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Brief Report

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EMERGENCY PHYSICIAN–ADMINISTERED SEDATION FOR PNEUMATIC REDUCTION OF ILEOCOLIC INTUSSUSCEPTION IN CHILDREN: A CASE SERIES

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☐ **Abstract—Background: Ileocolic intussusception is a major cause for intestinal obstruction in early childhood. Reduction of intussusception, in the vast majority of institutions, is performed on awake children, without sedation. Objective: The aim of this study was to report the course of the first patients who were sedated by emergency physicians for pneumatic reduction of intussusception (PRI). Methods: We conducted a case series analysis of prospectively collected data on patients undergoing PRI, using a sedation recording tool. This tool uses standardized definitions from the Quebec guidelines for terminology and reporting adverse events in emergency medicine. Recording of time interval measurements and adverse events was performed by the emergency physician and nurse. Results: Between February 2016 and March 2018, 11 males and 3 females, with a median age of 11 months (interquartile range [IQR] 6–20 months), underwent sedation for PRI by five attending pediatric emergency physicians. All of the reductions were successful and without complications. Eight patients received ketamine and propofol, 5 received ketamine, and 1 received ketamine and midazolam. Median times for the presedation phase, procedure, sedation, physiologic recovery and emergency department recovery were: 131 min (IQR 79–104 min), 10.5 min (IQR, 9–12 min), 21 min (IQR, 20–30 min), 25 min (IQR, 23–30 min), and 108 min (IQR, 82–161 min), respectively. Four respiratory adverse events that required intervention were recorded. All were effectively treated with airway repositioning, suctioning, oxygen administration, or bag-mask ventilation. Conclusions: The first series of patients sedated for PRI by emergency physicians is reported. Our initial findings suggest the feasibility of emergency physician–administered sedation for PRI.**

☐ **Keywords—intussusception; sedation; children; emergency**

INTRODUCTION

Ileocolic intussusception is a major cause for intestinal obstruction in early childhood. Timely, effective reduction of intussusception is critical to prevent bowel necrosis, perforation, peritonitis, shock, and even death (1). Pneumatic reduction of intussusception (PRI) under fluoroscopy is the usual treatment for intussusception, during which a catheter is inserted into the colon and insufflated to a pressure of approximately 80–100 mm Hg (2). Although there are currently no studies that have evaluated distress during PRI, by analogy, colonoscopy is performed routinely under deep sedation (3,4).

A number of recent studies have supported effectiveness of PRI with sedation performed by anesthesiologists (5–7). In most institutions, however, PRI is performed on awake children, with no sedation (8,9). Pediatric emergency physicians are trained for providing safe sedation across ages, including patients with complicated presentations; at our institution, as of 2016, sedation for PRI is performed routinely by attending

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pediatric emergency physicians. The aim of this case series study was to report the course of the first patients who were sedated for PRI by emergency physicians.

MATERIAL AND METHODS

Setting

In the emergency department (ED) of Rambam Health Care Campus (RHCC), attending pediatric emergency physicians routinely perform deep sedation, and regularly train to maintain their sedation skills (10–15). Attending pediatric emergency physicians routinely sedate high-risk patients, such as multi-trauma patients for computed tomography scan, pleuropneumonia for chest tube insertion, and facial injuries for intraoral laceration repair (14). The professional competence of the attending pediatric emergency physicians and their availability led to a change in hospital protocol and, as of January 2016, sedation for PRI is performed by attending pediatric emergency physicians.

Study Design

We conducted a case series analysis of a prospectively collected registry of patients undergoing PRI, using a sedation recording tool (15). The sedation recording tool was initiated to collect real-time procedural sedation data in pediatric emergency medicine and was developed by the information technology department to record directly into the electronic patient data management system of the hospital (Prometheus integrated computer system; Fort Lee, NJ) (11,15). This system is a mandatory tool for all clinical staff (11). The sedation recording tool records each phase of sedation care, from the preprocedural assessment to recovery and discharge. The tool uses standardized definitions from the Quebec guidelines, a consensus-based document developed by North American experts in pediatric procedural sedation, to report sedation data and adverse events (16).

When a decision to perform PRI was made, the attending pediatric emergency physician caring for the patient initiated the sedation recording tool with assistance of the radiology nurse. Data recording was performed using computers located in the ED and radiology suite. The following variables and data were abstracted: demographic characteristics (age, weight, and sex); history/clinical (history of ileocolic intussusception, symptom duration prior to ED admission, vital signs, and blood gases); sedation (time from last meal to ED admission, sedation medications and dosages, sedation duration, physiologic recovery time, ED recovery time, and adverse events); procedure duration and outcome (successful or unsuccessful); perforation, if any; and any other complication (16). The study was approved by the Institutional Review Board.

Study Variables

Time interval measurements were derived from the Quebec sedation guidelines, outlined in Figure 1 (16). Preprocedure phase was from ED registration until first administration of sedation medication. Procedure time was from insertion of the insufflation catheter to the anus until catheter removal. Sedation time was from first administration of sedation medication until catheter removal. Physiologic recovery time was from catheter removal until the patient returned to a physiologic state allowing safe disposition from the ED (Figure 1). ED recovery time was from catheter removal until discharge from the ED (Figure 1) (16). Serious adverse events were: apnea, laryngospasm, hypotension, bradycardia, complete airway obstruction, clinically apparent pulmonary aspiration, permanent neurologic injury, and death (16). Potentially serious adverse events were: oxygen desaturation and partial airway obstruction. Significant interventions in response to an adverse event were: bag-mask ventilation, tracheal intubation, administration of vasoactive medications, administration of neuromuscular blockade agents, and chest compressions (16).

Sedation Protocol

ED protocol allows three options for sedation; ketamine in a loading dose of 1 mg/kg in combination with propofol in a loading dose of 1 mg/kg followed by propofol boluses of 0.5–1 mg/kg every 0.5–2 min; ketamine as a single agent in a loading dose of 1 mg/kg, followed by boluses of 1 mg/kg every 2–3 min; and ketamine in a loading dose of 1 mg/kg in combination with midazolam in a loading dose of 0.1 mg/kg followed by ketamine boluses of 0.5 mg/kg every 1–2 min. The choice of the sedation agents is at the physician's discretion. During sedation and until complete recovery, the patient's pulse oximetry, electrocardiogram, heart rate, and blood pressure are monitored continuously. The patient is connected to end-tidal carbon dioxide monitoring via nasal cannula when propofol sedation is used. Radiology nurses who care for children undergoing reduction of intussusception are sedation-trained. A mandatory requirement is the successful completion of a simulation-based training in patient safety during sedation, performed at the simulation laboratory of RHCC. This training aimed at improving performance in identifying sedation adverse events.

PRI Protocol

Ileocolic intussusception diagnosis is confirmed by ultrasonography performed by a senior radiology house officer. Immediately after diagnosis, the patient is placed on nil per os status, if not previously. PRI is performed

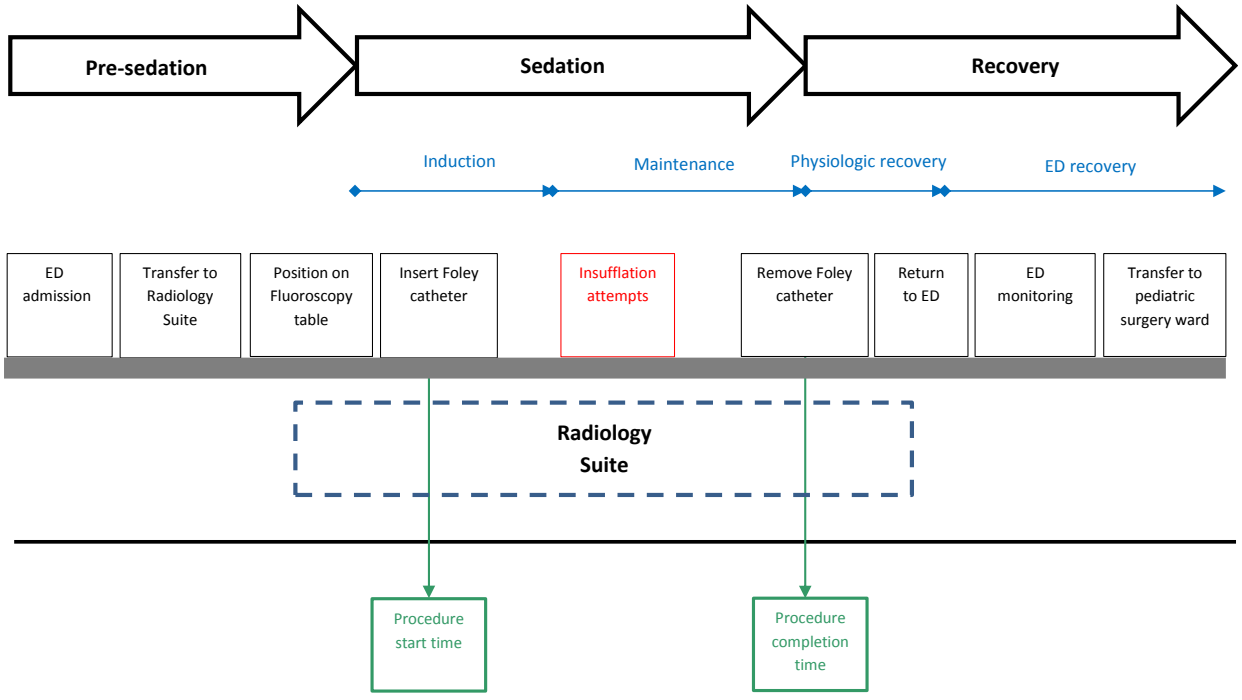

Figure 1. Sedation time intervals. ED = emergency department.

by an attending pediatric surgeon and a senior radiology house officer. Absolute contraindications are signs of peritonitis on physical examination, hypovolemic shock, and electrolyte abnormality. The procedure is performed in the pediatric radiology suite with real-time fluoroscopic guidance (Luminos dRF Max; Siemens Healthineers, Erlangen, Germany). A manual device consisting of a bulb insufflator, sphygmomanometer, 3-way stopcock, and tube connected to an 18-Fr Foley catheter is used. The surgeon connects the insufflator to the Foley catheter, which is placed in the rectum of the child in the supine position. The patient's buttocks are firmly taped together with adhesive tape. Then, insufflation pressure is gradually elevated, to a maximum pressure of 120 mm Hg, which can be maintained for up to 2 min, under constant fluoroscopy. The maximum allowable number of attempts is three, with 2 min of rest between. The procedure endpoint is reflux of air into the terminal ileum or failure after three attempts. Successful reduction is defined as copious reflux of air into the distal ileum with disappearance of the soft-tissue mass, without fluoroscopic evidence of bowel perforation (7).

Statistical Analysis

Descriptive statistics were generated, including medians and interquartile ranges (IQRs). All results were generated using StatsDirect statistical software, version 2.6.6 (StatsDirect Limited, Cheshire, UK).

RESULTS

Between February 2016 and March 2018, 11 males and 3 females, median age 11 months (IQR 6–20 months), underwent sedation for PRI by five attending pediatric emergency physicians. All 14 cases were reduced successfully, with no procedure complications. Patients' characteristics are presented in Table 1. One patient had a history of PRI, a 13-month-old male, with two previous episodes of ileocolic intussusceptions. Eight (57.2%) patients were treated with a combination of ketamine, median dose of 1 mg/kg (IQR 0.5–2 mg/kg) and propofol, median dose of 3 mg/kg (IQR 2–4 mg/kg). Five (35.7%) patients were treated exclusively with ketamine, median dose of 2 mg/kg (IQR 2–4 mg/kg). One (7.1%) patient was treated with the combination of ketamine, dose of 2 mg/kg, and midazolam, dose of 0.2 mg/kg.

Median times for the pre-sedation, procedure, sedation, physiologic recovery, and ED recovery were 131 min (IQR 79–104 min), 10.5 min (IQR 9–12 min), 21 min (IQR 20–30 min), 25 min (IQR 23–30 min), and 108 min (IQR 82–161 min), respectively. Four adverse events requiring interventions were recorded: two episodes of central apnea, each < 30 s; and, two episodes of oxygen desaturation, each < 30 s. Two apneas and one desaturation episode were recorded in patients sedated with propofol (a 13-month-old male and a 10-month-old female). One episode of desaturation was recorded in a patient sedated with ketamine alone (a 6-

month-old male). All were effectively treated with airway repositioning, suctioning, oxygen administration, or bag-mask ventilation.

DISCUSSION

Our case series study is the first reported series of sedation for PRI performed by emergency physicians. We performed a complete online literature search for previous studies on the use of sedation for PRI by emergency physicians. The search did not yield any studies. Two large studies reported on pediatric sedation for radiological procedures by non-anesthesiologists; 19,415 sedations by emergency physicians, and 1,649 sedations by pediatric hospitalists (17,18). None were performed for reduction of intussusception.

Estimates are that in the United States, only 7% of children with intussusception are treated with sedation during PRI (8,9). A possible justification against the use of sedation is the assumption that Valsalva maneuver protects against intestinal perforation during procedure (PDP) (19). It is assumed that during air enema, the presence of Valsalva maneuver increases intracolonic pressure and reduces the risk of PDP. This theory is based on a study of juvenile pigs that reported when pneumatic reduction is performed, perforation occurred at a mean pressure of 108 mm Hg without Valsalva maneuver vs. 145 mm Hg with Valsalva. The 108 mm Hg perforating pressure in the non-Valsalva group is close to the upper limit for pressure used during reduction of intussusception in children (20). This finding has not been demonstrated in humans. Two large meta-analyses of retrospective studies of PRI without sedation reported a PDP rate of 0.51% and 0.38%, respectively (2,21). There are limited data available on PDP rate of pneumatic reductions performed with sedation. Two Israeli single-center studies of PRI with propofol sedation reported a PDP rate of 1.5% (2 of 131) and 2.4% (3 of 124), respectively (6,7). These findings suggest that sedation with propofol alone may increase the risk of PDP.

Table 1. Demographic Characteristics, Hemodynamic and Laboratory Parameters, Time Variables, and Procedure Variables

Demographic Characteristics	Patients (n = 14)
Age, mo, median (IQR)	11 (6–20)
Weight, kg, median (IQR)	9.5 (8–10.5)
Male sex (%)	11 (78.6)
Hemodynamic vital signs on ED admission, median (IQR)	
Heart rate, beats/min	125 (118–135)
Systolic blood pressure, mm Hg	104 (100–115)
Blood gas tests, median (IQR)	
pH	7.38 (7.35–7.43)
Bicarbonate level, mEq/L	21.8 (21.3–23.4)
Lactate level, mmol/L	1.3 (1.2–2.1)
Duration of symptoms prior to ED admission, n (%)	
< 6 h	4 (28.6)
6–12 h	5 (35.7)
12–24 h	1 (7.1)
> 24 h	4 (28.6)
Duration from last meal to ED admission, h, median (IQR)	4 (1–6)
Maximal insufflation pressure during procedure, mm Hg, median (IQR)	90 (80–100)
PRI success, n (%)	
In first insufflation attempt	12 (85.8)
In second insufflation attempt	1 (7.1)
In third insufflation attempt	1 (7.1)

ED = emergency department; IQR = interquartile range; PRI = pneumatic reduction of intussusception.

In our study, pediatric emergency physicians used ketamine alone or with propofol or midazolam. Accounting for the experience of emergency physicians with these medications, the brevity of the procedure, the need for immobilization, patient aged older than 3 months, and painful nature of the procedure, the choice of ketamine-based sedation seems appropriate (22). A prior study from Ghana reported PRI in 18 children with the use of ketamine in a single dose of 1–2 mg/kg. In 12 of 18 (67%) patients, the procedure was successful and no PDP was observed (23). Ketamine was also used for hydrostatic reduction of intussusception in a series of 30 Indian children, and for manual reduction of intussusception in Spain (24–26). These studies provided no data on the length of sedation, recovery phases, and adverse events. A recent retrospective case-cohort study on hydrostatic reduction compared anesthesiologists' esketamine (S[+] enantiomer of ketamine) sedation with morphine analgesia. This study revealed no adverse events requiring intervention other than oxygen supplementation. Reduction success rate with esketamine was 90% (18 of 20) (27). In sum, these studies support the use of ketamine sedation for reduction of intussusception.

An important finding of our study is that the combination of ketamine and propofol was successfully used in 8 (57.2%) cases; serious adverse events were recorded in 3 of these 8 (37.5%) patients. Previous ED studies with the combination of ketamine and propofol reported adverse event rates of 12.1% (52 of 429), 19.5% (8 of 41), 15% (3 of 20), and 12% (8 of 67) (11,14,28,29). The adverse event rate found in our study is higher than in these reports. This finding suggests that reduction of intussusception is associated with a higher risk for serious adverse events.

A retrospective French study described 172 PRIs under general anesthesia. Patients underwent endotracheal intubation using propofol and succinylcholine prior to the procedure with propofol maintenance for the procedure. Authors did not include reporting of adverse events in their analysis (5). In the three studies that reported propofol sedation, PRI success rate was high: 90% (155 of 172), 92% (121 of 131), and 94.4% (117 of 124) (5–7).

We found two studies that investigated the success rate of PRI with and without sedation (7,30). Pneumatic reduction success rates of 89.5% in patients sedated with propofol vs. 83.3% in non-sedated patients. Hydrostatic reduction with midazolam sedation was associated with 10 times higher odds of success (30).

Limitations

This single-center pilot study has limitations. Firstly, our sample was small. Given the relative rarity of ileocolic intussusception, capturing a larger sample will require accumulation of experience over time or a multi-center study. The small number limits the ability of our data to evaluate complication rates. Secondly, our referral center is staffed by attending pediatric emergency physicians who are highly trained in procedural sedation. Thirdly, the location of the radiology suite in close proximity to the ED enabled physicians to spend less time outside the department. Our findings need to be taken with caution, as they are mainly applicable to centers such as ours.

CONCLUSIONS

This case series is the first report of emergency physician–administered sedation for PRI. In this initial report, all of the reductions were successful without complications, and sedation adverse events were managed effectively. The question of whether or not the potentially higher risk for perforation outweighs the benefits of treatment with sedation is still unanswered. Our results make a strong case for need of a large multi-center randomized controlled trial to evaluate the safety and efficacy of PRI under sedation.

Acknowledgments—Author contributions: IS conceived the idea for the study, designed the study, analyzed and interpreted the data, drafted the manuscript, and reviewed the literature; DS abstracted the data, and carried out the initial analysis; OF abstracted the data; NS critically reviewed the manuscript, and reviewed the literature. AI critically reviewed the manuscript, and reviewed the literature. DMS participated in manuscript drafting, analyzed and interpreted the data and reviewed the literature. IS has full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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ARTICLE SUMMARY

1. Why is this topic important?

Ileocolic intussusception is a major cause for intestinal obstruction in early childhood. In most institutions, reduction of intussusception is performed on awake children, without any sedation.

2. What does this study attempt to show?

This pilot study reports the first cases of emergency physician–administered sedation for pneumatic reduction of intussusception.

3. What are the key findings?

In this report, all of the reductions were successful without complications, and sedation adverse events were managed effectively by the emergency physicians.

4. How is patient care impacted?

Our initial results suggest the feasibility of sedation for pneumatic reduction of intussusception by skilled emergency physicians.