Epidemiology and management of painful procedures in children in Canadian hospitals

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Abstract

Background: Children being cared for in hospital undergo multiple painful procedures daily. However, little is known about the frequency of these procedures and associated interventions to manage the pain. We undertook this study to determine, for children in Canadian hospitals, the frequency of painful procedures, the types of pain management interventions associated with painful procedures and the influence of the type of hospital unit on procedural pain management.

Methods: We reviewed medical charts for infants and children up to 18 years of age who had been admitted to 32 inpatient units at eight Canadian pediatric hospitals between October 2007 and April 2008. We recorded all of the painful procedures performed and the pain management interventions that had been implemented in the 24-hour period preceding data collection. We performed descriptive and comparative (analysis of variance, χ^2) analyses.

Results: Of the 3822 children included in the study, 2987 (78.2%) had undergone at least one painful procedure in the 24-hour period preceding data collection, for a total of 18 929 painful procedures (mean 6.3 per child who had any painful procedure). For 2334 (78.1%) of the 2987 children who had a painful procedure, a pain management intervention in the previous 24 hours was documented in the chart: 1980 (84.8%) had a pharmacologic intervention, 609 (26.1%) a physical intervention, 584 (25.0%) a psychologic intervention and 753 (32.3%) a combination of interventions. However, for only 844 (28.3%) of the 2987 children was one or more pain management interventions administered and documented specifically for a painful procedure. Pediatric intensive care units reported the highest proportion of painful procedures and analgesics administered.

Interpretation: For less than one-third of painful procedures was there documentation of one or more specific pain management interventions. Strategies for implementing changes in pain management must be tailored to the type of hospital unit.

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Children who are being cared for in hospital undergo multiple painful procedures daily.[1–3] The association between pain and negative physiologic, emotional and psychologic consequences is well established.[4,5] In addition, the development of international pain guidelines[6–8] and an expanding body of research on the effectiveness and safety of pain management strategies[2,3] have led to improvements in assessing and managing procedural pain.[9,10] Because it is impossible to completely eliminate the pain experienced by pediatric inpatients, effective pain management is crucial. However, the use of specific interventions for procedural pain management within various types of hospital units is unknown.

The purpose of this study was to determine, for children being cared for in hospital, the frequency of painful procedures, the types of pain management interventions associated with painful procedures and the influence of the type of hospital unit on the management of procedural pain.

Methods

Study centres

Of the 15 children's hospitals in Canada at the start of the study, eight met our requirements of having four or more distinct units, excluding psychiatric units, with 30 or more beds. Psychiatric units and children on these units were ineligible because of the potential for adverse psychologic responses to pain and the low incidence of painful procedures on these units. The eight eligible sites were all urban-based university-affiliated pediatric hospitals that agreed,

upon invitation, to participate in the Canadian Institutes of Health Research (CIHR) Team in Children's Pain program of research and provided letters of support.

Study units within each site were eligible for inclusion if they had a distinct geographic location and administrative structure; admitted children for periods longer than 24 hours; administered painful procedures to inpatients; and had pharmacologic, physical and psychologic interventions available for managing pain. Each site had a site investigator from the CIHR Team in Children's Pain, who met with unit managers to explain the study and to determine which units met the criteria and were interested in participating. At sites with more than four eligible units, we randomly selected four units to participate, including at least one medical, one surgical and one critical care unit. We hired a research nurse as part of the study team at each site. This person's duties included orienting unit staff to the study through standardized presentations during staff meetings, as well as collecting the data for the study. All site investigators and research nurses attended a two-day training session to review the study protocol and learn about procedures for collecting data electronically.

The study protocol was approved first by the Research Ethics Board at the primary site (The Hospital for Sick Children, Toronto, Ontario) and then by the research ethics boards of the other participating hospitals.

Study participants and data collection

Infants and children up to 18 years of age who were admitted to the study units for more than 24 hours were eligible for inclusion. The research nurses collected data from 30 charts per unit over four consecutive four- to six-week periods between October 2007 and April 2008, for a total of 120 charts per unit. More specifically, the research nurses reviewed the charts of the first 30 consecutively admitted children meeting the inclusion criteria during each data collection period. The research nurses performed a comprehensive examination of all aspects of the chart to locate data on the frequency of all skin-breaking painful procedures (e.g., heel lance, finger prick, surgery), all non-skin-breaking painful procedures (e.g., suctioning, mobilization)[11,12] and any pharmacologic, physical or psychologic pain management interventions over the 24-hour period (midnight to midnight) closest to the time when the chart was reviewed.

The research nurses entered all data into a centralized web-based relational database (the Canadian Pediatric Pain Research database; www.childrenspainstudy.ca), which was created with Oracle version 9 by the Centre for Computational Biology at the core site (The Hospital for Sick Children). Data entry was based on a predetermined list of variables arranged over multiple online pages. The system included built-in validation checks and skipped-question prompts to ensure completeness and accuracy of data entry. The data entry process was pilot-tested at each site for feasibility, accuracy and security of data transferred into the database.

Statistical analyses

We conducted initial analyses of the data for demographic characteristics, painful procedures and pain management interventions obtained from each unit to assess completeness and consistency. We calculated means, standard deviations (SDs), medians and interquartile ranges (IQRs) for continuous data and frequency counts and proportions for categorical data. We performed Kruskal–Wallis tests to compare the median number of painful procedures across sites and unit types. We used contingency table χ^2 tests for binary data, such as whether or not a particular type of intervention had been used. To adjust for lack of independence (caused by sampling of multiple patients from the same hospital unit), we used Taylor linearization methods for simple bivariate associations (e.g., Rao-Scott χ^2 tests).[13] In addition to accounting for the clustered nature of the data, these methods are robust to misspecification of the correlation within clusters, when the structure of the correlations is unknown.[14] We specified a significance value of $p = 0.05$ for all statistical tests.

Results

Between October 2007 and April 2008, we reviewed the medical charts of 120 children per unit from 32 inpatient units (14 medical, 8 surgical, 10 critical care) at the eight research sites, for a total of 3840 children. Demographic data were missing for 4 children (0.1%), and 14 patients (0.4%) did not meet the inclusion criterion of age less than 19 years. We excluded these 18 cases, which reduced the final sample to 3822 children: 1684 (44.1%) from medical units, 1183 (31.0%) from critical care units and 955 (25.0%) from surgical units.

In the medical and pediatric intensive care units (ICUs), the most common reasons for admission were related to the respiratory and circulatory systems (e.g., pneumonia, congenital heart diseases). Oncology-related diagnoses were also common in the medical units. In the surgical units, the most common types of surgeries performed were related to general surgery (e.g.,

appendectomy) and orthopedics (e.g., for scoliosis or fracture). The most frequent diagnoses for neonates in the neonatal ICUs were related to prematurity and congenital conditions. Additional sample characteristics are presented in Table 1.

Numbers and types of procedures

Of the 3822 children included in the analysis, 2987 (78.2%) had one or more painful procedures recorded for the 24-hour period preceding data collection. The total number of painful procedures was 18 929 (mean 6.3 per child who underwent a painful procedure, SD 7.0, median 3.0, range 1–50, IQR 2.0–6.0). The 10 most commonly performed procedures accounted for 14 294 (75.5%) of all procedures. The most commonly performed procedures (i.e., administered to at least 1% of patients in the study sample) in each category of pain severity and the types of interventions administered within the 24-hour period preceding data collection for patients who underwent these procedures are summarized in Table 2.

Children in critical care units (pediatric and neonatal ICUs) underwent many more painful procedures than those on medical and surgical units: for children in ICUs, median 10.0 per day (IQR 4.0–17.0, mean 11.5, SD 8.7); for children on medical units, median 2.0 per day (IQR 1.0–4.0, mean 3.4, SD 3.2); and for children on surgical units, median 2.0 per day (IQR 1.0–4.0, mean 3.2, SD 2.8) ($p < 0.001$ for differences across unit types).

A greater proportion of children in critical care units underwent at least one painful procedure within the 24-hour period preceding data collection (1095 of 1183 [92.6%]) than was the case for children on medical units (1212 of 1684 [72.0%]) and surgical units (680 of 955 [71.2%]). In particular, children in pediatric ICUs underwent a median of 12.0 painful procedures daily (IQR 6.0–18.0, mean 13.1, SD 8.8), whereas infants in neonatal ICUs underwent a median of 5.0 painful procedures daily (IQR 2.0–11.0, mean 7.2, SD 6.7) ($p < 0.001$, Kruskal–Wallis test).

Table 1: Demographic characteristics of children admitted to eight Canadian pediatric hospitals between October 2007 and April 2008

Characteristic	No. (%) of patients *n = 3822*	
Age, yr		
< 1	1402	(36.7)
1–3	559	(14.6)
4–6	322	(8.4)
7–12	712	(18.6)
13–18	827	(21.6)
Male sex	2031	(53.1)
Primary diagnosis		
Acute	3377	(88.4)
Chronic	445	(11.6)
Secondary diagnosis		
Acute	178	(4.7)
Chronic	695	(18.2)
Surgery in previous 24 h	154	(4.0)
Mechanical tracheal ventilation	250	(6.5)
Continuous infusion of sedative or analgesic	361	(9.4)

Management of painful procedures

Overall, for 2334 (78.1%) of the 2987 children who underwent a painful procedure, a pain management intervention had been documented in the 24-hour period preceding data collection. Of these children, 1980 (84.8%) had documentation of at least one pharmacologic intervention (analgesic and/or adjuvant analgesic), 609 (26.1%) had a physical intervention, 584 (25.0%) had a psychologic intervention, and 753 (32.3%) received a combination of interventions (Table 3). Of the 1980 children who received a pharmacologic intervention, 348 (17.6%) were receiving a continuous opioid infusion (i.e., fentanyl, hydromorphone or morphine). The most frequent interventions are summarized in Table 3.

For 844 (28.3%) of the 2987 children who underwent a painful procedure, there was documentation of a pain management intervention administered specifically for a painful procedure. Of these children, 791 (93.7%) had a pharmacologic intervention, 80 (9.5%) had a physical intervention, 21 (2.5%) had a psychologic intervention, and 44 (5.2%) had a combination of interventions. About 21% of children who had a pharmacologic intervention associated with a specific painful procedure (168 of 791) were receiving a continuous opioid infusion (i.e., fentanyl, hydromorphone or morphine).

The proportion of children who received a pharmacologic or physical intervention increased with increasing numbers of procedures administered to an individual child. On the basis of the skewness of the data ($S = 2.04$), we used the following categories for this analysis: one to three painful procedures, four to six painful procedures and more than seven painful procedures. Of the 1498 children who underwent one to three painful procedures, only 226 (15.1%) received a pharmacologic intervention, whereas 166

Table 2: Most frequently performed painful procedures, arranged by pain severity, and pain management interventions administered to children who underwent these procedures*

Pain severity rating; procedure	*n*	Type of pain management intervention; no. (%) of patients				
		Pharmacologic only	Physical only	Psychologic only	Any type†	Continuous opioid infusion
Mild						
Suctioning: oral or nasal	628	55 (8.8)	3 (0.5)	1 (0.2)	60 (9.6)	197 (31.4)
Removal of peripheral intravenous line	534	6 (1.1)	2 (0.4)	0 (0.0)	9 (1.7)	52 (9.7)
Removal of urinary catheter	193	5 (2.6)	1 (0.5)	0 (0.0)	7 (3.6)	53 (27.5)
Removal of nasogastric tube	184	1 (0.5)	0 (0.0)	0 (0.0)	1 (0.5)	32 (17.4)
Scraping or swabs: nasopharyngeal	108	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	18 (16.7)
Removal of peripheral arterial line	91	14 (15.4)	2 (2.2)	0 (0.0)	16 (17.6)	33 (36.3)
Removal of central venous line	64	8 (12.5)	0 (0.0)	0 (0.0)	9 (14.1)	22 (34.4)
Accessing implantable venous port	35	5 (14.3)	0 (0.0)	0 (0.0)	7 (20.0)	3 (8.6)
Mild to moderate						
Capillary sampling	896	42 (4.7)	3 (0.3)	0 (0.0)	47 (5.2)	69 (7.7)
Suctioning: endotracheal	575	90 (15.7)	0 (0.0)	0 (0.0)	91 (15.8)	255 (44.3)
Dressing change or removal	535	59 (11.0)	9 (1.7)	1 (0.2)	72 (13.5)	92 (17.2)
Mobilization	364	89 (24.5)	1 (0.3)	0 (0.0)	94 (25.8)	92 (25.3)
Injection: subcutaneous	234	24 (10.3)	4 (1.7)	0 (0.0)	29 (12.4)	20 (8.6)
Removal of endotracheal tube	199	29 (14.6)	0 (0.0)	0 (0.0)	29 (14.6)	71 (35.7)
Removal of tape from skin	191	10 (5.2)	0 (0.0)	0 (0.0)	10 (5.2)	24 (12.6)
Insertion of nasogastric tube‡	180	7 (3.9)	2 (1.1)	1 (0.6)	11 (6.1)	37 (20.6)
Scraping or swabs: for culture or specimen	109	2 (1.8)	0 (0.0)	0 (0.0)	2 (1.8)	18 (16.5)
Tracheotomy care	55	2 (3.6)	0 (0.0)	0 (0.0)	2 (3.6)	9 (16.4)
Repositioning or restrapping of endotracheal tube	45	16 (35.6)	0 (0.0)	0 (0.0)	16 (35.6)	27 (60.0)
Suctioning: tracheotomy	34	2 (5.9)	0 (0.0)	0 (0.0)	2 (5.9)	4 (11.8)
Wound irrigation	31	2 (6.5)	0 (0.0)	0 (0.0)	2 (6.5)	8 (25.8)
Moderate to severe						
Venipuncture or phlebotomy	771	23 (3.0)	4 (0.5)	1 (0.1)	29 (3.8)	84 (10.9)
Insertion of peripheral intravenous line‡	410	32 (7.8)	3 (0.7)	0 (0.0)	36 (8.8)	46 (11.2)
Insertion of urinary catheter‡ or suprapubic aspiration	136	5 (3.7)	0 (0.0)	0 (0.0)	5 (3.7)	31 (22.8)
Cleaning or care of excoriated skin	130	22 (16.9)	18 (13.8)	0 (0.0)	43 (33.1)	13 (10.0)
Insertion of endotracheal tube‡	103	84 (81.6)	0 (0.0)	0 (0.0)	85 (82.5)	22 (21.4)
Insertion of peripheral arterial line‡	83	25 (30.1)	0 (0.0)	0 (0.0)	25 (30.1)	18 (21.7)
Removal of chest tube	56	35 (62.5)	0 (0.0)	0 (0.0)	35 (62.5)	19 (33.9)
Insertion of peripherally inserted central catheter‡	56	37 (66.1)	0 (0.0)	0 (0.0)	39 (69.6)	9 (16.1)
Lumbar puncture‡	49	25 (51.0)	0 (0.0)	0 (0.0)	28 (57.1)	4 (8.2)
Endoscopy	43	36 (83.7)	0 (0.0)	0 (0.0)	36 (83.7)	3 (7.0)
Insertion of nasojejunal tube‡	40	11 (27.5)	0 (0.0)	0 (0.0)	11 (27.5)	11 (27.5)
Insertion of central venous line‡	39	22 (56.4)	0 (0.0)	0 (0.0)	22 (56.4)	12 (30.8)
Injection: intramuscular	35	10 (28.6)	0 (0.0)	0 (0.0)	10 (28.6)	1 (2.9)

*Data for both procedures and interventions relate to the 24-hour period before data collection, but interventions were not necessarily administered for the procedures recorded. The table does not include procedures administered to less than 1% of the study population.
†Alone or in combination. There were no patients who received all three types of intervention (pharmacologic, physical and psychologic).
‡Includes unsuccessful attempts.

(30.8%) of the 539 who underwent four to six procedures and 399 (42.0%) of the 950 who had seven or more procedures received pharmacologic interventions ($p < 0.001$, contingency table χ^2 test). Similarly, 1.4% (21/1498) of the children who underwent one to three painful procedures received a physical intervention, whereas 3.9% (21/539) of those who had four to six procedures and 4.0% (38/950) of those who had seven or more procedures received a physical intervention ($p = 0.001$, contingency table χ^2 test). In contrast, a significant inverse relationship was noted for psychologic interventions: 0.9% (19/2037) of children having one to six procedures received a psychologic intervention, whereas only 0.2% (2/950) of those who had seven or more procedures received this type of intervention ($p = 0.015$, contingency table χ^2 test).

Children in pediatric ICUs were more likely than those in other types of units to receive pharmacologic and physical interventions for painful procedures (Table 4).

Interpretation

More than three-quarters (78.2%) of the children in our sample had undergone at least one painful procedure in the 24-hour period preceding data collection, with an average of 6.3 procedures per child (range 1–50). Similarly, for the majority (78.1%) of children who underwent a painful procedure, some type of pain management intervention was documented in the same time period. For these children, pharmacologic interventions were administered most frequently (84.8%), followed by physical interventions (26.1%), psychologic interventions (25.0%) and combinations of interventions (32.3%). However, only about one-quarter (28.3%) of the interventions were specifically linked with a painful procedure. Pediatric ICUs reported the highest proportion of painful procedures and analgesics administered.

Researchers have reported the untoward consequences of pain in children for decades.[4,15,16] Although the frequency of painful procedures documented in our study was lower than in previous studies, it remains unacceptably high and varies considerably across patients and types of hospital units. Carbajal and colleagues[1] reported that neonates from multiple neonatal ICUs underwent a mean of 12 (SD 8) painful procedures daily, and 79.2% of these procedures were performed without specific analgesic. Others have reported similar findings.[9,10,17–19] Thus, the scope of this issue is broad and universal.

There has been some improvement in the proportion of children who received any pain management intervention during the 24-hour period preceding data collection, relative to previous studies.[20] However, despite an abundance of evidence on effective pain management strategies,[2,3] only a small proportion of children in our study had interventions specifically linked to the painful procedure. Pharmacologic interventions were documented most frequently, especially in pediatric ICUs. Our findings contrast with prospective observational studies conducted in neonatal ICUs, where nonpharmacologic interventions were used more frequently than pharmacologic interventions. For example, in another study,[19] our research group found that nonphar-

Table 3: Most frequently performed pain management interventions for children undergoing at least one painful procedure

Intervention	No. of patients receiving intervention	% of patients in intervention category	% of all patients *n = 2987*
Pharmacologic	*n = 1980*		
Opioid			
Morphine	351	17.7	11.8
Fentanyl	300	15.2	10.0
Codeine	236	11.9	7.9
NSAID			
Ketorolac	82	4.1	2.7
Naproxen	40	2.0	1.3
Ibuprofen	20	1.0	0.7
Non-opioid			
Acetaminophen	1397	70.6	46.8
Topical or local anesthetic			
Bupivacaine	50	2.5	1.7
Lidocaine	46	2.3	1.5
Liposomal lidocaine	32	1.6	1.1
Sucrose	36	1.8	1.2
Adjuvant			
Ketamine	140	7.1	4.7
Clonidine	50	2.5	1.7
Physical	*n = 609*		
Positioning	274	45.0	9.2
Heat or cold therapy	124	20.4	4.2
Non-nutritive sucking	106	17.4	3.5
Psychologic	*n = 584*		
Preparation or education	214	36.6	7.2
Reassurance	158	27.1	5.3
Deep breathing	103	17.6	3.4
Behavioural distraction	57	9.8	1.9

Note: NSAID = nonsteroidal anti-inflammatory drug.

macologic interventions (physical 84.0%, behavioural 51.2% and environmental 28.4%) were implemented more frequently than pharmacologic interventions (23.2%). Similarly, Johnston and associates[10] reported that more than 70% of infants received nonpharmacologic interventions for heel lance in neonatal ICUs. Carbajal and colleagues[1] reported that only 2% of painful procedures in neonatal ICUs were managed with pharmacologic interventions, whereas 18% were managed with nonpharmacologic interventions and 20% with a combination of pharmacologic and nonpharmacologic interventions. Study design and the exclusivity of the setting (i.e., neonatal ICUs only) could account for these differences in relation to the present study. In addition, the more frequent use of nonpharmacologic interventions may reflect beliefs associated with pain in infants, safety concerns related to the administration of analgesics (e.g., opioids)[21–24] or an appreciation of the best evidence (e.g., Cochrane systematic review on sucrose[25]). The use of psychologic interventions decreased with higher numbers of painful procedures.

The type of hospital unit also influenced pain management practices. For example, medical units documented the most psychologic interventions for managing pain. Health care professionals on these units may see more children with chronic pain, and their use of these interventions for chronic pain may cross over to management of acute pain. Similarly, in critical care and surgical units, more emphasis was placed on pharmacologic pain management, perhaps because of a closer association with anesthesiologists and patient-controlled analgesia. Units that accessed specialist pain services also had less frequent administration of analgesia, perhaps because the number of patients with complex needs seen on these units was limited or because staff members had less perceived "ownership" of overall pain management for other patients on the unit. A systematic review of the effectiveness of acute pain teams in improving the quality of analgesia and postoperative outcomes for adults was inconclusive.[26] However, Werner and coauthors[27] reported that acute pain services were associated with reduced intensity of pain.

Limitations

Design limitations suggest that the results of this study should be interpreted with caution. To accommodate the large sample size and to standardize data collection, our design involved a retrospective examination of medical charts. Incomplete and variable documentation prevented analyses by standardized diagnostic category or categorization of the intensity of procedural pain. Furthermore, documentation may not always have reflected actual practices, especially in relation to physical and psychologic interventions and how pharmacologic interventions were combined or linked to specific procedures. We had no opportunity to observe or question health care professionals about their rationale or preferences related to pain practices. Although the use of corrections for multiple testing during analysis helped to control type I error, type II error may have become inflated. The reporting of precise unadjusted *p* values allows for the degree of significance to be evaluated within the context of all tests examined.

Conclusions

Decreases in the number of painful procedures performed and improvements in pain management associated with procedures are essential to relieve pain and suffering and to capitalize on the associated benefits for patients and the decreased use of health care resources.[28] Careful

Table 4: Number of painful procedures and types of pain management interventions administered to children who underwent these procedures in the 24-hour period preceding data collection, by type of unit*

			Any pharmacologic intervention†		Any physical intervention‡		Any psychologic intervention§	
Type of unit	No. of patients	No. of procedures	No. (%) of patients	95% CI for percentage	No. (%) of patients	95% CI for percentage	No. (%) of patients	95% CI for percentage
Surgical	680	2 161	539 (79.3)	72.7–85.9	54 (7.9)	5.8–10.0	133 (19.6)	8.9–30.2
Medical	1 212	4 162	600 (49.5)	41.4–57.7	119 (9.8)	4.2–15.4	295 (24.3)	8.0–40.7
NICU	296	2 135	133 (44.9)	33.4–56.5	32 (10.8)	1.4–20.2	6 (2.0)	0.0–4.3
PICU	799	10 471	708 (88.6)	85.5–91.8	441 (55.2)	45.2–65.2	150 (18.8)	5.1–32.4

Note: CI = confidence interval, NICU = neonatal intensive care unit, PICU = pediatric intensive care unit.
*Design-based χ^2 analysis with 95% CIs. Significant *p* values indicate differences across types of units with respect to each pain management intervention.
†Any pharmacologic intervention: $p < 0.001$.
‡Any physical intervention: $p = 0.07$.
§Any psychologic intervention: $p = 0.19$.

consideration of the need for painful procedures for pediatric inpatients and the importance of ensuring a balanced array of pharmacologic and nonpharmacologic interventions should be emphasized during health care professionals' training. Current evidence-based guidelines for dealing with procedural pain and future research using prospective study designs should address and reflect the benefits of documentation that will allow for precise determination of the efficacy of various pain management approaches. Given that units in our study that accessed specialist pain services administered analgesia less frequently, ongoing education for health care professionals about the role of pain specialists, as well as the evidence-based effectiveness of both pharmacologic and nonpharmacologic interventions within different hospital units, is required. Changing the behaviour of health care professionals is complex and challenging. Therefore, solutions to reduce the pain that children experience while in hospital must involve a social dialogue that engages clinicians and researchers and customization of interactive strategies (i.e., strategies involving interaction between health care professionals) that are consistent with the practice culture on the unit and the very fabric of the caregiving model.

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