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Procedural sedation in non-intubated children with severe trauma - A single center study

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ABSTRACT

Background: Non-intubated children frequently undergo emergent procedures in the trauma-bay. This study evaluates whether patients treated with procedural sedation have an increased risk for severe adverse events.
Methods: Retrospective analysis of 1182 children with an injury severity score (ISS) of greater than 15.
Results: Of the 565 patients who were spontaneously breathing on arrival, 455 were hemodynamically stable with a Glasgow Coma Score of 15, 201 of whom were treated with sedation; 144 (71.6%) had computerized tomography scan, 35 (17.5%) wound debridement, and 22 (10.9%) fracture reduction. Sedation patients had an ISS of 20 (interquartile range 17–25). There were no death cases, no cases of cardiopulmonary resuscitation, and no cases of neurologic sequelae on hospital discharge. There were 2 (1%) cases of unanticipated endotracheal intubation.
Conclusions: Non-intubated patients who were hemodynamically stable with a Glasgow Coma Score of 15 had a low risk for severe adverse events due to sedation.

Introduction

Sedation has been recognized as an important and humane medical treatment for the pain and anxiety that accompany pediatric injuries and, if left untreated, these symptoms may provoke later psychological sequela and even posttraumatic stress disorder.[1–4] Over the last years, a major advancement in the provision of sedation to injured children in the emergency department (ED) has been made, supported by clinical evidence and practice guidelines.[5–8]

Rambam Health Care Campus (RHCC) is a level one trauma center that serves a population of approximately 600,000 children in northern Israel. The staff of the trauma bay of the ED treats approximately 120 children with an Injury Severity Score (ISS) higher than 15, each year.[9,10] In RHCC, non-intubated children admitted to the trauma bay of the ED who are hemodynamically stable and have a Glasgow Coma Score (GCS) of 15 are frequently treated with sedation when a painful or distressful emergency procedure is required.

This study evaluates whether patients treated with procedural sedation have an increased risk for severe adverse events.

Patients and methods

Study design

A single-center retrospective study was conducted over a 10-year period. We extracted the electronic medical records of all patients aged 0–18 years with an ISS greater than 15 who were admitted to the trauma bay of the ED between January 2008 and December 2017.[11] The patient records and information were anonymized and de-identified before analysis, and the study was approved by the Institutional Review Board.

Abbreviations: Emergency Department, ED; Glasgow Coma Score, GCS; Injury Severity Score, ISS.

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Indications for procedural sedation

The pediatric trauma team includes a trauma surgeon who serves as the team leader, a pediatric surgeon, a trauma nurse, and a pediatric emergency physician. After initial assessment of the airway, breathing, hemodynamic and neurologic status hemodynamically stable children with GCS of 15 are treated with sedation if needed. According to ED protocol, if a wound debridement or fracture reduction is required, the patient will be treated with sedation. Similarly, if the impression of the trauma team leader is that the patient is unable to tolerate immobilization during computerized tomography (CT) scan, he/she is treated with sedation. Sedation is performed by a designated trauma team physician (team leader or pediatric emergency physician). A mandatory requirement to perform sedation is a proof of successful completion of the simulation-based course in pediatric sedation safety. This one-day training was developed and established at the Israel Center for Medical Simulation, and focuses on providing physician with effective strategies to identify and treat sedation adverse events.[12] The choice of the sedation agents and order of administration is per physician discretion. Department protocol recommends using midazolam and/or ketamine for sedation, and fentanyl or morphine for analgesia. Midazolam is provided in a loading dose of 0.1 mg/kg, and ketamine in a loading dose of 1 mg/kg. Additional boluses of 0.1 mg/kg of midazolam and/or 1 mg/kg of ketamine every 1–2 min are administered as necessary. Fentanyl in a dose of 1–2 mcrg/kg or morphine in a dose of 0.1–0.2 mg/kg can be given to patients who need further analgesia.[13]

Data collection

Data were extracted from the hospital's electronic medical records ('Prometheus', RHCC, Haifa, Israel). This computerized system is a mandatory working tool for all ED health care personnel. The 'Prometheus' includes complete demographic data, vital signs, mechanism of injury, and any data collected in real time by the nurses and physicians during evaluation in the trauma bay.[14] Using a structured form, two abstractors (NB and NS) reviewed the charts independently. Chart review was conducted in accordance with published methods for retrospective studies, with the sole exception that abstraction of data was not done blindly in regard to study hypothesis and group assignment.[15]

The following variables were abstracted from the 'Prometheus' database: demographics (age, weight, and sex), airway status on arrival (spontaneously breathing, intubated), vital signs (saturation, heart rate, and blood pressure), GCS, mechanism of injury, performance of cardiopulmonary resuscitation during sedation or during hospital stay, survival to hospital discharge, time of admission to the trauma bay, sedation medications provided, successful completion of procedure, hospital admission department, trauma bay length of stay (LOS), intensive care unit (ICU) LOS, hospital LOS, neurologic sequela on hospital discharge as determined by a pediatric neurologist. Complementary data was obtained from patient records at the National Trauma Registry. Data collected from this registry included mechanism of injury, and Injury Severity Score (ISS), and mortality.[16] This registry is maintained by Israel's National Center for Trauma and Emergency Medicine Research, located in the Gertner Institute for Epidemiology and Health Policy Research.[16]

Outcome measures

The primary outcome for the study was the rate of severe adverse events defined as death, cardiopulmonary resuscitation, neurologic sequela on hospital discharge. The secondary outcome measure was unanticipated endotracheal intubation due to sedation.[17,18] Tertiary outcome measures were the trauma bay LOS, intensive care unit (ICU) LOS, and hospital LOS.

Primary data analysis

Descriptive statistics were generated, including means and standard deviations (SD) for continuous variables and frequencies, medians, and interquartile ranges (IQR) for the categorical variables. The nonparametric Mann–Whitney test was used to assess differences in LOS between patients who underwent procedural sedation in the trauma bay and patients who did not undergo procedures. All statistics were calculated with StatsDirect (version 2.6.6; StatsDirect Limited, Cheshire, UK).

Results

Overall, 1182 injured children with an ISS of greater than 15 were admitted to the trauma bay of the ED between January 1, 2008, and December 31, 2017. Fifty five patients did not survive to hospital discharge. On admission to trauma bay, 565 patients were spontaneously breathing and 455 of them were hemodynamically stable with GCS of 15. Of these 455 patients, 201 underwent procedural sedation in the trauma bay or radiology suit, and 176 did not undergo procedure during trauma bay stay (Fig. 1). Demographic characteristics, hemodynamic characteristics on admission, mechanisms of injury, procedures, and sedation medications are presented in Table 1. In four patients, neurologic status on discharge was not documented. We obtained outcome data in these patients by contacting the parents by phone. All patients survived hospital stay. No cases of cardiopulmonary resuscitation during sedation or during hospital stay were recorded among the patients who were treated with procedural sedation. No cases of neurologic sequelae on hospital discharge were recorded among the patients who were treated with procedural sedation. Midazolam was used in 55 (27.4%) patients as a single drug; in all cases the indication was CT scan. All the procedures were successfully completed. Two (1%) patients had endotracheal intubation due to reasons attributed directly to sedation and the procedures were completed after intubation. The first patient was a 2 year old boy who fell from a height and required wound debridement. He was sedated with midazolam and fentanyl for a CT scan and was intubated due to intermittent hypopnea and prolonged apnea. The second patient was a 2 year old girl who was involved in a motor vehicle collision as a pedestrian and suffered multiple craniofacial fractures, a pelvis fracture and a liver laceration. She was sedated with midazolam and ketamine for a CT scan and was intubated due to prolonged hypoxia.

When compared with patients who did not undergo procedures during their trauma bay stay, patients treated with procedural sedation had a median trauma bay LOS of 1.6 h (IQR 1.1–2.3) versus 1.3 h (IQR 0.7–2.0), $p < 0.0001$; a median ICU LOS of 1 day (IQR 1–2) versus 1 day (IQR 1–3), $p = 0.26$; and a median hospital LOS of 5 days (IQR 3–8) versus 4 days (IQR 3–7), $p = 0.18$.

Discussion

In the trauma bay of the ED, injured children frequently undergo emergent painful procedures, such as fracture reduction, and wound debridement, or procedures that require immobilization such as CT scan.[19–21] In our cohort, non-intubated children with moderate to severe injury were treated with sedation by a trauma team physician. All the procedures were completed without any severe adverse events, but there were two (1%) cases of unanticipated endotracheal intubation due to sedation; the patients

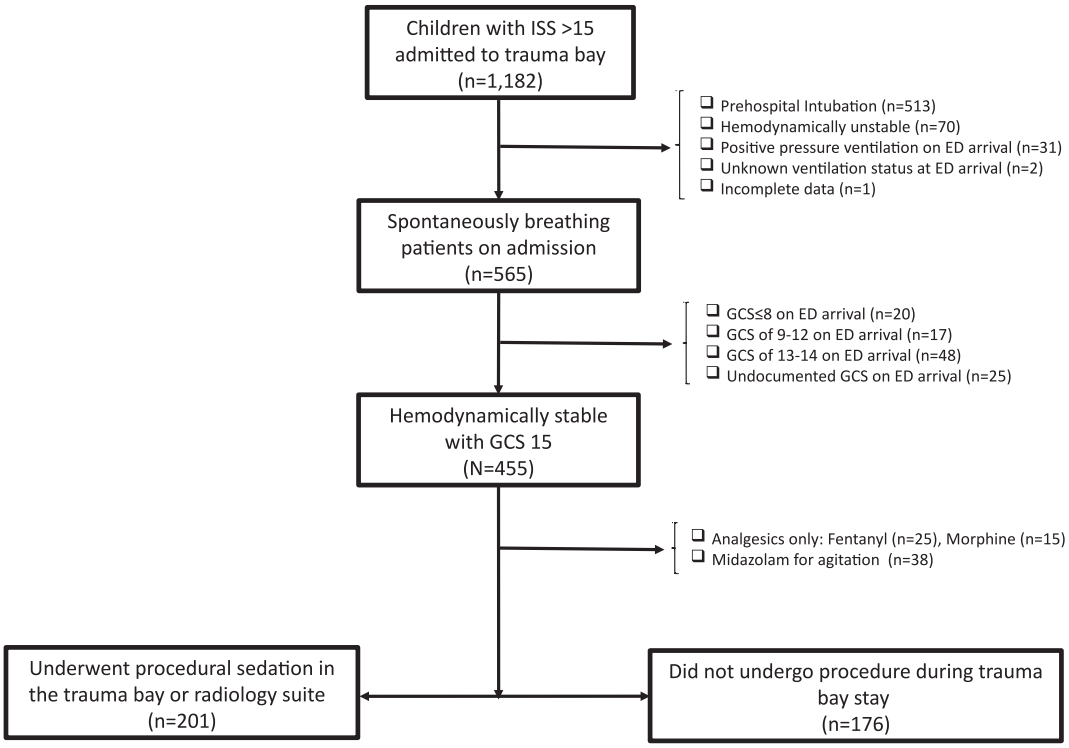

Fig. 1. Study flowchart.

recovered with an uneventful course of disease. These findings suggest that in a trauma unit where physicians are skilled in pediatric sedation, non-intubated children with severe trauma who are hemodynamically stable and have a GCS of 15 are at a low risk for severe adverse events due to sedation. The implication of the 1% rate of endotracheal intubation in these patients is that competence in pediatric airway management is an essential skill for physicians who sedate these children. Green et al. reported that pediatric intensivists skilled in ketamine administration can safely facilitate procedures in critically ill children; although potentially severe airway complications occurred, the events were quickly identified and treated.[22] These findings corroborate our results suggesting that moderately-severe injured children can be safely sedated by non-anesthesiologists. We believe that since these injuries can be extremely painful and distressing to children, the benefit of treatment with sedation outweighs the potential harm of an adverse event that can be effectively dealt with by a skilled trauma team physician.

Although the performance of the procedure was associated with a longer LOS in the trauma bay; the difference was surprisingly small, 1.6 h versus 1.3 h. ICU LOS and hospital LOS were similar between patients who had procedures and patients who did not have procedures during their trauma bay stay. These findings suggest that procedural sedation during trauma bay stay did not have a major influence on the course of injury and response to treatment.

In our cohort, the choice of the sedative agent (ketamine and/or midazolam) and the order of administration were per physician discretion. Ketamine and midazolam are widely used in procedural sedation; these agents and their combination have proven efficacy and safety profile and were the most frequently used agents in our study.[22–25] Midazolam as a single drug was used for CT scan only. All other procedures required a combination of analgesics and sedatives or the combination of midazolam and ketamine (Table 1). This finding supports our view that these children suffer pain and distress and need to be treated for this condition.

Our study has several limitations. First are the limitations inherent in a retrospective chart review, including dependence on the quality of the database. We believe that this factor has minimal impact, as the data extracted was objective and not prone to abstractor bias. Secondly, data allowed analysis of death, cardiopulmonary resuscitation, and neurologic sequela on hospital discharge. Sedation adverse events that were identified and treated such as apnea or transient laryngospasm could not be obtained from the records. Thirdly, our sample came from a single center where CT scan is frequently performed under sedation, and where trauma team physicians are skilled in pediatric procedural sedation; conclusions of this study may not apply to other trauma centers. The use of sedation in patients with GCS of less than 15 is not recommended by this study.

Conclusions

We found that sedation was not associated with severe adverse events, but there was a low risk for unanticipated endotracheal intubation. The findings suggest that in a trauma center where physicians are skilled in pediatric sedation, non-intubated children with severe trauma who are hemodynamically stable and have a normal level of consciousness on arrival have a low risk for severe adverse events due to sedation.

Authors contributions

Dr. Neta Baram designed the study, analyzed the data, performed the statistical analysis, and critically revised the manuscript for important intellectual content.

Table 1
Demographic characteristics, hemodynamic parameters, mechanisms of injury, procedures and medications Procedural sedation in non-intubated children: 1.

	Patients with GCS of 15 who underwent procedural sedation in the trauma bay or radiology suit (n = 201)	Patients with GCS of 15 who did not undergo procedure during trauma bay stay (n = 176)
Age, mean±SD	8.7 ± 6.1	9.5 ± 5.8
0–2 years, n (%)	31 (15.4)	19 (10.8)
3–5 years, n (%)	39 (19.4)	26 (14.8)
6–8 years, n (%)	25 (12.3)	28 (15.9)
9–11 years, n (%)	26 (12.9)	21 (11.9)
12–18 years, n (%)	80 (40)	82 (46.6)
Males/Females	146/55	139/37
ISS, median, IQR	20, 17-25	19, 16-25
Oxygen saturation on admission, %, mean±SD	99.2 ± 1.4	99.2 ± 1.1
Hemodynamic characteristics on admission		
Systolic BP, mmHg, mean ± SD	123.4 ± 18.9	120.0 ± 18.4
Diastolic BP, mmHg, mean ± SD	75.42 ± 15.6	73.3 ± 12.8
Heart rate, beats per min, mean ± SD	116.04 ± 30.7	105.8 ± 24.7
Mechanism of Injury		
MVC - Passenger, n (%)	38 (18.9)	32 (18.2)
MVC - Pedestrian, n (%)	40 (19.9)	29 (16.5)
Bicycle, n (%)	20 (9.9)	31 (17.6)
Fall, n (%)	84 (41.8)	67 (38.0)
Burn, n (%)	0 (0)	6 (3.4)
Blast, n (%)	5 (2.5)	1 (0.6)
Penetrating, n (%)	7 (3.5)	5 (2.8)
Firearm, n (%)	2 (1)	2 (1.2)
Stabbing, n (%)	5 (2.5)	3 (1.7)
Disposition from the ED		
To ICU, n (%)	59 (29)	46 (26)
To the Operating Room, n (%)	52 (26)	34 (19)
To a ward, n (%)	90 (45)	96 (55)
Procedures performed under sedation		
CT scan, n (%)	144 (71.6)	112 (63.6)
Wound debridement, n (%)	35 (17.5)	–
Fracture reduction, n (%)	22 (10.9)	–
Sedation medications		
Midazolam, n (%)	55 (27.4)	–
Ketamine, n (%)	10 (4.9	–
Midazoalm + Ketamine, n (%)	43 (21.4)	–
Midazolam + Fentanyl, n (%)	51 (25.4)	–
Midazolam + Ketamine + Fentanyl, n (%)	31 (15.4)	–
Midazolam + Morphine, n (%)	11 (5.5)	–

Notes. SD=Standard Deviation, IQR=Interquartile Range, GCS = Glasgow Coma Score, MVC = Motor Vehicle Collision, ISS=Injury Severity Score, BP=Blood Pressure, ICU-=Intensive Care Unit, LOS = Length Of Stay, CT=Computerized Tomography.

Dr. Nir Samuel designed the study, analyzed the data, drafted the first version of the manuscript and critically revised the final manuscript for important intellectual content.

Mrs. Hen Ben-Lulu contributed to the conceptualization of the study, and critically revised the manuscript for important intellectual content.

Dr. Hany Bahouth designed the study, analyzed the data, and drafted the manuscript; HB has equal contribution as last author.

Prof. Itai Shavit conceived the idea for the study, designed the study, analyzed the data, and drafted the manuscript.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Competing interest

None declared for all 5 authors.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.amjsurg.2018.08.016.

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