Paediatric procedural sedation using ketamine in a UK Emergency Department: a 7 year review of practice

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Abstract:

Background: Ketamine is growing in popularity for procedural sedation in the paediatric population, yet safety concerns remain. We performed a retrospective review of practice and outcomes of paediatric ketamine sedation using the World SIVA International Sedation Task Force reporting tool.

Methods: A retrospective inspection of the dedicated Emergency Department electronic sedation database and subsequent note and sedation chart review was performed for all paediatric sedations over a 7 year period from September 2006. All adverse events were stratified.

Results: During the study period a total of 243 paediatric procedural sedations were undertaken, of which 215 used ketamine, most commonly for wound management (n=131). The median patient age was 4 years (14 months – 15 years). 63.7% were male. 76.7% were discharged home either directly (n=101), or following brief observation (n=64). One patient required subsequent General Anaesthetic following a failed sedation with paradoxical agitation. 9.8% of patients had an adverse event, the most severe risk stratification being “minor risk”. All interventions were “minimal risk”. There were no “sentinel risk” outcomes.

Conclusions: This data supports the on-going use of ketamine for paediatric procedural sedation in the Emergency Department by non-anaesthetists. Relatively high resource requirements mean ensuring adequate numbers may prove challenging.

MESH keywords: Anaesthesia - emergency service; Anaesthetics i.v. – ketamine; Safety – techniques; Sedation

Introduction: The phencyclidine derivative ketamine has a number of characteristics that make it popular for procedural sedation, nowhere more so than in the Emergency Department where otherwise painful procedures are performed. Unlike other general anaesthetic agents, ketamine causes a "dissociative anaesthesia" as a result of a functional dissociation between the cortical and limbic systems[1,2]. Due to its relative cardiovascular stability and maintenance of protective airway reflexes[2,3] there has been a gradual increase in its use and popularity as a sedation agent, particularly within the paediatric population[4].

Historically, paediatric sedation using ketamine was introduced in radiotherapy and burns patients[5-7]. Evidence has subsequently built up supporting its use in the Emergency Department[8–16] particularly in North America where it is standard practice in many hospitals[17-19]. By comparison the UK has been relatively slow to develop this technique into mainstream practice[20-21]. The Royal College of Emergency Medicine issued a guideline as early as 2004. The update in 2009[22] outlined several advantages including a wide safety margin, avoidance of a general anaesthetic and physical restraint, as well as high efficacy. However, like all drugs, ketamine, is not without side effects which include respiratory depression, airway compromise, hypersalivation, emesis and emergence phenomena[3,4].

The debate around provision of sedation by non-anaesthetists is one that continues[23-26]. Proponents argue that ketamine is fundamentally different and should be treated as such[27]. Recently, in response to disparities in sedation adverse event reporting[28], the World Society for Intravenous Anaesthesia (World SIVA) developed an adverse event reporting tool[29] with the intention of providing outcome standardisation and aggregation, with subsequent transparent comparison of adverse sedation practice outcomes. This has been used in other non-anaesthetist delivered settings[30]. In light of the availability of this tool, the on-going debate around non-anaesthetist delivered paediatric sedation, and the need for continual scrutiny of our practice we performed a retrospective review of paediatric ketamine sedation in our UK-based Emergency Department.

Methods: The Royal Devon and Exeter Hospital Emergency Department has maintained an electronic database of all procedural sedation undertaken since 2006. This was interrogated to identify all paediatric sedations over a 7-year period. A retrospective note review, including the departmental ketamine sedation proforma, of those patients identified was performed. Any adverse events identified were scrutinised using paper and electronic records, and risk stratification performed using the World SIVA adverse event reporting tool[29].

Demographic information was collected, alongside indications, sedation methods and the any adverse events. All data was anonymised, and subsequent statistical analysis performed using Microsoft Excel (Professional Plus 2010). Statistical significance (p) was placed at 0.05. In accordance with local policy and following completion of the Health Research Authority/Medical Research Council decision tree, ethical approval was deemed unnecessary. Incomplete data domains were excluded from statistical analysis.

Royal Devon and Exeter Emergency Department has developed a Paediatric Ketamine Procedural Sedation Protocol that has evolved over several years, and all sedations were performed according to this protocol. The most recent version is shown in Appendix 1. In accordance with this departmental protocol all sedations were performed in the "Resus" area of the department with Emergency drugs including suxamethonium, defibrillators and advanced airway equipment available. All patients underwent close monitoring using ECG, blood pressure, oxygen saturation and respiratory rate. Nasal capnography was introduced in the department in late 2011 and used routinely therein.

Local guidelines were updated in 2008 to mandate staffing to include at least one sedating doctor at Consultant level, a procedure-tasked operator and nurse. These fulfil obligations set out in UK guidelines issued[31].

Discharge criteria following sedation include pre-procedure ambulation, adverse symptom resolution and appropriate supervision. In addition, there must be no injury related reason for on-going observation or admission.

Results: From September 2006 to September 2013, a total of 243 paediatric procedural sedations were undertaken, of which 215 used ketamine. All non-ketamine sedations were excluded from subsequent analysis but included both inhalational and intravenous techniques (see Table 1). After ketamine, the most common technique was nitrous oxide, in isolation (n=9) or in combination with other techniques (n=9).

Sedation method	Number performed
Ketamine	208
Ketamine & IN diamorphine	4
Ketamine & morphine	3
Nitrous oxide	9
Nitrous oxide & midazolam	8
Propofol	3
Midazolam	2
Morphine	1
Propofol & morphine	1
Propofol & IN diamorphine	1
Alfentanil & nitrous oxide	1
Midazolam & morphine	1
Fentanyl & nitrous oxide	1
	243

Table 1: Methods used for paediatric sedations. Nitrous oxide refers to 70% nitrous oxide, 30% oxygen mix.

The median patient age was 4 years (range 14 months – 15 years). 137 (63.7%) of all patients undergoing ketamine sedation were male. The most common indication for ketamine sedation was wound management (n=131), followed by management of fracture and/or dislocation (n=62) (Table 2).

Foreign body	19
Dental procedure	3
Fracture/dislocation management	62
Wound management	131

Table 2: Indications for paediatric ketamine sedation (n=215)

Intravenous (IV) sedation was used in 187 cases (87.0%), whilst intramuscular (IM) ketamine was administered in 28 patients. Median initial dose was 1.25mg/kg IV, and 3.94mg/kg IM. Supplemental doses were required in 70 cases – in 34.8% of IV dosed patients and 17.9% IM patients. Supplemental doses were given for a prolonged procedure time (n=32) or in response to inadequate seda-

tion (n=38). There was no difference between mean initial doses for those patients requiring additional sedation with intravenous (p=0.07) or intramuscular (p=0.20) administration. Median (mean) total doses were 1.65 mg/kg (1.5 mg/kg) IV and 4.63 mg/kg (4 mg/kg).

Over the period examined, with the exception of one year (September 2011-12), there was a decrease in the annual number of paediatric ketamine sedations performed. The mean year-on-year reduction in numbers performed was 10.9%. Over the entire study period, 186 sedations (86.5%) were performed with at least one Consultant present. Of those performed without documented direct consultant involvement, 80% of those were prior to 2008.

Of all patients, 165 (76.7%) were discharged home. This includes 101 who were discharged directly, with a further 64 discharged following a brief period of observation. In 2010, a Paediatric Assessment Unit (PAU) was introduced from which 25 patients underwent transient post-sedation observation. Prior to this, 39 patients were briefly admitted to the General Paediatric ward for observation under the care of the duty senior emergency physician prior to discharge. One patient was admitted for failed sedation, requiring a subsequent procedure under General Anaesthetic. Forty-nine admissions (43.0%) were attributable to the injury itself, and were unrelated to the sedation.

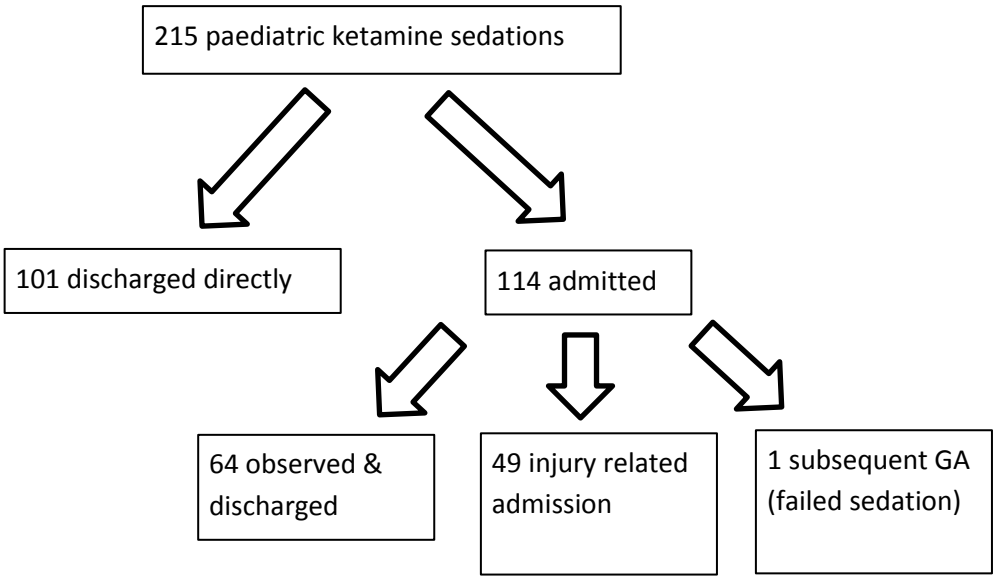

Figure 1: Overview of patient destinations.

According to the specified adverse event tool, 21 patients (9.8%) had an “adverse outcome”(Table 3). The most common of these were agitation and apnoea. Of all adverse events documented, the most severe according to the greatest risk posed were “apnoea” and “desaturation”. These were both clas-

sified as being of “minor risk” as a result of the transient nature of the events. With the exception of one paradoxical agitation requiring admission and a subsequent General Anaesthetic, all outcomes fell into the “minimal risk” category. All interventions were “minimal risk”, with the single most frequent intervention being “none required”. There were no “sentinel risk” (i.e. critical enough to represent real or serious imminent risk of serious and major patient injury) descriptors, interventions or outcomes over the 7 year period.

Adverse Events	Minimal risk descriptors	Minor risk descriptors
Recovery agitation	4	0
Apnoea (not prolonged, <60s)	0	4
Paradoxical response	1	0
Desaturation (75-90%, <60s)	0	2
Failed IV access	3	0
Rash	3	0
Vomiting/retching	3	0
Hypersalivation	1	0
Interventions	Minimal risk intervention	Minor risk intervention
Supplemental oxygen, new or increased	4	0
Airway repositioning	5	0
Tactile stimulation	1	0
None required	11	0
Outcome	Minimal risk outcome	Moderate risk outcome
	20	1

Discussion: We have demonstrated that the paediatric procedural ketamine sedation appears safe in our department. Over a 7-year period there were no major or sentinel adverse events or outcomes in 215 consecutive children. This is the first time the World SIVA adverse event tool[29] has been used for paediatric ketamine sedation, although the tool has been used elsewhere in both adults, and children[26, 30, 32-36]. There are many advantages to using an internationally recognised sedation reporting tool, including the standardisation of terminology of adverse events, and allowing ease of comparison between different centres. There are other paediatric sedation tools available[37], however we found applying the World SIVA tool retrospectively straightforward.

One advantage of this tool is that it clearly categorises events and outcomes (Table 2) for subsequent analysis. In this case series, the most severe events were both categorised as minor risk descriptors and were “apnoea (not prolonged, <60 s)” and “oxygen desaturation (75-90%, <60 s)”. One episode of desaturation was due to partial airway obstruction, and the other was a probable meas-

urement error with a documented rapid “jump” to normal values. The interventions were also deemed “minimal risk”. It is worth noting that the majority of adverse effects demonstrated were recognised side-effects of ketamine itself.

No drug is without side-effects and ketamine is no exception. Experience from North America has identified a number of predictors of airway complications including age (< 2 years, > 13 years), high-doses and co-administration of anticholinergics or benzodiazepines[38]. Similarly, patterns of post-emergence agitation and emesis have been identified[39]. The encompassing nature of the World SIVA tool means that many recognised side-effects of ketamine such as vomiting or hypersalivation are included in the 9.8% overall adverse event rate. It is a therefore a strength of this tool that it can differentiate the degrees of severity of events.

Over the time period of this study, our Emergency Department admissions increased by over 30%. It is perhaps surprising therefore, that over the same time period numbers of paediatric ketamine sedations decreased by a mean 10.9% per year. As with any procedure, maintaining patient safety is paramount and because of the necessary patient safety precautions, procedural sedation is “resource heavy” in its requirements for senior staff and a “Resus” bay for appropriate monitoring[31]. With increasing pressures on Emergency Departments, it may be that providing this service becomes more challenging.

It has been argued that the differing mechanism, clinical effects and safety profile of ketamine mean traditional definitions and sedation scales are inappropriate[27]. Furthermore, the lack of a defined dose-response continuum has led to the definition of dissociative sedation as achieving profound analgesia and amnesia, with retention of protective airway reflexes, spontaneous respirations, and cardiopulmonary stability”[27]. In the context of this definition, it is arguable that those patients requiring simple airway manipulation and becoming apnoeic were receiving general anaesthesia.

The decreasing numbers of paediatric sedations performed raises an interesting dilemma regarding maintenance of skills. When a sedation goes unremarkably - as the vast majority of these did, there is little testing of the robustness of the rescue systems that are in place. It is when adverse events of an escalating severity occur that the systems are truly tested. In a review of 95 adverse paediatric sedation events (including 51 deaths), it was noted that severe complications are most often attributable to the skills of the practitioner in failing to rescue the patient[40]. This is not a new phenomenon[41],

and it has been argued that paediatric sedation outside large centres may result in poorer outcomes[42]. However this data suggests that this may not be the case providing that on-going training and continuous reviewing of practice occurs amidst a robust clinical governance strategy. For example, our current departmental strategy includes annual review of cases and physician caseload, an annual workshop on laryngospasm with senior anaesthetist input, and having the management of laryngospasm embedded within the ketamine sedation chart

The same adverse events review noted physician type was unrelated to complications – and certainly this is an opinion that has been raised vociferously elsewhere[43]. It has been argued that dividing providers into anaesthetist/non-anaesthetist subgroups does not account for the discrepancies in skills and training, and that instead studies regarding complications should be stratified by skill level and competency to ensure rigorous safety standards[42]. A recent review of our Emergency Department adult propofol sedation practice[30], and the debate that ensued, demonstrates the variety in acceptance and perceptions of emergency physician delivered sedation[23-25,44,45].

Some anaesthetists will be more comfortable providing a General Anaesthetic[46] for the paediatric population than sedation. By contrast, Emergency Physicians may be more frequently exposed to and potentially be more comfortable performing paediatric sedation.

In children undergoing MRI and CT, it has been demonstrated that a General Anaesthetic provides better image quality and an improved safety profile[47]. Nonetheless, to our knowledge no direct comparison studies in terms of safety or satisfaction, comparing General Anaesthetic with sedation, have been performed in the Emergency Department setting.

Our results showed that 76.7% of patients were discharged home following a period of supervised recovery either within the Emergency Department, the PAU or the paediatric ward. Only one patient had a sedation that failed due to paradoxical agitation, requiring a subsequent General Anaesthetic. The remainder of patients admitted were done so for definitive management of their original injury following initial management performed under sedation. This overall equates to a total of 165 avoided General Anaesthetics – a clear reduction of pressure on both theatre and anaesthetic services. In addition, there are other advantages such as reducing admission times and minimising further disruption to the lives of the parents and families.

These results are limited by the fact they are from a single institution and are based upon a retrospective chart/notes review, from which extrapolating quantitative data can be "fraught with error"[48]. However, the majority of reported outcomes such as complications and discharge outcomes are clear-cut and there was very limited abstraction or room for interpretation. Similar methods have been used previously in a multi-centre study to demonstrate that ketamine procedural sedation provides a faster turnaround time in paediatric radial fractures when compared to a general anaesthetic[49]. This faster discharge time has benefits for both child and family in terms of minimising disruption and loss of earnings.

We have demonstrated that an emergency department paediatric ketamine sedation programme can be delivered safely in a UK non-specialist tertiary paediatric centre. This will be no surprise to many given the established safety profile of paediatric ketamine sedation elsewhere[8-21]. However, with increasing pressures on departments, maintaining safety standards is paramount. Sufficient numbers of procedures must be performed to maintain skills and procedural familiarity, and as such efforts need to be made to ensure procedural sedation continues to be done in a safe and timely manner – and in sufficient numbers to ensure continued safety of this valuable service that benefits children and their families.

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LK: Manuscript preparation, data collection, data analysis

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