

Pediatric Procedural Sedation with Ketamine: Time to Discharge after Intramuscular versus Intravenous Administration

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Abstract

Objectives: Ketamine is an attractive agent for pediatric procedural sedation. There are limited data on time to discharge comparing intramuscular (IM) vs. intravenous (IV) ketamine. The authors set out to determine whether IM or IV ketamine leads to quicker discharge from the emergency department (ED) and how side effect profiles compare.

Methods: All patients who had received ketamine IM or IV at a tertiary children's hospital ED during the 3-year study period (2004–2007) were identified. Prospective sedation registry data, retrospective medical records, and administrative data were reviewed for drug dosages, use of additional agents, time of drug administration to discharge, total ED time (triage to discharge), and adverse events. A subgroup analysis for patients requiring five or fewer sutures (short suture group) was performed.

Results: A total of 229 patients were enrolled (60% male) with median age of 2.8 years (IQR = 1.8–4.3 years) and median weight of 15.7 kg (range = 8.7–74 kg). Ketamine was most frequently employed for laceration repair (80%) and foreign body removal (9%). Overall, 48% received ketamine IM and 52% received it IV. In the short-suture subgroup, 52% received ketamine IM, while 48% received it IV. Multivariate linear regression analysis determined time from drug administration to patient discharge as 21 minutes shorter for IV compared with IM administration, adjusted for age and number of additional doses ($R^2 = -0.35$; 95% CI = -0.5 to -0.19 ; $p < 0.001$). Total time in the ED (triage to discharge) comparing IV versus IM administration, adjusting for age and gender and number of additional doses, was not significantly different ($p = 0.16$). In the short-suture subgroup, time to discharge from administration was also shorter in the IV ketamine group ($R^2 = -0.454$; 95% CI = -0.66 to -0.25 ; $p < 0.001$) but similar for total time in ED ($p = 0.16$). Overall, adverse events occurred in 35% (95% CI = 27% to 45%) of the IM group and 20% (95% CI = 13% to 28%) of the IV group ($p = 0.01$). Only one patient required brief bag-mask ventilation.

Conclusions: In this institution, time from drug injection to discharge was shorter in the IV compared to IM ketamine group, both overall and for the short-suture group. However, time from triage to discharge was similar.

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Parenteral ketamine is an attractive agent for procedural sedation in children in the emergency department (ED). Numerous studies and randomized controlled trials (RCTs) on the use of ketamine show a favorable safety profile, with a low risk of airway complications and emergence phenomena.^{1–10} One of the key disadvantages of ketamine, however, is the long recovery period. The optimal parenteral mode of ketamine administration—intravenous (IV) versus intramuscular (IM)—has been discussed in only a small number of studies and reviews in terms of time to discharge and its relationship to the incidence of adverse events.^{4–6,11} To the best of our knowledge, there is only one recently published randomized controlled pediatric trial of IM

versus IV ketamine for orthopedic procedures,⁶ which investigated differences in duration of sedation and adverse event rates. Duration of sedation was significantly longer in the IM group ($p < 0.001$).

In our ED, ketamine (IV and IM) is most frequently used for laceration repair in young children, mostly in very brief procedures. Each mode of administration is used in almost equal proportions by senior physician preference. We set out to determine which mode of parenteral ketamine administration is preferential based on time to discharge as a practical measure of patient flow.

METHODS

Study Design

This was a prospective case series utilizing sedation registry data, medical records, and administrative records to determine if there was a difference in ED length of stay or adverse events for patients with different modes of ketamine administration. The study was approved as an audit and exempt from informed consent, by the Ethics and Research Committee, Royal Children's Hospital, Melbourne, Australia.

Study Setting and Population

We conducted this study at the ED of a pediatric tertiary referral center with an average annual census of 60,000 patient visits. All patients undergoing procedural sedation and analgesia were prospectively enrolled in a sedation registry. We then posed the study question (duration of stay) to the registry data set, augmented by a retrospective review of medical records and the administrative ED database. All patients who presented to the ED aged up to 18 years, and who received ketamine for procedural sedation, were eligible for enrollment. We excluded patients who received ketamine at analgesic doses via the pain management service.

In addition to an analysis of all patients who had received IM or IV ketamine, we investigated a subgroup of comparable patients, i.e., those who had only a brief procedure (in particular, laceration repair with five or fewer sutures as a proxy marker of procedure length) and who had not received a potentially confounding agent (morphine and/or midazolam) as part of their pharmacologic management prior to or as an adjunctive agent for the sedation. The exact parameters of the planned subgroup analysis were defined post hoc.

Study Protocol

In our ED, sedation using ketamine is carried out using standardized published guidelines, stipulating two accredited doctors (one to provide airway management and the other to perform the procedure) and an accredited nurse, in a resuscitation cubicle.^{12,13} Five-minute recordings of oxygen saturation, heart rate, blood pressure, respiratory rate, and sedation score, in addition to subjective nursing assessments, are made prior to, during, and after the procedural sedation (until recovery to the preprocedural state). Data are recorded on a standard sedation observation record. Adverse events, sedation score, and fasting times are entered onto the sedation checklist, which becomes part of the medical record.

Although departmental guidelines provide a dosing range for the initial dose of ketamine (3–4 mg/kg IM and 1–1.5 mg/kg IV) and possible adjunctive agents (0.02 mg/kg atropine to a maximum of 0.6 mg), route of administration (IM or IV), supplementary doses, and use of adjunctive agents are left to the discretion of the individual clinician.

Data Collection. The study participants were identified from a prospective sedation database, which contains details of all patients who have received procedural sedation, irrespective of agent used, between 2004 and 2007. The sedation database is derived from the sedation checklist used in all sedations and contains demographic information, pharmacologic agents used, adverse events, sedation scores, and fasting times. For the purposes of this study, all information was also verified by retrospective review of the medical records of patients who had received ketamine. The information contained in the sedation database was augmented with additional information collected in a piloted case report form specifically designed for this study.

Additional information recorded in the case report form included timing of events, vital signs, drugs used, route of administration, dosing schedule, American Society of Anesthesiologists scores, complications, interventions needed, and sedation scores. Data were obtained from a combination of clerical, nursing, and medical records. Ten percent of the data were abstracted by two different researchers to ensure standardization.

Definitions. Different time points in the patient stay were defined as follows: triage time was defined as the time when the patient was entered onto the electronic ED log in system (Hospital Administrative System [HAS]) after assessment by the triage nurse, i.e., entry into the department. Time of drug administration is defined as the time when first dose of ketamine was administered, from nursing chart. The time at discharge was defined as the time when patient was recorded as discharged from department, obtained from the HAS system. A drug was deemed to be given "preprocedure" if it had been administered up to 2 hours prior to the procedure. In particular, we recorded the use of midazolam, atropine, glycopyrolate, parenteral morphine, oral paracetamol, and codeine.

Specific airway adverse events recorded included apnea, laryngospasm, airway malalignment, oxygen desaturations below 90%, and excess salivation. Other adverse events included vomiting during or after the procedure and recovery reactions including excessive crying, agitation, unusual behavior, and abnormal muscle tone. Complications were defined as adverse events with sequelae, including unexpected hospital admissions, intubation, aspiration, neurologic impairment, and death.

Routes of drug administration were primarily divided into IM or IV, based on the initial mode of drug administration. Supplementary dosing information included route of administration as well as number and dose of increments and total additional dose given. We defined sedation as adequate if the procedure could be

completed using the agent, irrespective of the dosage or number of additional doses required.

Outcome Measures

The primary outcome measure was duration of ED stay for the procedure. Specifically, we compared the time from administration of the drug to discharge from the department and time from triage to discharge (total ED time) between the two routes of drug administration. Secondary outcome measures included the incidence and type of adverse events, the level of sedation achieved, and the types of procedures performed under sedation with ketamine.

Data Analysis

All data were entered into a Microsoft Excel database. Values were reported as median and interquartile range (IQR) when mean and standard deviation (\pm SD) were not appropriate. Statistical analysis, including Student's t-tests for normally distributed values, Wilcoxon rank sum tests for nonnormally distributed values, chi-square or Fisher's exact test for dichotomous variables, and multivariate linear regression analysis, were performed. Results were considered significant if $p \leq 0.05$. The different time variables were log transformed for use in the regression models, adjusting for differences in patient and treatment characteristics, ultimately to compare the influence of the route of ketamine administration on the time variable selected. The amount of variance explained by the final model was indicated by the adjusted R^2 . Statistical calculations were performed on Stata software (Version 10.0, Stata Corp., College Station, TX).

RESULTS

During the 3-year study period (2004–2007), we enrolled all 229 patients who received ketamine for procedural sedation in the ED. Basic demographics are included in Table 1. Additional agents given within 2 hours of the procedure were mainly oral analgesics. Agents administered adjunctively with ketamine (atropine and midazolam) were given at low rates. The majority of the procedures performed were laceration repair (79.5%). Children who had received IM ketamine were younger, weighed less, and underwent fewer fracture reductions than those who had received IV ketamine (Table 1).

All but one of the patients (228 of 229) successfully completed the procedure. That patient received 3 mg/kg of IV ketamine to suture three facial lacerations (1, 1.5, and <1 cm), did not have the procedure successfully completed due to inadequate sedation, and required admission for definitive surgical management under general anesthesia. Another patient received 4 mg/kg IM sedation to suture a facial laceration, and although the procedure was completed successfully, it was documented as a failure due to the proceduralist feeling that the patient had not been adequately sedated. No patients were admitted due to adverse reactions secondary to the sedation.

As shown in Table 2, 48% of the patients received ketamine IM, and 52% received it IV. Additional doses (supplemental doses of ketamine) were given via the IV route, except for nine patients in the IM group (3.9%) who received an additional dose via the IM route. Overall, 15% of the IM group needed supplemental doses compared with 51% of the IV group ($p < 0.001$).

Table 1
Ketamine Procedural Sedation in Children: Demographics and Procedures

	Total (N = 229)	IM (n = 110)	IV (n = 119)	p-Value
Age, years				
Median (IQR)	2.8 (1.8–4.3)	2.3 (1.7–3.1)	3.3 (3.2–5.2)	<0.001
Range	0.9–14.4	0.9–7.8	0.9–14.4	
Gender, n (%)				
Male	138 (60.3)	68 (61.8)	70 (58.8)	0.64
Weight, kg				
Median (IQR)	15.7 (12.7–18.8)	13.9 (12.3–16.7)	17 (13.5–20)	<0.001
Range	8.7–74.0	9.0–37.8	8.7–74.0	
Additional/adjunctive agents,* n (%)				
Topical anesthetics	40 (17.5)	18 (16.4)	22 (18.5)	0.7
Codeine based analgesia	22 (9.6)	6 (5.5)	16 (13.4)	0.05
Atropine	21 (9.2)	13 (11.8)	8 (6.7)	0.25
Paracetamol	13 (5.7)	5 (4.5)	8 (6.7)	0.6
Morphine IV/IM	7 (3.1)	—	7 (5.9)	0.02
Midazolam	5 (2.2)	—	5 (4.2)	0.06
Procedures, n (%)				
Laceration repair	182 (79.5)			
Facial	164 (71.6)	82 (74.5)	82 (68.9)	0.34
Nonfacial	18 (7.9)	9 (8.2)	9 (7.6)	0.86
Foreign body removal	20 (8.7)	12 (10.9)	8 (6.7)	0.26
Orthopedic, n (%)				
Fracture reduction	18 (7.9)	3 (2.7)	15 (12.6)	<0.01
Other	9 (3.9)	4 (3.6)	5 (4.2)	1.0

IM = intramuscular; IQR = interquartile range; IV = intravenous.
*Agents given within 2 hours (see text).

Table 2
Ketamine Procedural Sedation in Children: Comparison of Modes of Drug Administration

	IM* (n = 110)	IV† (n = 119)
Modal distribution, n (%)		
No additional doses	93 (84.5)	58 (48.7)
One additional dose	11 (10)	36 (30.2)
Two additional doses	1 (0.9)	17 (14.3)
Three additional doses	5 (4.5)	5 (4.2)
Four additional doses	—	2 (1.7)
Five additional doses	—	1 (0.8)
Adverse events, n (%)		
No adverse events	71 (64.6)	95 (79.8)
Gastrointestinal		
Emesis during	1 (0.9)	1 (0.8)
Emesis after	18 (16.4)	13 (10.9)
Airway		
Desaturation	2 (1.8)	3 (2.5)
Malalignment	3 (2.7)	2 (1.7)
Excess salivation	12 (10.9)	2 (1.7)
Neurologic and other		
Emergence reactions	2 (1.8)	3 (2.4)
Excessive drowsiness	—	1 (0.8)
Motor disorders	2 (1.8)	1 (0.8)
Seizures	—	1 (0.8)
Dosages of ketamine, mg/kg (±SD)		
Initial dose of ketamine	3.6 ± 0.7	1.1 ± 0.3
Range	1.0–5.3	0.1–2.3
Total dose of ketamine	3.7 ± 0.7	1.5 ± 0.7
Range	1.0–5.7	0.2–4.0
Time variables, hours (±SD)		
Time to discharge from triage time	5.7 ± 1.9	5.3 ± 1.8
Range	2.2–12.4	1.6–14.2
Time to drug administration from triage	2.9 ± 1.5	3.1 ± 1.5
Range	0.2–9.8	1.0–13.0
Time to discharge after drug administration	2.9 ± 1.3	2.2 ± 1.2
Range	0.8–8.8	0.2–6.3
<p>N = 229. Data represented as mean ± SD, or number (%) IM = drug administered via intramuscular route initially; IV = drug administered via intravenous route initially; SD = standard deviation. *Additional dose given IV except in nine cases, where initial and additional doses were given IM †One patient who received IM was assigned to IV group after failed IV insertion (see text).</p>		

For the purposes of analysis, a 1-year-old child was allocated to the IV arm of the study despite two unsuccessful attempts at IV cannulation, necessitating ultimate IM injection of the drug. He required sedation for repair of a 1-cm laceration to his face and received ketamine 133 minutes after arrival in the ED. He received a total of 4.0 mg/kg by means of an initial IM injection and a supplemental dose by the same route. Median pre-sedation fasting times for solids were similar in the IM and IV groups, at 5 hours (IQR = 4–6 hours).

Adverse events occurred in 39 patients in the IM group (35.4%; 95% CI = 26.6% to 45.1%) versus 24 (20.2%; 95% CI = 13.4% to 28.5%) in the IV group (p = 0.01). Overall, the most common adverse events of the sedation were emesis after sedation and excess salivation. There was no difference in the rate of vomiting between patients in the IM group (17.3%; 95% CI = 10.7% to 25.7%) and the IV group (11.8%; 95%

CI = 6.6% to 18.9%; p = 0.24). Excess salivation occurred more frequently in the IM group (10.9%; 95% CI = 5.8% to 18.2%) than in the IV group (1.7%; 95% CI = 0.2% to 6.0%; p = 0.004). In the cases where excessive salivation was noted, atropine was given to 2 of the 11 IM cases and none of the IV cases. Oropharyngeal suctioning was the most common intervention documented and occurred in 13 patients.

There were five episodes of desaturation or airway malalignment in each group (IM 4.5%, 95% CI = 1.5% to 10.3% vs. IV 4.2%, 95% CI = 1.4% to 9.5%; p = 0.9). The lowest saturation in the five patients who experienced desaturations was 80%. They were treated with supplemental oxygen, suctioning, and jaw thrust. One patient required brief bag-mask ventilation. Five additional patients who sustained airway malalignment without desaturation were treated with simple airway maneuvers and oxygen via face mask. No patient aspirated, required intubation, required admission secondary to the effects of sedation, or sustained other complications.

The log-transformed variables of the times between drug administration and discharge, and the total time spent in the ED, were used in univariate then stepwise multivariate linear regression, to determine the influence of relevant patient and treatment characteristics. For the time spent in the ED after drug administration, those who had IV ketamine were discharged on average 21 minutes faster than those who had IM ketamine, adjusted for age and if they had additional doses ($R^2 = -0.35$; 95% CI = -0.5 to -0.19; p < 0.001). Child age showed a small but significant influence ($R^2 = -0.033$; 95% CI = -0.064 to -0.003; p = 0.03) as did the "additional dose required" binary variable ($R^2 = 0.24$; 95% CI = 0.08 to 0.39; p = 0.003). Gender was not significant and thus was not kept in the model. The final model was significant (prob > F < 0.001) and accounted for 14.5% variance (adjusted $R^2 = 0.145$). Comparatively, there was no significant difference between the two groups for the total time spent in the ED ($R^2 = -0.07$; 95% CI = -0.17 to 0.02; p = 0.16), adjusted or not; age, gender, and additional doses showed no significant influence.

Table 3 shows data for a subgroup of 128 patients who received no morphine or midazolam as adjunctive agents and required five or fewer (short stitch subgroup) sutures to repair their lacerations. Most sutures were facial, and demographics were similar to the overall data set. Adverse events occurred in 21 patients (31.8%; 95% CI = 20.9% to 44.4%) in the IM group and 10 patients (16.1%; 95% CI = 8.0% to 27.7%) in the IV group (p = 0.04), with emesis in recovery and excessive salivation being the commonest.

Analysis of the short-stitch subgroup showed a significant difference in the time spent in the ED after drug administration between the two groups; the IV group staying 27 minutes less on average than the IM group ($R^2 = -0.454$; 95% CI = -0.66 to -0.25; p < 0.001). This was adjusted for additional doses, which was significant (adjusted $R^2 = 0.158$). Age and gender showed no significant influence. For the time from triage to drug administration, the IV group experienced 14.4 minutes longer waits than the IM group, adjusted

for age and gender ($R^2 = -0.25$; 95% CI = 0.04 to 0.45; $p < 0.019$). There was no significant difference between IV and IM groups for the total time spent in the ED.

Even when the crossover group ($n = 9$, received IM + IV ketamine) was removed from the analysis, there was still a significant difference ($p = 0.0094$) in the time spent in the ED after drug administration, with "IM only" at 2.7 hours, "IV only" at 2.1 hours, and "IM + IV" at 3.8 hours. The longer time to drug administration still persisted in the IV-only group; mean values were 2.7 hours in the IM-only, 3.2 hours in the IV-only, and 2.7 hours in the IM + IV. There was no difference in the total time spent in the department in the two modes of drug administration when crossover patients were excluded ($p = 0.87$).

DISCUSSION

This study describes a single-center experience comparing duration of ED stay with IM versus IV ketamine for procedural sedation, where the majority of procedures were laceration repair (80%). We found a statistically significant and clinically relevant difference in the time to discharge after administration of ketamine, with the IM group staying on average 21 minutes longer than the IV group ($p = 0.001$). However, we found no difference in the average total time spent in the ED between the two groups ($p = 0.16$).

The choice of IM versus IV has historically been based on level of expertise with IV cannulation, ED resources, perceived patient comfort and characteristics, and physician experience and preference.^{5,11} Ketamine has been shown to be safely administered both IM and IV, and the clinical questions affecting this choice now focus on side effect profiles and time spent recovering from the sedation.^{6,11} Although our study was not a randomized trial, and there were some important baseline differences between groups, the use of IM and IV administration at equal rates, even in a comparative subgroup, has shown some important findings that may have practical implications on the use of ketamine.

The only similar recent study, by Roback et al.,⁶ compared the two modes of parenteral ketamine sedation directly, but was prematurely terminated due to nursing resistance to prolonged ketamine sedation via IM injection (median of 129 minutes in the IM vs. 80 in the IV group). The study was a prospective RCT where the patients were randomized to receive 4.0 mg/kg IM or 1 mg/kg IV, and the main outcome measures were adverse events, efficacy, and the length of sedation.

In a case series of IV ketamine in 1998 by Green et al.,⁴ and a subsequent review of the topic by Green and Krauss in 2004,⁵ recovery appeared 20 minutes faster when ketamine was administered IV compared to IM. Although it was not possible to precisely reconstruct why IV patients took longer from triage to drug administration in our study, it can be assumed that this was due at least in part to the time needed for insertion of IV access itself or waiting for topical anesthesia to work. It may be possible to reduce the delay caused by topical anesthesia, which is routinely applied in our department prior to IV insertion, through earlier application.

The rationale behind IV ketamine sedation may be the preference of having IV access as a precautionary measure or the desire to titrate drug dose to effect. Ketamine does not display the dose-dependent response continuum shown by most procedural sedation and analgesia agents.⁵ It has a narrow transition zone, suggesting that adequate sedation is either present or not at a given dose, and giving additional doses to a patient in an already dissociative state does not deepen or enhance sedation.⁵ Therefore, it is perhaps more important to give a "reasonable" initial ketamine dose to attain ideal procedural conditions.

Morton suggests that a blood serum level of 1.5 mg/L of ketamine in children is associated with slow arousal to consciousness with sustained painful stimulus; this level corresponds to 1.5 mg/kg IV and 2–4 mg/kg IM.¹⁴ Reviews of clinical studies suggest an initial IV dose of 1.5 mg/kg and 4–5 mg/kg IM to reliably achieve dissociative sedation.^{5,11,15} In the overall group, the initial doses were 3.6 mg/kg IM and 1.2 mg/kg IV. The fact that 52% of the IV group (vs. 15% IM) required supplemental doses and a mean total dosage of 1.6 mg/kg to achieve adequate sedation makes an argument for a higher initial IV ketamine dose. The main criticism of the trial of Roback et al. comparing IV and IM, where the latter was found to be more effective, was based on the low 1 mg/kg IV dose versus the 4 mg/kg IM dose.¹¹

In the ketamine ED series by Green et al.,² all administered IM, airway complications were noted in 1.4% of children, consisting of airway malalignment (0.7%), transient laryngospasm (0.4%), and apnea or respiratory depression (0.3%). In our data we found a higher rate of respiratory complication in the IM group (oxygen desaturations below 90% occurring in 1.8% and malalignment in 2.7%), when compared with the figures of Green et al.,² but less than those from the RCT by Roback et al. comparing IV versus IM.⁶ We found airway events beyond excessive salivation to occur at equal rates in both IV and IM groups. However, excessive salivation was noted more frequently in the IM group (11%) versus IV (2%; $p = 0.004$). In the study by Roback et al.,⁶ excessive salivation, recorded under respiratory events, was seen in both groups at similar rates (1.8% IM group vs. 1.7% IV). Ketamine stimulates oral secretions, and there is no consensus on whether co-administration of an anticholinergic is essential, with evidence from observational studies and RCTs to support both sides of the argument.^{5,9,10} Hypersalivation to a degree requiring interventions is difficult to distinguish from the increased salivation expected with ketamine use. We did not define this in our study and accepted any report of hypersalivation as an adverse event, which might account for the high rate in our study.

Patients in the IM group had, overall, more adverse events than those in the IV group ($p = 0.01$). It has been said that when emesis occurs in conjunction with ketamine sedation, it happens late in the recovery phase when the patient is able to clear his or her own airway.⁵ While the rates of vomiting we observed (17.3% in the IM group and 11.8% in the IV group, with most occurring in the recovery phase) were higher than

Table 3
Ketamine Procedural Sedation in Children: Comparison by Mode of Administration in Short-Suture Subset Group (Five Sutures or Fewer and No Confounding Morphine or Midazolam)

	IM (n = 66)	IV (n = 62)
Age, years		
Median (IQR)	2.3 (1.7–3.0)	3.4 (2.1–4.0)
Range	0.9–7.2	1.2–10.0
Weight, kg		
Median (IQR)	13.7 (12.2–16.0)	15.9 (13.0–18.4)
Range	9.0–24.2	10.0–43.0
Gender ratio, male	41 (62.1)	37 (59.7)
Procedure: laceration		
Facial	59 (89.4)	57 (91.9)
Nonfacial	7 (10.6)	5 (8.1)
Dosages of ketamine, mg/kg		
Initial dose of ketamine	3.6 ± 0.7	1.2 ± 0.3
Range	1.9–5.3	0.5–2.2
Total dose of ketamine	3.8 ± 0.7	1.6 ± 0.7
Range	1.9–5.7	0.8–4.0
Adverse events		
No adverse events	45 (68.2)	52 (83.9)
Gastrointestinal		
Emesis during	1 (1.5)	—
Emesis after	8 (12.1)	5 (8.1)
Airway		
Desaturation	1 (1.5)	1 (1.6)
Malalignment	1 (1.5)	1 (1.6)
Excessive salivation	8 (12.1)	1 (1.6)
Neurologic and other		
Emergency reaction	1 (1.5)	2 (3.2)
Motor disorder	2 (3.0)	1 (1.6)
Time variables, hours (±SD)		
Time to discharge from triage time	5.5 ± 2	5.3 ± 1.8
Range	2.2–12.4	1.6–14.2
Time to drug administration from triage	2.7 ± 1.6	3.2 ± 1.7
Range	0.2–9.8	1.0–13.0
Time to discharge after drug administration	2.8 ± 1.3	2.1 ± 1.0
Range	1.0–8.8	0.2–5.1

n = 128. Data represented as mean ± SD or number (%), unless specified otherwise. IV = intravenous; IM = intramuscular; SD = standard deviation; IQR = interquartile range.

those suggested by cumulative analysis of trial data on the subject,¹¹ they are lower than those suggested by Roback et al.,⁶ where emesis was twice as frequent in the IM group (26% vs. 12%).

LIMITATIONS

Limitations to our study include its observational nature. Attending clinician preference may have selected patients into the two study groups (IM or IV) and introduced systematic bias. However, the analysis of the largely comparable subgroup yielded results similar to those of the overall sample. Although the registry was prospective, the data used for this study were extracted retrospectively. Assessment of times in the ED was based on a number of disparate data sources (clerks, medical staff, nursing staff) and factors beyond sedation and recovery affected patient flow. We expect that any bias introduced by postprocedural administrative and

logistic tasks would impact on both IM and IV groups in a similar fashion. However, ultimately only an RCT can address these confounding factors. As in most studies, the quality of data recorded in the medical notes varied between staff, but we feel it is likely that all significant events were recorded and reviewed. Finally, an important limitation of the study is the difficulty in generalizing the results to other EDs. Many factors contribute to the time from triage to discharge, which may vary from ED to ED, including available resources and IV placement skills. In addition, similar to the practice in some other Australian EDs, most fracture reduction in children in the ED is performed using IV regional anesthesia (such as Bier's block), which will skew procedural use of ketamine away from orthopedic use.

CONCLUSIONS

In our prospective case series of pediatric ketamine sedation, we found time to discharge after drug administration to be shorter with IV administration compared to the IM route, both overall and in a comparable subgroup. However, there was no difference in the total time spent in the ED between the two groups, both overall and in the subgroup. Clinically, this suggests that the time saved by administering the drug IV is balanced by the time delay due to IV catheterization, making the choice of route of administration for children requiring very brief procedures one largely of clinician preference.

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