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Fracture pain in children in the emergency department: the impact of a new pain management procedure

Mélany Liber[1,8*], Claire De Jorna[2], Déborah Abidji[3], Nassima Ramdane[4], Justine Avez-Couturier[5,6] and François Dubos[1,7]

Abstract

Purpose To compare compliance with the French national guidelines before and after the implementation (in 2018) of a new protocol on acute fracture pain management in the pediatric emergency department of a French university medical center.

Methods We conducted a retrospective, before-after study in patients aged below 16 years presenting at the pediatric emergency department with a fracture. We compared pain management before (in 2017) and after (in 2019 and 2020) implementation of the new procedure. The primary endpoint was appropriate pain management, defined as (i) an appropriate initial assessment of pain, (ii) appropriate treatment with analgesic drugs (acetaminophen for mild pain, acetaminophen and ibuprofen for moderate pain, ibuprofen and morphine for severe pain) and (iii) reassessment of the pain intensity.

Results 572 patients were included (mean age: 6.5 years; male: 60%). 190 in 2017 and 382 in 2019–2020. Pain management was appropriate for 40% of the patients in 2017 and 52% in 2019–2020 ($p=0.004$). Pain was rated for 98% of patients in 2017 vs. 100% in 2019–2020 ($p=0.04$). The frequency of appropriate treatment for mild pain and moderate pain increased significantly from 52 to 76% and from 0 to 44%, respectively. The administration of ibuprofen increased by 26% points (from 3 to 20 patients treated) and the administration of morphine increased by 29% points (from 1 to 17 patients treated). Pain reassessment rose significantly from 21 to 43%. Levels of compliance with the guidelines were similar in 2019 and 2020. Analgesia was significantly more effective in 2019–2020 than in 2017 (in 20% vs. 14% of the patients, respectively; $p=0.005$).

Conclusion After the implementation of a new protocol for the management of acute fracture pain, we observed an increase in compliance with the guidelines. Although the use of ibuprofen and morphine rose significantly as did the frequency of pain reassessment, further improvements are required.

Keywords Pain management, Children, ED, Acute fracture pain

*Correspondence:
Mélany Liber
melany.liber@chu-lille.fr

Full list of author information is available at the end of the article

Introduction

It is known that pain is not managed optimally in emergency departments (EDs) [1, 2]. Acute fracture pain is typically moderate to severe during the first two days [3]. Pain during childhood must be managed appropriately, in order to avoid a negative impact on the individual's perception of pain in the future [4]. Given that pain is a subjective, individual experience, its management requires the most objective assessment possible. The inappropriate assessment and management of pain may have an impact on the medical investigations and procedures that the child subsequently undergoes [5]. Ideally, pain should be quantified over time by means of standardized, reproducible, validated scales [6]. Children aged 7 or over are capable of self-assessing the intensity of pain; the "gold standard" is a visual analog scale (VAS) ranging from 0 ("no pain") to 10 ("worst possible pain"). For younger or disabled children, observation scales (EVENDOL) rated by a healthcare professional are commonly used in the ED [7, 8]. EVENDOL is a 5-item behavioral pain scale for young children in the ED and has been validated in several studies [8].

In France, codeine was widely used to manage pain in children until the regulatory authorities warned against this practice in 2013 [9]. The 2016 French national guidelines recommend the assessment of pain on a standardized scale before and after treatment [10]. A combination of ibuprofen and acetaminophen is recommended for moderate post-traumatic pain, and a combination of ibuprofen and either tramadol or morphine is recommended for severe pain. In France, tramadol can be given to children over the age of 3.

At Lille University Medical Center (Lille, France), 29,000 children per year (including 1120 with a fracture) are admitted to the pediatric ED (PED). Prior to June 2018, the PED did not have a specific pain management protocol for patients with fractures. The overall objective of the present study was to assess the impact of the PED's implementation of a new protocol (based on the 2016 French national guidelines) for acute fracture pain management.

Methods

Study design and participants

We performed a retrospective cohort study in Lille University Medical Center's PED before/after protocol implementation. This study followed all guidelines for strengthening the reporting of observational studies in epidemiology (STROBE). Three 3-month periods (from July 1st to September 30th in 2017, 2019 and 2020) were assessed and compared. The protocol for acute fracture pain management (i.e. the intervention) was implemented in June 2018. Hence, 2017 corresponded to the pre-intervention period, and 2019 and 2020 corresponded to the post-intervention period. We included all PED patients under the age of 16 and with a discharge diagnosis of "fracture". The exclusion criteria were as follows: treatment by a pre-hospital medical team or another ED before admission to the PED; a fracture of the femur (often treated with a fascia iliaca block); an open fracture or a dental fracture, ongoing participation in another clinical study; refusal of pain management; and refusal of inclusion by the patient's parents.

New acute fracture pain management protocol

In the new protocol (Supplementary Material 1), acute fracture pain was assessed and initially managed on admission by the triage nurse, using the prescription instructions available in the PED's triage software. These instructions included the analgesic drugs available in the triage nurse's room (including acetaminophen, ibuprofen and tramadol). Most of the PED's physicians and nurses had been trained in the application of the new protocol. Physicians who worked in the PED at night only or on the weekend only were given a written copy of the protocol and were invited to attend a non-mandatory presentation.

Objectives and outcome measures

As mentioned above, the study's primary objective of the present was to assess the impact of the new protocol for acute fracture pain management. Therefore, our primary endpoint was compliance with three aspects of the French national guidelines on the fracture pain management: (i) assessment of pain on a standardized, validated scale (a vertical VAS for children aged 7 or over, or EVENDOL for disabled children or children aged 6 or under [11]); (ii) appropriate treatment with analgesic drugs -acetaminophen for mild pain, acetaminophen and ibuprofen for moderate pain, acetaminophen or ibuprofen and tramadol or morphine for severe pain; and (iii) reassessment of pain initially assessed as moderate or severe.

The study's secondary objectives were to evaluate the non-drug-based management of fracture pain and the effectiveness of analgesic management; the corresponding endpoints were respectively appropriate initial fracture management (as defined below) and a VAS score ≤ 3 or an EVENDOL score ≤ 4 upon reassessment.

Definitions

Mild pain was defined as a VAS score ≤ 3 or an EVENDOL score ≤ 4. Moderate pain was defined as VAS score between 3 and 6 or an EVENDOL score between 4 and 10. Severe pain was defined as VAS score ≥ 7 or an EVENDOL score ≥ 11 [12]. Appropriate pain rating was defined as the use of an appropriate scale for the pain assessment. Appropriate initial fracture management (other than

treatment with orally administered medication) by the triage nurse was defined as the use of an equimolar mixture of oxygen and nitrous oxide (EMONO), early immobilization, and alerting a physician in cases with severe pain. If the child had taken an analgesic in the hour prior to arrival at PED, this was included in the calculation of compliance with the protocol.

Study procedure, data collected, and ethics

As mentioned above, we chose to analyze data from the summer of 2017 as the pre-intervention period; this was a year after the publication of the new French national guidelines and a year before implementation of the new protocol in the PED. These data were compared with the same calendar months in summers of 2019 and 2020 - the first two years after implementation of the protocol. The data were collected from the PED's management software (Resurgences®, Berger-Levrault, Lyon, France). Demographic and administrative data (age, weight, sex, time of admission, etc.), clinical data (VAS/EVENDOL, site and type of fracture), management data and outcomes were extracted and anonymized. In line with the French legislation on retrospective studies of de-identified data recorded during routine clinical practice, the study did not require approval by an institutional review board but was registered with the French National Data Protection Commission (*Commission nationale de l'informatique et des libertés*, Paris, France; reference: CNIL DEC20-308). Each patient's parent(s) received a study information sheet and could refuse the inclusion of their child.

Statistical analysis

We first compared the characteristics of the patients in 2017 vs. 2019–2020 by using a chi-squared test or Fisher's exact tests for qualitative variables and a Mann-Whitney U test for quantitative variables. Next, the three time periods were compared separately with regard to (i) the overall level of compliance with the guidelines on drug treatment of acute fracture pain, (ii) appropriate pain assessment, (iii) appropriate initial fracture management (other than treatment with orally administered medication) and (iv) the effectiveness of pain management, using a chi-squared test. The threshold for statistical significance was set to $p<0.05$. All statistical analyses were performed using SAS® software (SAS Institute, Cary, NC, USA) at Lille University Medical Center's Biostatistics Unit.

Results

A total of 871 patients attended the PED for a fracture during the two study periods. Of these, 299 were excluded, and so 572 patients (mean age: 6.5 years; male sex: 59%) were included in the analysis (Fig. 1; Table 1). The patients in the 2017 period did not differ significantly from those in the 2019–2020 period in general and with regard to the pain intensity on admission in particular. On admission, a nurse rated the pain for 98% of children in 2017 and 100% in 2019–2020. An appropriate pain assessment scale was used for 87% of the children in the 2017 period and for 91% in the 2019–2020 period.

The treatment of acute fracture pain with analgesic drugs was considered to be appropriate for 40% of the

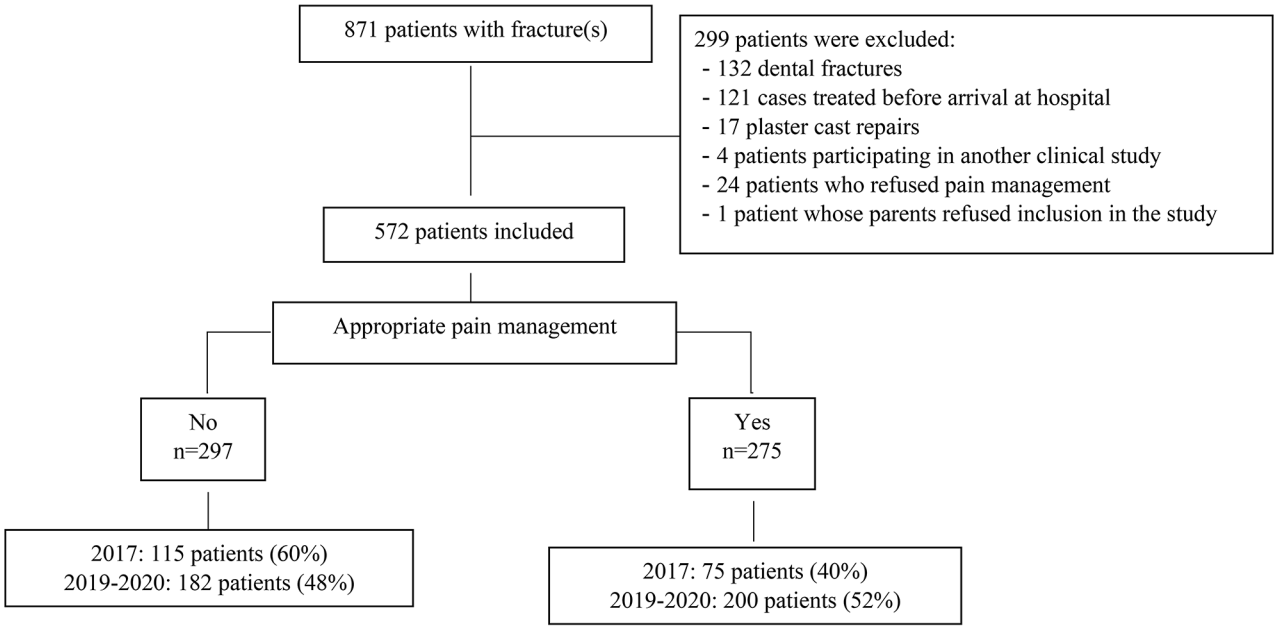

Fig. 1 Study flow chart

Table 1 Demographic characteristics of the children in the pre- and post-intervention groups

Characteristics		2017	2019–2020	*p*-value
Population		*n* = 190	*n* = 382	
Sex (male)		111 (58%)	224 (59%)	0.96
Median [IQR] age (years)		6 [3–10]	7 [4–10]	0.14
Median [IQR] weight (kg)		23 [15–37]	26 [17–39]	0.09
Admission during office hours		61 (32%)	154 (40%)	0.06
Forearm fracture		84 (44%)	157 (41%)	0.5
Transverse fracture		60 (32%)	168 (44%)	0.06
Analgesic drug(s) administered before arrival at the hospital*	Yes	39 (20%)	83 (22%)	0.86
	No	68 (36%)	141 (37%)	
	Not known	83 (44%)	158 (41%)	
Admitted to hospital		22 (12%)	66 (17%)	0.08
Pain intensity	Mild	29 (15%)	69 (18%)	0.45
	Moderate	75 (40%)	162 (42%)	0.60
	Severe	23 (12%)	46 (12%)	0.93

*acetaminophen, in all cases

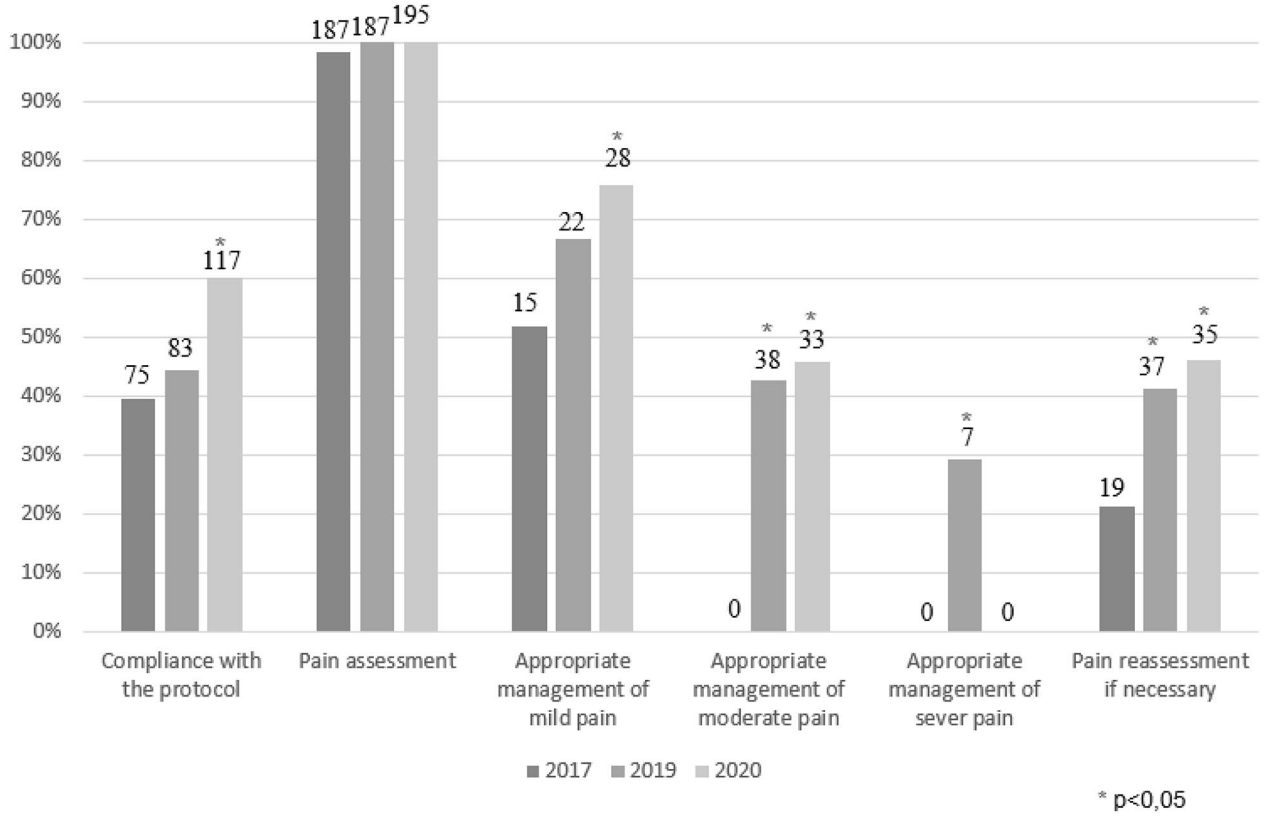

Fig. 2 Frequency of appropriate drug-based management of acute fracture pain before and after implementation of our new procedure *(the number of patients is given above each histogram bar)*

patients in 2017 and 52% in 2019–2020 ($p=0.004$) (Fig. 2). We compared the two periods in terms of the appropriateness of pain management (by pain level) and the frequency of pain reassessment (Fig. 2). The frequency of ibuprofen administration on admission increased by 26% points and that of tramadol decreased by 35% points. There was a significant increase in reassessment of pain: from 21% in 2017 to 43% in the 2019–2020 period. The median time interval between the initial pain assessment and the reassessment was 3 h in 2017 and 2 h in 2019–2020. The proportion of children in severe pain referred to a physician by the triage nurse increased (although

not significantly) from 22% in 2017 to 37% in 2019–2020 ($p=0.2$).

The proportion of children receiving non-drug-based pain treatments from the triage nurses increased from 58 to 69% ($p=0.01$). EMONO was given less frequently in 2017 than in 2019–2020 ($p=0.02$). The pain management by pain level is detailed in Table 2.

The drug prescription profile changed over time, with a 26% point increase in ibuprofen prescription ($p=0.02$) and a 29% point increase in morphine prescription ($p=0.05$). We observed a 21% point decrease in tramadol use ($p=0.03$). Nalbuphine prescription did not change between 2017 and 2019–2020 (34% of all medical prescriptions; only prescribed for moderate-to-severe pain). The criteria for morphine prescription were never checked in the 2017 period. In the 2019–2020 period, the contraindications for morphine administration were checked in 88% of cases, the respiratory rate was assessed in 59%, and the sedation score was rated in 47% of patients. No adverse effects of morphine were observed in 2017 or 2019–2020.

The patients' pain management was considered to be effective (VAS<3 or EVENDOL<4) more frequently in 2019–2020 than in 2017 (20% vs. 14%, respectively; $p=0.005$). When considering changes in drug prescriptions at discharge between 2017 and 2019–2020, there was a 17% point increase in ibuprofen prescription and a 3% decrease in tramadol prescription.

Discussion

Our results showed that acute fracture pain was well assessed but insufficiently managed: less than 50% of the children in pain received appropriate drug treatments. However, our results also showed that the intervention resulted in a significant improvement in professional practices; the frequency of compliance with the national guidelines rose by 12% points. We found that drug prescription at discharge increased (with 77% of patients treated, after the implementation of our protocol). The prescription of ibuprofen increased by 17% points.

Although pain management in children has been extensively studied [6, 13], few researchers have focused on the management of acute fracture pain [14]. A systematic review (from the 1980s to April 2015) found that a reduction in the pain score after trauma was evaluated in only eight randomized controlled trials [15]. Assessments of acute fracture pain appear to differ from one ED to another [2]. In an Israelian study, a pain score was documented in fewer than 20% of patients in both PEDs and general EDs [16]. A large study of practices in the UK and Ireland found that pain was documented in 57.5% of patients during their ED visit, with large variations between centers [17]. In our study, almost all patients had a pain assessment; this was probably due to inclusion of a pain scale in the nurses' triage software and systematically use on admission, as described by others [18]. Pain rating at triage nurse appears to improve subsequent pain management and should be mandatory in all EDs. As emphasized by Cunico et al., pain must be assessed on standardized, age-appropriate scales [2]. The VAS has been validated in older children able to self-assess their pain [19]. Other scales are necessary for preverbal (young) children and non-verbal children of any age who cannot express their discomfort adequately. Behavioral signs and physiological changes can be used to define the presence and severity of pain. The EVENDOL scale used in our study is a validated, appropriate scale [8].

However, specific acute fracture pain management protocols (as implemented in our study) have not been evaluated in the literature. Thanks to the application of our protocol, the proportion of fracture pain initially managed by the triage nurse rose significantly (to 69%, an 11% point rise) over the two study periods. In 2009, Corwin et al. found that the implementation of a pain management protocol in a pediatric ED had much the same impact as in our study [20]. The researchers reported a 16% point increase in the number of patients receiving analgesic treatment and a 70% point increase in the number of patients with a pain reassessment. In 2020, Granata et al. compared pain management before and after the implementation of a pain management protocol for triage nurses and found that the proportion of the staff assessing pain rose from 4 to 95% [21].

Table 2 Treatment administered on admission, according to the pain intensity

Pain intensity	Mild			Moderate			Severe		
Treatment, by period	**2017 (*n*=29)**	**2019–2020 (*n*=69)**	***p***	**2017 (*n*=75)**	**2019–2020 (*n*=162)**	***p***	**2017 (*n*=23)**	**2019–2020 (*n*=46)**	***p***
Orally administered drugs, n (%)	12 (41%)	37 (54%)	0.27	58 (77%)	142 (88%)	0.04	22 (96%)	39 (85%)	0.25
acetaminophen	8 (28%)	36 (52%)	0.03	15 (20%)	125 (77%)	<0.001	0 (0%)	28 (61%)	<0.001
ibuprofen	0 (0%)	1 (1%)	1	0 (0%)	69 (43%)	<0.001	1 (4%)	30 (65%)	<0.001
tramadol	4 (14%)	1 (1%)	0.03	44 (59%)	3 (2%)	<0.001	22 (96%)	3 (6%)	<0.001
morphine	0	0	/	0	9 (29%)	0.04	1 (11%)	8 (57%)	0.04
EMONO	1 (3%)	2 (3%)	1	1 (1%)	14 (9%)	0.04	0 (0%)	5 (11%)	0.16
Immobilization, n (%)	3 (10%)	9 (13%)	1	22 (30%)	63 (39%)	0.19	13 (56%)	20 (43%)	0.31

Researchers have reported that only 32–41% of patients admitted in ED for a fracture receive analgesics [22, 23]. Although insufficient, the rate of compliance with the guidelines was higher for children than for adults in an audit of general EDs in the UK (24% vs. 11%, respectively) [24]. We observed a significant overall increase in the proportion of patients receiving appropriate pain management. It has been shown that ibuprofen is as effective as opioids in the indication of acute fracture pain and is associated with a lower incidence of adverse drug reactions [3]. We found that severe pain was rarely managed appropriately (only 13% in 2019–2020 period). In 2003, Brown et al. reported that 60% of children with moderate-to-severe pain received an analgesic but only 25% received an opioid [25]. Our results and the literature data indicate that opioids are under-prescribed to children with acute severe fracture pain on admission to the ED [1, 3, 26]. In the USA, opioid misuse after pediatric orthopedic procedures - even after discharge - has been reported; reducing opioid use in certain situations is essential in this country [27, 28]. As shown by our present results, children whose pain warrants opioids should receive this treatment. However, there are very few published data on the management of acute trauma pain. Opioid treatment for pain is typically justified in the first 24 h after pediatric trauma in the ED but not beyond this period [29].

Our study had a number of limitations. Firstly, the study's single-center design limits the external validity of our results because the impact of our protocol might vary in a different ED. However, the fact that our protocol is simple and well-defined (Supplementary Material 1) might facilitate its reproducible implementation elsewhere. Secondly, the study's retrospective design increased the likelihood of missing data. We suspect that the triage nurse's referral of children in severe pain to a physician was probably underreported because this alert was frequently verbal. EMONO provides effective, rapid-acting analgesia and is therefore very useful in the ED - especially when the fractured bone is being immobilized [30]. Although we found a significant increase in the use of EMONO in cases of moderate and severe pain, its use was also underreported. This was also true for immobilization, which is known to be useful for pain control [31] but was not mentioned in our ED software. Thirdly, the fact that most of our patients were admitted during on-call periods might have led to reporting bias. However, the two study periods were similar with regard to the proportion of on-call admissions, and we consider that this factor was unlikely to have had a major impact. Fourthly, some patients received analgesic treatment prior to ED admission. However, this proportion was low and similar in the two study periods. Lastly, our study did not consider the use of non-drug-based methods of pain control, such as distraction, relaxation, hypnosis, and explanations for the child and his/her family. These methods may contribute to pain relief [10].

The reassessment of fracture pain was not sufficiently frequent in our study or in literature (from 3.5 to 52% of cases) [17, 32, 33]. It might be improved by providing a tool that enable children and/or their parents to re-evaluate pain themselves, as recommended by the Task Force on Pain in Infants, Children, and Adolescents [34]. Allowing the triage nurse to give oral morphine might be a good solution to improve severe post fracture pain management; but less comfortable for nurses as reported by Thomas et al. [35].

Intranasal fentanyl administration for severe acute trauma pain is safe and effective [36]. It would be interesting to evaluate its use by triage nurse through a nurse-led pain protocol. A study evaluating the choice of oral morphine or intranasal fentanyl in triage and analyzing the disincentives to opioid administration would be an asset in the management of severe post-traumatic pain in children.

Artificial intelligence (AI) may be useful specifically for fracture pain management. Even though AI is already used to detect fractures in many pediatric emergencies [37], it may also be helpful in analyzing potentially pain-related facial expressions on admission [38]. Some experts have pointed out the potential advantages of AI: standardization, greater effectiveness (relative to assessment by a triage nurse), and a reduction in nurses' workload [38]. Through the use of machine learning algorithms and data analysis techniques, AI can automate feature extraction and perform repetitive, time-consuming tasks requiring much human effort [39]. AI could be useful for creating an algorithm that simultaneously assesses a child's fracture and the level of pain, with a view to quicker, more effective treatment (as shown by others in the triage of patients with acute abdominal pain) [40].

Conclusion

An increase in compliance with the guidelines on pain management and reassessment was observed after the implementation of a new protocol in the pediatric ED. As a part of a protocol, triage nurses should be able to administer analgesics such as acetaminophen, ibuprofen and (for insufficiently relieved severe pain) even oral morphine.

Supplementary Information

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Supplementary Material 1

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Author contributions
Melany Liber: concept and design; data collection; analysis and interpretation of data; write and revise the manuscript, approval of the final version of the manuscript Claire de Jorna: interpretation of data; revision of the manuscript, approval of the final version of the manuscript Deborah Abidji: data collection; analysis and interpretation of data; revision of the manuscript, approval of the final version of the manuscript Nassima Ramdane: analysis and interpretation of data; revision of the manuscript, approval of the final version of the manuscript Justine Avez-Couturier: concept and design; analysis and interpretation of data; revision of the manuscript, approval of the final version of the manuscript François Dubos: design; interpretation of data; write and revise the manuscript; approval of the final version of the manuscript.

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Data availability
All data and materials are available. To obtain access to data, please contact MD Melany Liber melany.liber@chu-lille.fr.

Declarations

Ethics approval and consent to participate
In line with the French legislation on retrospective studies of de-identified data recorded during routine clinical practice, the study did not require approval by an institutional review board but was registered with the French National Data Protection Commission (*Commission nationale de l'informatique et des libertés*, Paris, France; reference: CNIL DEC20-308). The CNIL approved that all we needed was a letter of information to parents according ro reference methodology MR-004, deliberation no. 2018 – 155 of May 3, 2018. Each patient's parent(s) received a study information sheet and could refuse the inclusion of their child. We confirm that all methods were carried out in accordance with relevant guidelines and regulations in the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Pediatric Emergency Department, Univ. Lille, CHU de Lille, Lille Medical Center, Lille F-59000, France
[2]Pediatric Emergency Department, CHU de Lille, Lille University Medical Center, Lille F-59000, France
[3]GHICL, Department of Pediatrics, Saint-Vincent-de-Paul Hospital, Lille F-59000, France
[4]Department of Biostatistics, CHU Lille, Lille F-59000, France
[5]Pediatric Pain Clinic, Chronic Pain Clinic, CHU de Lille, Lille University Medical Center, Lille F-59000, France
[6]CIC-IT 1403, Lille University Medical Center, Lille F-59000, France
[7]Univ Lille, ULR 2694: METRICS, Lille F-59000, France
[8]Urgences pédiatriques, Hôpital Roger Salengro, avenue du Professeur Emile Laine, Lille F-59037, France

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