An audit of the use of intravenous ketamine for paediatric dental conscious sedation

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IN BRIEF

- Highlights that the use of ketamine as a single drug operator/seditionist technique has been shown to be safe and effective in the treatment of anxious children.
- Suggests that the application of intravenous sedation is a valuable option in the variety of strategies available for the management of anxious children, particularly reducing the need for general anaesthesia.

RESEARCH

VERIFIABLE CPD PAPER

Aim An audit of the use of intravenous ketamine for the provision of conscious sedation in paediatric dentistry was carried out over a three-year period. **Audit design** In the audit, 3,751 children were treated and an evaluation was carried out for safety and effectiveness of the drug and procedure, the quality of sedation and clinical procedures provided. In addition, the occurrence of any adverse effects and parental satisfaction were noted along with recovery. All children were ASA I and II, with an average age of 7.5 years. Children were referred because of management problems and were assessed to be at the high anxious level of four and five on the Venham scale. A weight related 0.25 mg/kg was initially administered with additional increments of 0.25 mg/kg given if required. The average total dose provided was 0.41 mg/kg. **Results** The majority of children (76%) accepted all treatment with no problems, with 19% experiencing a small amount of resistance. Although a range of dental treatment was provided, it was mostly exodontias of carious primary dentition. A 27% response was provided assessing satisfaction which was very favourable. No adverse reactions occurred although the most common postoperative experience was nausea. **Conclusion** This audit demonstrated the safety and effectiveness of using intravenous ketamine for paediatric conscious sedation and implications for training and appropriate service delivery were discussed.

INTRODUCTION

The management of pain and anxiety in children can be a challenging process.[1] Various strategies are available ranging from behavioural management,[2] conscious sedation[3] and general anaesthesia.[4] How these are employed depends on resources, service availability, expertise in techniques and differing professional practices. Professional standards play a significant role in this area of care, particularly to ensure the safety of children, and in 1998 the GDC endorsed the need for conscious sedation.[5] One of the most marked influences for change came as a result of the Poswillo report,[6] following which the strategy of general anaesthesia was transferred to the hospital environment. The results of this had a major effect on the availability of this service and the dental profession responded positively by exploring alternative strategies to general anaesthesia. Conscious sedation seemed appropriate and its use was expanded by the profession within primary care.[7] Although alternative options are available, for example the use of restraint, this is not commonly accepted within the UK,[8] whereas inhalation sedation tends to be the preferred option in paediatric dentistry.[9] The use of nitrous oxide inhalation sedation combines the excellent properties of nitrous oxide with the requirement to focus on careful and considered child management in order for success to be achieved. In some cases however, the degree of child cooperation required to comply with continuing nasal respiration is not forthcoming and various alternatives of more advanced sedation techniques have been explored. For example, the use of sevofluorane in combination with nitrous oxide inhalation sedation,[10] use of nitrous oxide in combination with oral midazolam,[11] intravenous midazolam as a single drug technique,[12] propofol intravenous sedation,[13] transmucosal (intranasal) and in combination with intravenous midazolam,[14] and the use of ketamine and midazolam administered intravenously.[15] All these techniques have advantages and disadvantages and require expert knowledge and experience to ensure complete safety and efficacy. For adults, intravenous midazolam sedation provided by an operator sedationist is regarded as a basic technique by the dental profession;[16] however, for children intravenous conscious sedation is not included in the same way. Work has been carried out to explore midazolam as a single intravenous drug use for conscious sedation in paediatric dentistry and has shown some favourable results.[12] Other single drug intravenous techniques, such as propofol, have been trialled with good results but require a second professional to control the drug administration.[17] Ketamine has been used for conscious sedation in children with very favourable results in accident and emergency departments,[18] although this particular drug has not been commonly employed by the dental profession.[1] Therefore the integration of ketamine into the range of conscious sedation as a management technique within dentistry could provide a valuable option, albeit an advanced technique for challenging paediatric cases.

Ketamine, a derivative of the psychedelic drug phencyclidine, was introduced in 1962, and approved for human use in 1970 as a safe anaesthetic. It produces dissociative anaesthesia or dissociative sedation depending on the dose and route of administration. Sedation is characterised by a state of profound analgesia, amnesia, sedation and catalepsy. A definition by Green[19] suggests that sedation is 'a trancelike cataleptic state induced by the dissociative agent, ketamine, characterised by profound analgesia, and

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Refereed Paper
Accepted 9 April 2015
DOI: 10.1038/sj.bdj.2015.390
©British Dental Journal 2015; 218: 573–577

amnesia, with retention of protective airway reflexes, spontaneous respirations and cardiopulmonary stability'.

The onset of action and peak plasma concentration of ketamine occurs about a minute after intravenous administration. The distribution half-life is 10–15 minutes and elimination half-life is 2–3 hours. Ketamine is highly lipid soluble and only 12% of the agent is bound to proteins so that it rapidly crosses the blood-brain barrier. The duration of sedation is dose-dependent and is usually 5–10 minutes when administered intravenously. For this reason ketamine is probably more suitable for procedures of shorter duration when used for sedation.

In contrast to other anaesthetic/sedative agents, which may have a depressive effect, mild cardiovascular stimulation occurs when ketamine is administered. As it has a positive inotropic effect on the heart, increasing the heart rate, cardiac output and the blood pressure, it should not be used in patients who are hypertensive and at risk of cerebrovascular accidents and ischaemic heart disease. Uniquely among anaesthetic agents, ketamine is able to maintain the functional residual capacity of the lungs during sedation decreasing, the chances of intra-operative hypoxaemia. Patients will breathe spontaneously, even when fully anaesthetised, as they would in their awake state with the minute volume being maintained. Ketamine may be used for asthmatic patients because it causes bronchodilation and does not induce histamine release, airway and respiratory events are rare.[20] Ketamine may stimulate salivary and trachea-bronchial secretions and laryngospasm has been reported when high doses of ketamine are used and in children younger than three-months-old. In addition, ketamine has also demonstrated anticonvulsant properties and has a recognised analgaesic property very valuable for dental sedation.[21]

Emergence phenomena, the most reported side-effect of ketamine occurs in less than 5% in some studies and about 1% in children.[22] This includes vivid dreams, floating, hallucinations and delirium. The incidence is dose related as well as rate of administration of the drug.

When used for sedation the intravenous doses reported have generally ranged from 0.25–0.5 mg/kg intravenously, however much of the evidence for sedation has involved the use of ketamine in combination with other drugs.[15,23–25]

Evidence for the use of ketamine has tended to involve its combination with other drugs, such as midazolam which has amnesic properties valuable in negating the rare unpleasant emergence effects of

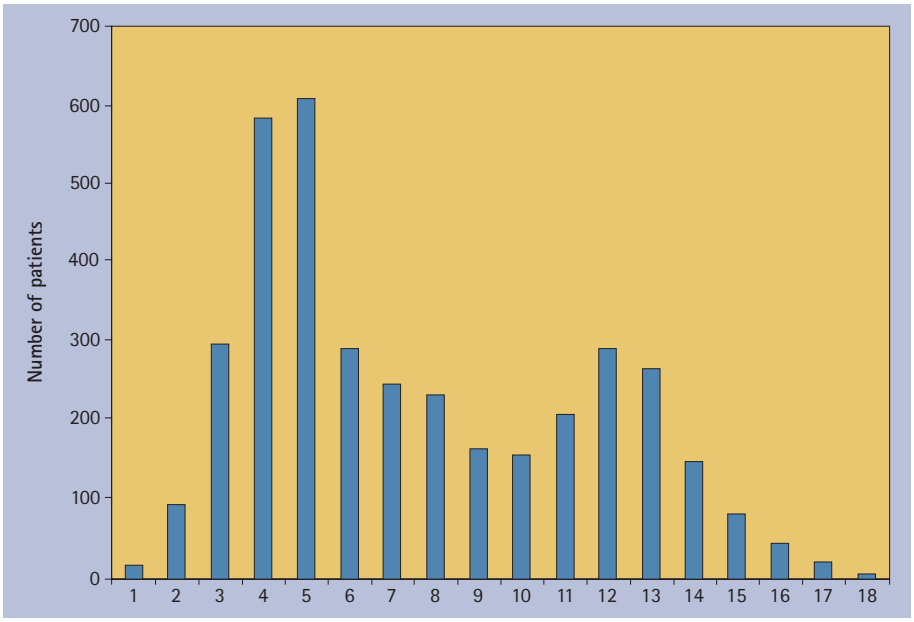

Fig. 1 Age distribution

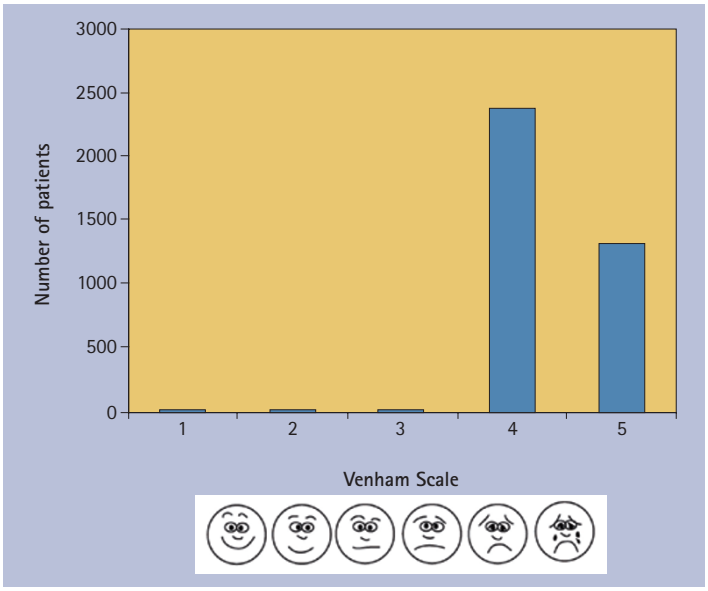

Fig. 2 Venham anxiety scale

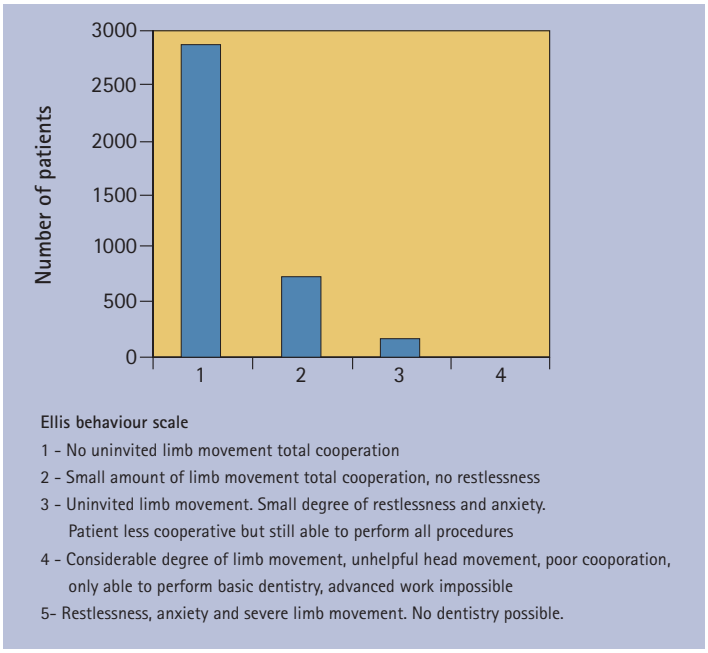

Fig. 3 Response of acceptability to sedation and treatment

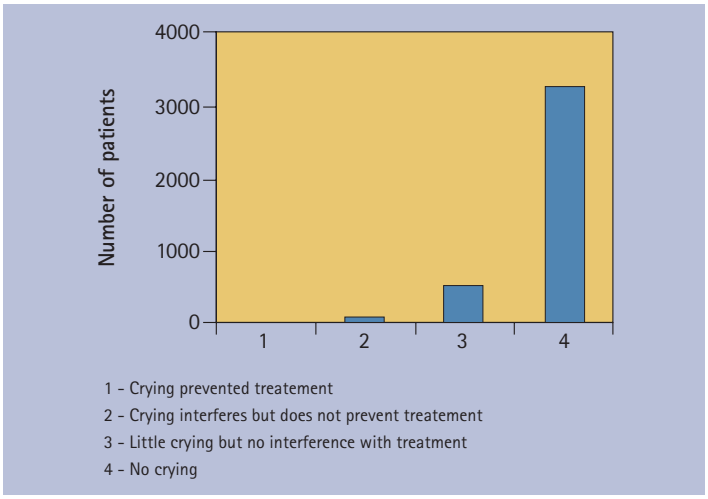

Fig. 4 Emotional response represented by crying

ketamine. Midazolam and ketamine have been demonstrated to be safe and effective for intravenous paediatric dental sedation.[15] The combination of low dose propofol and a titrated dose of ketamine for paediatric dental sedation has also been used and were shown of be safe and effective in results for 2082 cases.[23]

The body of this evidence suggests that ketamine may be an effective and safe drug to be used for paediatric dental sedation as an operator seditionist technique.

In view of the concerns in the UK associated with intravenous paediatric sedation,[1,26] a prospective audit of a single drug regime was therefore undertaken to determine the safety and efficacy of ketamine when administered intravenously for conscious sedation in children.

AIM

The aim of this audit was to investigate the safety, efficacy and acceptability of intravenous ketamine for paediatric dental sedation.

Objectives were defined with which to assess achievement of this aim.

Objectives

- To determine the effectiveness of the use of ketamine administered intravenously to provide conscious sedation for dental treatment of children
- To assess the safety of the technique described
- To investigate the quality of the sedation provided
- To determine the range of dentistry possible using this sedation
- To record the duration of treatment episodes and recovery time
- To record any adverse effects during, and after treatment in recovery, for 24 hours and a week follow-up
- To determine the acceptability of this technique from the patients' and parents point of view.

AUDIT DESIGN

Patients included in this audit were obtained by referral from primary care dental practitioners within the Luton area. All patients were accepted for referral with no age exclusion, however ASA I and ASA II only were almost exclusively included in the audit. Information was obtained over a three-year period and all treatment was carried out by one dental practitioner working within primary care as an operator seditionist. The following patient related information was initially recorded: weight, medical history, ASA status, anxiety level and dental treatment required.

In addition to routine pulse oximetry monitoring, assessments of patient response were recorded during sedation including: cooperation and quality of sedation Ellis scale, emotional response that is, incidence of crying. Also noted were side effects during immediate recovery and post-operative 24-hour period, recovery times and dental treatment provided.

CLINICAL TECHNIQUE

Patients were initially assessed, the treatment plan discussed and the parents' written consent was obtained, following treatment confirmation. Clear pre- and post-operative written instructions were then provided. Children were asked to fast for four hours and were limited to clear fluids for two hours before their appointment. A Eutectic Mixture of Local Anaesthetic (EMLA cream) was applied to their skin pre-operatively.

Ketamine was obtained at the 50 mg/ml concentration and diluted in water for injection providing a 1 mg/ml preparation and ease of administration. Venous access was obtained using a 26 gauge Venflon cannula, usually in a superficial vein on the dorsum of the hand or the antecubital fossa. Parents were asked to distract the child during this procedure while the nurse stabilised the child's hand for venepuncture with gentle hand-holding. This enabled the veins to become more visible and was in preference to a tourniquet On occasion, as required, clinical holding was used to facilitate this procedure.

A weight related initial dose of ketamine 0.25 mg/kg was then administered. Following this, further doses of ketamine (0.25 mg/kg) were administered if required, depending on patient response and clinical need. Local anaesthesia was achieved by buccal and lingual/palatal infiltration of articaine 4% with 1:200 000 adrenaline solution. The procedure followed the strict guidelines of conscious sedation ensuring that patients maintained consciousness and were responsive throughout. Following completion of treatment, patients were transferred to a dedicated recovery area where trained recovery nurses constantly monitored the heart rate and oxygen saturation. Patients were discharged according to strict criteria which required the child being fully responsive, reacting well to verbal commands, having the ability to stand and walk unaided. An appropriate escort was provided with clear post-operative verbal and written instructions and a dedicated telephone number for contact if concerned. Data was recorded on a specifically designed audit form. The surgery monitoring and responses were recorded by an attending dental nurse.

RESULTS

Results from 3,751 cases are presented, 49% (1,838) being male and 51% (1,913) female. The average age was 7.56 years (± SD 3.82) with an age range from 1–18 years (Fig. 1).

88.4% of the children were ASA I, 11.5% were ASA II, with the remaining small number of 11 children (0.2%) being ASA III. The mean weight in kg was 31.11 (±SD 15.9) with a range of 8–145 kg.

Using a simple Venham scale, figure 2 shows that children who were initially assessed for treatment with sedation were predominantly at anxious levels of the four and five range.

The average total ketamine dose was 0.41 mg/kg (±SD 0.17) with a range of 0.1–2.06 mg/kg

In terms of assessing cooperation for the process of sedation and treatment, 75.55% of children accepted cannulation well, whereas 24.45% presented some behavioural problems.

Assessment of the quality of sedation and cooperation for treatment as represented by the Ellis scale showed that 2,873 (76.5%) were at level one, 709 (18.9%) were at level two and the remaining 5% at levels three and four (Fig. 3), demonstrating that in 95.4% of cases all planned treatment was completed.

By recording crying to reflect an expression of emotional response, results indicate that in the majority of cases this was not a common occurrence (Fig. 4).

Pulse oximetry showed that during treatment there were no incidents where oxygen saturation dropped below 90%. The side effects from sedation were monitored in all patients during treatment, recovery and discharge. For a further 24 hours information was also available from 1,023 (27%) patients who responded to a post-treatment questionnaire (Fig. 5). Nausea was seen to be the most common problem, which is a recognised effect of ketamine. Of the group who responded to the post-treatment questionnaire, there was predominantly a high level of satisfaction (Fig. 6). The average treatment time was 6.7 minutes and recovery time 26.6 minutes. Although a range of treatments were provided they were mostly extractions (Fig. 7).

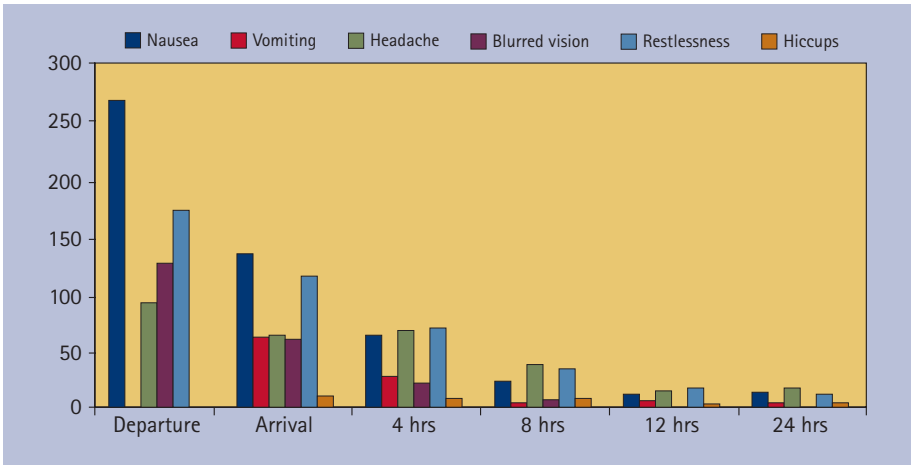

Fig. 5 Side effects represented by 27% of sample

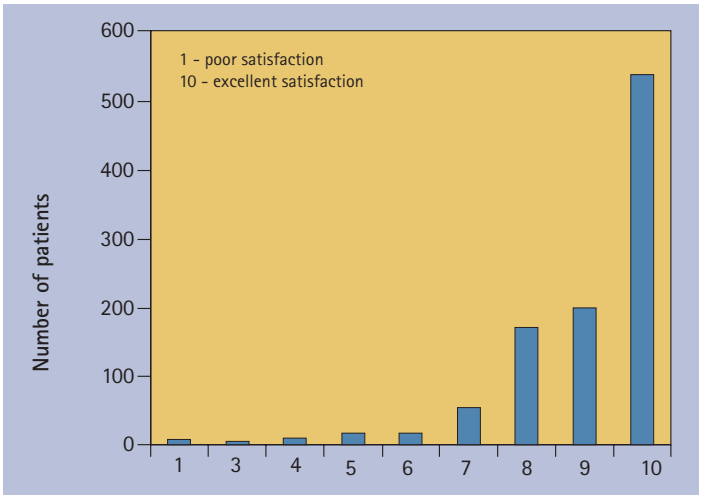

Fig. 6 Satisfaction with sedation and treatment represented by 27% of sample

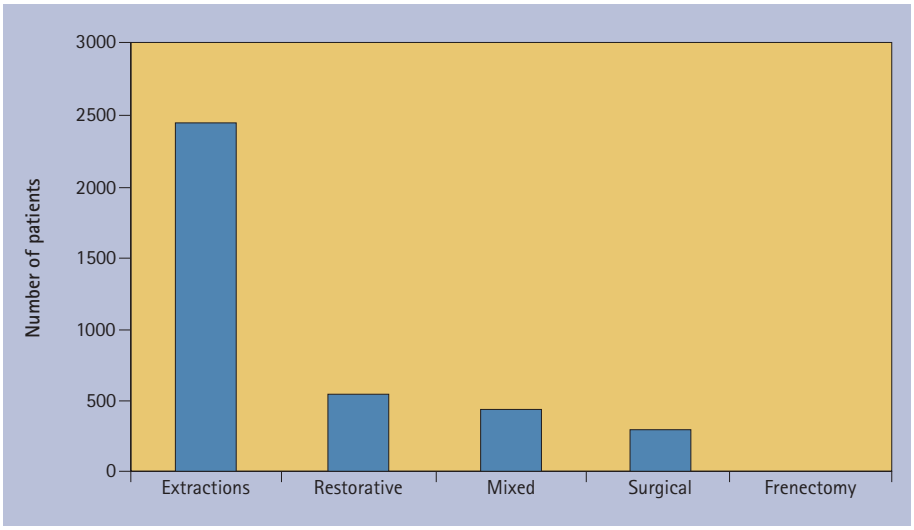

Fig. 7 Range of treatment provided

DISCUSSION

The total sample size (3,751) was evenly divided between male and female with an age distribution predominantly at four and five years old, with the average being 7.5 years old. The children were fit and healthy with the majority ASA 1 and II, although they were referred for treatment because of behavioural and cooperation problems. This was confirmed at assessment with the majority being in the Venham four and five end of the scale. The quality of sedation provided, as assessed by the Ellis scale, shows good level of cooperation with 94% of the patient group exhibiting no or little undue movement or resistance, enabling completion of all planned treatment. In addition the emotional response of the patient group was favourable with the most in the 'no' or 'little crying' groups. Results showed insignificant reduction in oxygen saturation, with only one case where the level dropped below 90%, and this was corrected by simple means. The technique of drug administration involved a weight-dose related process. The initial 0.25 mg/kg being a conservative quantity, and in addition the average total dose administered (0.41 mg/kg) was a dose at the low end of other studies that have used this drug.[27,28] One of the potential barriers to the use of intravenous sedation in children is the acceptability of cannulation. In this sample 24% presented some slight resistance, although this did not prevent the eventual process of cannulation. This may be in some way explained by the efficiency of the clinical operator in this procedure, which is undoubtedly essential to its success. Ketamine is reported to be associated with unpleasant effects, for example crying/dysphoria, nausea and sickness and blurred vision. Figure 5 shows the occurrence of such side effects in patients at discharge and followed post-operatively. Although nausea was the most common problem (approximately 25%), and this is known to occur with ketamine, the effect was fairly brief in occurrence and sickness was not experienced at discharge but more frequently reported later. This may have been as a result of food intake and or swallowing blood post-operatively. Results from patient satisfaction in the responding group (Fig. 6) indicate very favourable response. It should be noted that these results are from parental/carer feedback and may be subject to variable interpretation. In addition, since this responding group represents 27% of the total group treated, this cannot be considered to be a representative viewpoint of the audit; however, 1,012 is not a small number of patients providing response. Treatment time for the procedures was short, with the average clinical operative time being 6.7 minutes. This

may be accounted for by a number of factors: firstly, topical anaesthetic paste was not used as routine since good analgaesia was provided by ketamine; secondly the majority of procedures were extraction of the primary dentition which is a relatively quick process; and finally due to the skill and efficiency of the operator. Results (Fig. 7) show that both restorative and a mixture of restorative and extractions can be effectively provided, including surgical extractions. The main clinical requirement in this sample group was however for extraction of carious primary dentition.

If we refer to the objectives of this audit it is evident that the first three, ie effectiveness, safety and quality of sedation, were clearly reported to be satisfactorily achieved. Treatment and recovery time was short which related to the short redistribution period of the drug. Although there was a report of the well-recognised side effect of nausea, this did not seem to detract from the high level of satisfaction reported by carers. Although exodontia was the most common treatment provided results showed that a mixture of both conservation and extractions could readily be provided. The emphasis on exodontias was driven by the presenting need for treatment rather than the restrictions imposed by the use of this technique. In terms of cost, this technique provided a safe, effective and economically attractive alternative to general anaesthesia. A pragmatic approach was used in the audit and this may be criticised in contrast to a detailed double blind clinical trial. The work followed a sound methodological process of a clinical audit with a very big sample group, which is extraordinary for this area of study.

IMPLICATIONS FOR RESULTS OF THE AUDIT

This audit presents a number of issues which need to be addressed in order to further employ this conscious sedation technique in children's dentistry. Ketamine has a somewhat unfavourable association in that it is used as a recreational drug and may be viewed as unsuitable for purpose due to its effect associated with this practice. This audit, along with a number of studies, has shown that when used both in small doses and for children, undesirable effects are not common. Aspects of the process of administration, particularly venepuncture, may be a concern for some clinicians and it is without doubt a skill that needs to be effectively and efficiently delivered. In addition there is a perception that children are unable to accept venepuncture. This audit and other work[7] has not shown this to be the case, even for this anxious group for whom sedation is required.

The use of intravenous ketamine is an advanced technique and requires training and experience. These are issues that need to be addressed both by the sedation and paedodontic professional groups. The importance of a theoretical understanding and a good and supported practical experience to the use of ketamine are essential parts of the training process. Conscious sedation for children should only be undertaken by teams that have training and experience in the case selection, behavioural management, administration of sedation for this age group and in an appropriate environment.

Sedation for this age group with this sample size using intravenous ketamine is unusual in dentistry in the UK. In this particular audit the use of the technique was driven by the demand for treatment of children who would not accept other conventional forms of conscious sedation and also the interest and challenge for the operator.

Dedication to Michael Wood

The qualities of a positive attitude, a desire for efficient effectiveness, good clinical skills and a caring and empathetic approach to childrens dentistry were an essential part of this audit. These were the qualities held by the operator conducting this audit Michael Wood and which ensured the success of this technique. Furthermore the audit was carried by a general dental practitioner working within primary care providing this care within the National Health Service.

This audit presents exceptional work carried out by a practitioner highly skilled and committed to conscious sedation in dentistry. He was a valued expert in this field, generous, welcoming as a mentor and supportive to colleagues in this area of care. Sadly he has unexpectedly passed away at a young age but it is hopeful that this valuable area of care will be developed by interested colleagues.

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