural conversation, focusing on objects
Deep breathing	Have the child breathe rhythmically with slow deep breaths.
Blowing[156]	Have the child blow out imaginary candles or take a deep breath and ''blow away the pain.'' Party blowers have been used successfully.[72]
Suggestion	Help the child put on a ''magic glove'' that does not allow pain, or apply ''magic invisible cream,'' or turn off a ''pain switch.''
Superhero imagery	Have the child imagine that he or she is a superhero and the procedure is a special mission.
Guided imagery	Help the child imagine a favorite place or activity, concentrating on all the associated sensations.
Thought-stopping and positive self-statements	Teach the child to think or say ''Stop!'' when feeling pain and then to think or say, ''I can handle this,'' or similar positive self-statements.
Rewards	Let the child know that rewards such as stickers, decorative bandages, small trophies, certificates, or prizes are available. Make behavior such as cooperation a goal, but give all children the reward.
Spot pressure or counterirritation	Rub the surrounding skin or provide spot pressure to the surrounding skin.
Sweet solution or pacifier or breastfeeding	Useful for infants for minor procedures. Give 2 mL of 30% sucrose or 30% glucose immediately before or during the procedure. Allow sucking on pacifier or breastfeeding during the procedure.
Cognitive behavior therapy	Preparation with dolls or other materials, role playing, role modeling, practicing desirable behavior, desensitization (slow introduction to subparts of procedure), hypnosis, guided imagery, progressive muscle relaxation, memory alteration

techniques if coached by an adult.[99] Parents are ideal coaches because they know what is likely to interest their child, and although they wish to remain present for the procedure, they may not know how to help their children. Added benefits include reduction of parents' anxiety by giving them an assigned role and teaching parents techniques that they can use for other painful events.[70]

Distraction is a proven effective psychological intervention.[100] A variety of distraction items may be kept available in the treatment area; the method used depends on the child's age and interests. Nonprocedural conversation (eg, discussing school, hobbies, sports, and even math problems) is a distraction technique that requires no preparation and is always available. For infants, sweet solutions with pacifiers or breastfeeding are effective.[101-103]

Complex psychological techniques grouped under the term ''cognitive behavior therapy'' are effective, possibly more so than sedation or general anesthesia.[104-106] Cognitive behavior therapy is time-intensive and requires specially trained personnel such as child life specialists or pediatric psychologists, making it unsuitable for minor procedures and for use in the ED. Cognitive behavior therapy plays an important role, however, in the treatment of children with cancer or other chronic illnesses requiring multiple invasive procedures.

PHARMACOLOGIC INTERVENTIONS

Topical and local anesthesia, combined with environmental and simple nonpharmacologic techniques, may be sufficient for minor procedures. Eutectic mixture of local anesthetics cream is effective in reducing the pain and distress of skin punctures.[107] Cost and the long time to onset of effect, 40 to 60 minutes, have precluded widespread use. A new nonprescription topical anesthetic, 4% liposomal lidocaine, has an onset of effect of 20 to 30 minutes.[108,109] Iontophoresis of lidocaine is effective and has an onset of effect of 10 minutes but requires an initial investment in the equipment.[110,111] Vapocoolant sprays, ethyl chloride and fluoromethane, produce immediate brief (seconds) anesthesia but may not be tolerated well by young children.[112] Although effective, rapid-onset topical anesthetics exist, they are underused for minor procedures. Adult health care workers who underestimate the negative effect of minor procedures for a child may wrongly conclude that the costs outweigh the benefits.

Topical lidocaine-epinephrine-tetracaine gel is effective for laceration repair and does not have the adverse event risks of tetracaine-adrenalin-cocaine solution.[113] Injected local anesthetics may be required for additional anesthesia. Methods to decrease pain and distress from injection of local anesthetics include keeping needles out of sight of the child (especially the large-gauge needle used to draw up the anesthetic), buffering lidocaine with sodium bicarbonate in a 9:1 ratio,[114,115] warming the local anesthetic,[115] using a small-gauge needle (27 to 30 gauge),[116] injecting slowly,[117] injecting from wound edges rather than through intact skin,[118] and counterirritating surrounding skin during the injection.[119] Mixing bupivacaine with lidocaine or using lidocaine with epinephrine (except where contraindicated) increases the duration of anesthesia.

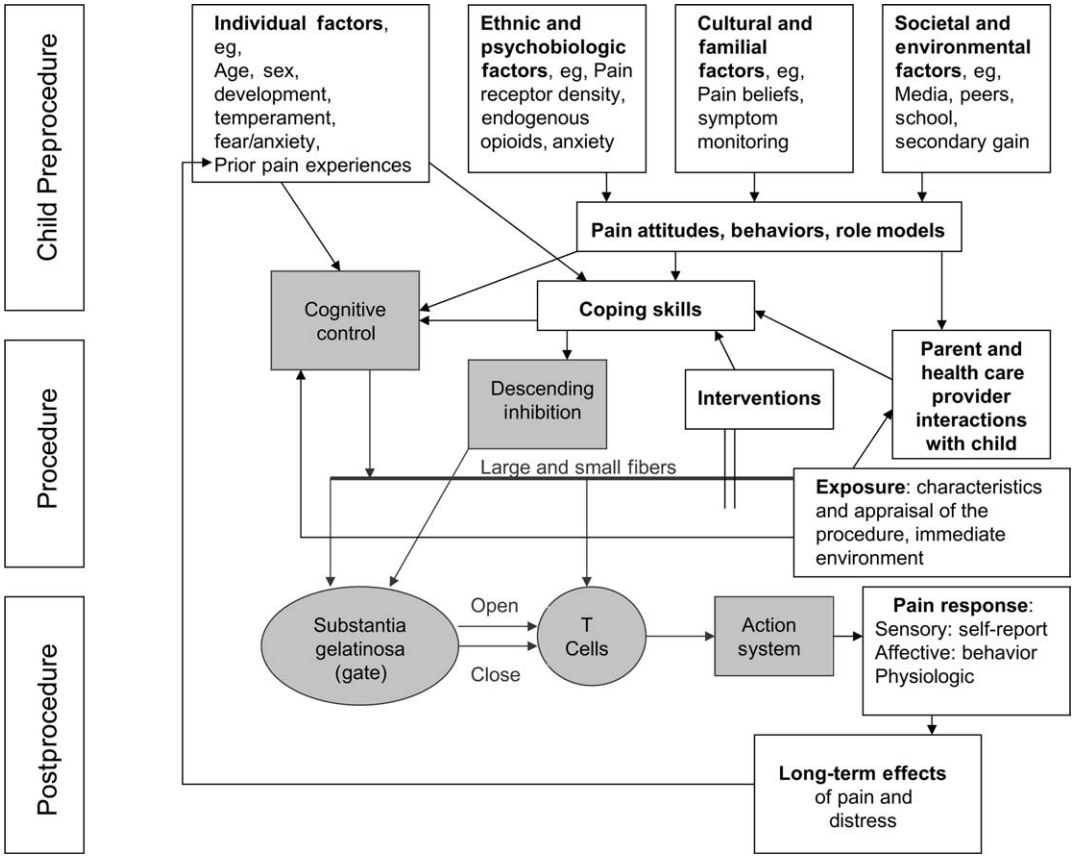

Figure 4. Before the procedure, each child has specific pain attitudes, behaviors, role models, and coping skills based on that child's individual psychobiologic, cultural, and societal influencing factors. Additional procedural influences include characteristics of the specific procedure and environment, interactions with parents and health care workers, and use of interventions. The central shaded portion of the figure represents Melzack and Wall's original gate control theory.[122] The individual's pain attitudes and coping skills determine the level of cognitive control and descending inhibition exerted on the substantia gelatinosa pain ''gate.'' Postgate impulses activate the pain action system, resulting in pain sensation, as well as affective and physiologic responses. Experience with the current procedure exerts long-term effects on the child's pain response to subsequent procedures.

Long noninvasive procedures in which motion control is important, such as diagnostic imaging, and more invasive painful procedures, such as fracture reduction or abscess drainage, may require procedural sedation and analgesia. The term ''procedural sedation and analgesia'' is preferred over the older misleading term ''conscious sedation.''[120] Thorough review of procedural sedation and analgesia is beyond the scope of this article; readers are referred to excellent recent reviews of this topic.[14,113,121]

FUTURE RESEARCH DIRECTIONS

Models to conceptualize the pain response have grown in complexity.[34] The gate control theory of Melzack and Wall[122] was the breakthrough model integrating sensory nociceptor perception with individualized cognitive control. The theory proposes that a gating mechanism exists that can be ''closed'' through cognitive control and descending inhibition (eg, through relaxation) or ''opened'' by psychological factors (eg, anxiety). Subsequent multidimensional social ecology models include the effects of social learning, pain experiences, and other influencing factors.[123,124]

Figure 4 shows a proposed model for understanding and studying children's pain responses specifically to procedures. This framework integrates individual determinants present before the procedure with procedure-related factors into a model that incorporates the gate control theory. Research on modifying preprocedural factors; improving parent and health care provider interactions with the child; using environmental, nonpharmacologic, pharmacologic, and multidimensional interventions; and reducing the long-term effects of procedural pain and distress is needed to improve children's immediate procedural experiences and possibly their responses to future pain events.

Lack of a clear outcome measure impedes research on the long-term effects of inadequately treated procedural pain. Pain response at a subsequent procedure is the most clinically relevant outcome. However, other than immunizations, most procedures are unscheduled, and immunizations are widely

spaced after 6 months of age. Responses to a sham procedure (ie, to cues such as skin cleansing and positioning) present another possibility, but the distress engendered by a sham procedure raises ethical concerns. Ethical concerns may also preclude the use of experimentally induced pain, although it has been used successfully.[125] Children's ratings of hypothetical painful situations, medical and nonmedical, have been used.[20,126] Posttraumatic stress disorder symptoms have been proposed as a measure of the long-term effects of repeated painful procedures and medical treatment.[23,127] A practical outcome instrument for investigating the long-term effects of repeated or inadequately treated painful procedures, and for demonstrating the efficacy of interventions, is needed.

In conclusion, even minor medical procedures produce significant pain and distress for some children. Inadequate prevention and treatment of children's pain and distress responses to medical procedures may have long-term negative effects on their future pain responses. The pain response is unique to each child and each procedural situation and depends on several determinants. The approach to prevention and treatment of procedural pain should be multidimensional, incorporating changes in the environment, routine use of nonpharmacologic techniques, and use of pharmacologic methods when indicated. Improved pain management may require a change in the ED "culture" and the beliefs of health care workers and the creation of a multidisciplinary team to implement effective interventions and protocols.

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Address for reprints: Kelly D. Young, MD, MS, Department of Emergency Medicine, Harbor-UCLA Medical Center, 1000 W. Carson Street, Box 21, Torrance, CA 90509; 310-222-3501, fax 310-782-1763; E-mail kyoung@emedharbor.edu.

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