A Prospective Evaluation of "Ketofol" (Ketamine/Propofol Combination) for Procedural Sedation and Analgesia in the Emergency Department

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Study objective: We evaluate the effectiveness and consider the safety of intravenous ketamine/propofol combination ("ketofol") in the same syringe for procedural sedation and analgesia in the emergency department (ED).

Methods: A prospective case series of consecutive ketofol procedural sedation and analgesia events in the ED of a trauma-receiving community teaching hospital from July 2005 to February 2006 was studied. Patients of all ages, with any comorbid conditions, were included. Ketofol (1:1 mixture of ketamine 10 mg/mL and propofol 10 mg/mL) was administered intravenously at the discretion of the treating physician by using titrated aliquots. The presence or absence of adverse events was documented, as were procedural success, recovery time, and physician, nurse, and patient satisfaction. Physiologic data were recorded with established hospital procedural sedation and analgesia guidelines.

Results: One hundred fourteen procedural sedation and analgesia events using ketofol were performed for primarily orthopedic procedures. The median dose of medication administered was ketamine at 0.75 mg/kg and propofol at 0.75 mg/kg (range 0.2 to 2.05 mg/kg each of propofol and ketamine; interquartile range [IQR] 0.6 to 1.0 mg/kg). Procedures were successfully performed without adjunctive sedatives in 110 (96.5%) patients. Three patients (2.6%; 95% confidence interval [CI] 0.6% to 7.5%) had transient hypoxia; of these, 1 (0.9%; 95% CI 0.02% to 4.8%) required bag-valve-mask ventilation. Four patients (3.5%; 95% CI 1.0% to 8.7%) required repositioning for airway malalignment, 4 patients (3.5%; 95% CI 1.0% to 8.7%) required adjunctive medication for sedation, and 3 patients (2.6%; 95% CI 0.6% to 7.5%) had mild unpleasant emergence, of whom 1 (0.9%; 95% CI 0.02% to 4.8%) received midazolam. No patient had hypotension or vomiting or received endotracheal intubation. Median recovery time was 15 minutes (range 5 to 45 minutes; IQR 12 to 19 minutes). Median physician, nurse, and patient satisfaction scores were 10 on a 1-to-10 scale.

Conclusion: Ketofol procedural sedation and analgesia is effective and appears to be safe for painful procedures in the ED. Few adverse events occurred and were either self-limited or responded to minimal interventions. Recoveries were rapid, and staff and patients were highly satisfied. [Ann Emerg Med. 2007;49:23-30.]

0196-0644/$-see front matter

doi:10.1016/j.annemergmed.2006.08.002

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INTRODUCTION

Background

Propofol is a nonopioid, nonbarbiturate, sedative-hypnotic agent[1] with rapid onset and short duration of action. It possesses antinauseant effects and reliably produces sedation.[2,3] Adverse effects include dose-related cardiovascular and respiratory depression[4,5] and bradycardia.[6] Propofol is known to be amnestic but not known to be analgesic, which for some clinicians is a potential concern when performing painful procedures.

Ketamine is a phencyclidine derivative classified as a dissociative sedative[7] and is known to provide analgesia[8,9] and amnesia. It causes little or no respiratory or cardiovascular depression.[1,10] However, widespread use of

Editor's Capsule Summary

What is already known on this topic

Ketamine and propofol are common agents for emergency department (ED) procedural sedation and analgesia; however, they are not traditionally used together. In theory, the opposing hemodynamic and respiratory effects of each drug might be complementary and minimize overall adverse effects.

What question this study addressed

Ketamine and propofol were administered together at doses of 0.75 mg/kg each (subdissociative for the former and less than typical for the latter), in total doses at the discretion of the practitioner in this case series.

What this study adds to our knowledge

So-called ketofol was highly effective in the 114 administrations described, and staff and patient satisfaction was high. The few adverse effects were minor and self-limited.

How this might change clinical practice

This study demonstrates that adding subdissociative ketamine to propofol appears to be an acceptable alternative regimen for ED procedural sedation and analgesia. Studies directly comparing this regimen to others will be needed to draw firm conclusions about relative safety and efficacy.

Research we'd like to see

Given that the hemodynamic effects of ketamine seemed to overbalance those of propofol, a study using less ketamine in the mixture would help clarify the optimal ratio.

ketamine as a single agent for procedural sedation and analgesia in adults has been limited by the occurrence of emergence phenomena and the concern of inducing vomiting or laryngospasm.[11-13]

Ketamine and propofol administered in combination from separate syringes has been used successfully in a variety of settings, including sedation for spinal anesthesia,[11] as well as for gynecologic,[14] opthamologic,[15] and cardiovascular procedures in adults[10] and children.[8] This combination has been favored because of the opposing hemodynamic and respiratory effects of each drug. Friedberg,[16] in a prospective study of 1,264 patients undergoing procedural sedation and analgesia for surgical procedures with ketamine and propofol, concluded that this combination was safe and effective. The use of ketamine in conjunction with propofol has been shown to reduce the dose of propofol required to achieve sedation,[10] and this combination is believed to result in less toxicity than either drug alone because their complementary effects enable the use of lower doses of each drug.[8]

Administering ketamine and propofol mixed in the same syringe (so-called ketofol) has been shown to be efficacious in the operating room and in ambulatory settings.[8,15,17] Although ketamine and propofol combined in the same syringe has been described in the emergency department (ED) as an induction regimen for rapid sequence intubation,[18] there are no published studies regarding their use together in the ED for procedural sedation and analgesia.

Importance

Procedural sedation and analgesia for painful procedures is the standard of care in emergency medicine and is commonly performed using a variety of medication regimens, each possessing particular advantages and disadvantages. Ketofol has the potential to provide efficacious procedural sedation and analgesia for painful procedures in the ED while minimizing the adverse effects of either drug alone.

Goals of This Investigation

We wished to evaluate the effectiveness and consider the safety of intravenous ketofol for procedural sedation and analgesia in the ED. Secondary objectives included assessments of recovery time and staff and patient satisfaction.

MATERIALS AND METHODS

Setting and Study Design

Our facility is a 250-bed community teaching hospital and district trauma center with an annual census of 45,000 emergency patient visits. Consecutive patients who received ketamine and propofol in the same syringe for procedural sedation and analgesia were enrolled as a prospective case series between July 2005 and February 2006. Procedural sedation and analgesia events were captured through the attachment of a special ketofol study data form to every mandatory procedural sedation and analgesia clinical record. These forms were located in the same single location where all medications used in the ED for procedural sedation and analgesia were stored and prepared for administration. ED staff was regularly queried to ensure that forms were completed for all consecutive ketofol patients. We did not systematically record the number of times in which patients received propofol or ketamine alone for procedural sedation and analgesia but estimate that the ketofol patients represent approximately 75% of procedural sedation and analgesia with either drug during the study period. This study was approved by the hospital's research and ethics committee.

Selection of Participants

We included patients of all ages for whom the treating physician selected ketofol for procedural sedation and analgesia. The only absolute exclusion criterion was known allergy to either study medication.

In accordance with the existing institutional procedural sedation and analgesia guidelines, all procedures were performed

in a location that allowed continuous oxygen saturation and cardiac monitoring and was equipped for emergency resuscitation and airway management. All procedural sedation and analgesia events required the attendance of a certified emergency physician, registered nurse, and respiratory therapist. Whenever possible, a second certified emergency physician dedicated to the administration of the procedural sedation and analgesia medication was also present.

Interventions

Ketofol was prepared as a 1:1 mixture of ketamine 10 mg/mL and propofol 10 mg/mL mixed in a 10-mL or 20-mL syringe fitted with a blunt-tip cannula. Procedural sedation and analgesia using ketofol was performed by the intravenous administration of 1- to 3-mL aliquots titrated at the discretion of the physician administering the medication. The goal of procedural sedation and analgesia was to attain deep or dissociative sedation.[19] Patients received opioid analgesia before the procedure at the discretion of the treating physician. The dose and timing of medication administration, as well as the ultimate depth of sedation achieved, were intentionally not standardized to more accurately reflect the variability in physician preference, patient response, and the differing procedural sedation and analgesia requirements for various procedures in emergency medicine practice.

Methods of Measurement

The hospital's standard procedural sedation and analgesia record form was used for all procedures conducted and was completed by the assisting registered nurse. The information collected included presedation documentation of fasting time, cardiorespiratory examination, body weight, and vital signs. The provision of supplemental oxygen by nasal cannula at 2 to 5 L per minute was recommended but not required, and its use was recorded. This form was also used to record medication doses and times, vital signs during and after the procedure, and discharge criteria.

On the separate ketofol data form, the treating physician recorded comorbid conditions, adjunctive medications administered (eg, opioid analgesics or additional sedation medication), adverse events, and patient, nurse, and physician satisfaction.

Data Collection and Processing

The nurse assisting with procedural sedation and analgesia recorded vital signs before, during, and after each procedure until specific discharge criteria were met. Discharge criteria consisted of a 4-item scale (Figure); the total score must be equal to or greater than 7 before completion of the protocol. During each procedure, the treating physician documented the presence or absence of an explicit list of adverse events on the separate ketofol data form, including necessity for airway intervention, apnea, hypotension, hypoxia, myoclonus, seizure, rash, dysphoric emergence phenomena (agitation, hallucinations), or vomiting. One hundred fourteen data sheets were collected for analysis. Five of these sheets were missing demographic data but were otherwise complete. The missing data were obtained from the patients' hospital records.

Activity

0=Unable to lift head or move extremities voluntarily or on command

1=Lifts head spontaneously and moves extremities voluntarily or on command

2=Able to ambulate without assistance

Breathing

0=Apneic

1=Dyspnea or shallow, irregular breathing

2=Able to breathe deeply and cough on command

Circulation

0=Systolic blood pressure <80 mm Hg

1=Systolic blood pressure >80 mm Hg and <100 mm Hg

2=Systolic blood pressure within normal range for patient

Consciousness

0=Not responding or responding only to painful stimuli

1=Responds to verbal stimuli but falls asleep readily

2=Awake, alert, and oriented to time, person, place (child oriented to parent)

Figure. Procedural sedation and analgesia discharge criteria key.

Outcome Measures

The dose of ketofol administered is described as the amount of each of the ketamine and propofol components, reported in milligrams per kilogram of body weight. Procedural sedation and analgesia with ketofol was considered efficacious if the required procedure was completed and no adjunctive medications were required. Satisfaction ratings were recorded on a 10-point scale, with zero being very unsatisfied and 10 being completely satisfied. Recovery time was calculated as the time from the last dose of medication given until discharge criteria were met.

Vital sign changes were noted as the maximum variation recorded during the procedure or recovery period compared with preprocedural levels. Apnea was defined as cessation of breathing for at least 20 seconds with or without oxygen

Table 1. Characteristics of ED patients receiving intravenous ketofol for procedural sedation and analgesia.*

Characteristic	Subjects (n=114)
Age, y	
Median (IQR)	36 (20–58)
Range	4–88
Distribution, No.	
1 mo to 5 y	7
6–10 y	9
11–15 y	9
16–40 y	38
41–60 y	28
61–80 y	18
>80 y	5
Male sex, No. (%)	77 (67.5)
Comorbid medical conditions, No. (%)	
None	66 (57.9)
Concurrent multisystem trauma	4 (3.5)
Coronary artery disease	11 (9.7)
Cerebrovascular disease	4 (3.5)
Hypertension	28 (24.6)
Atrial fibrillation	7 (6.1)
Pacemaker	1 (0.9)
Asthma/COPD	8 (7.0)
Seizures	2 (1.8)
Endocrine (DM/hypothyroid/hypopituitary)	8 (7.0)
HIV	2 (1.8)
Hepatitis C/liver dysfunction	3 (2.6)
Alcohol abuse	3 (2.6)
Acute alcohol intoxication	1 (0.9)
Mood/psychiatric disorder	3 (2.6)
Sleep apnea	1 (0.9)
Gastroesophageal reflux disease	5 (4.4)
Nephrectomy	1 (0.9)
Polymyalgia rheumatica	1 (0.9)

COPD, Chronic obstructive pulmonary disease; *DM,* diabetes mellitus.
*Some patients had >1 condition.

Table 2. Procedures performed with ketofol procedural sedation and analgesia (n=114).

Procedures Performed	Procedures, No. (%)
Total orthopedic	79 (69.3)
Wrist fracture	29 (25.4)
Shoulder dislocation	15 (13.2)
Elbow dislocation	9 (7.9)
Ankle fracture/dislocation	7 (6.1)
Hip dislocation	5 (4.4)
Tibia/fibula fracture	5 (4.4)
Locked knee	3 (2.6)
Patellar dislocation	1 (0.9)
Elbow fracture/dislocation	1 (0.9)
Jaw dislocation	1 (0.9)
Shoulder fracture/dislocation	1 (0.9)
Supercondylar fracture	1 (0.9)
Wrist/finger fracture/dislocation	1 (0.9)
Incision and drainage	13 (11.4)
Cardioversion	9 (7.9)
Laceration	5 (4.4)
Tube thoracostomy	4 (3.5)
Foreign body removal	2 (1.8)
Hernia reduction	2 (1.8)

desaturation. Hypotension was defined as a decrease in mean arterial blood pressure of 20% from preprocedural levels, consistent with previous literature examining the use of ketamine-propofol combinations.[10,17] Hypoxia was defined as oxygen saturation below 90% at any time during the procedural sedation and analgesia protocol.

A minor adverse event was defined as an event not resulting in a change in vital signs and requiring no more than minimal intervention, such as airway positioning (chin lift, jaw thrust) or physical stimulation. A significant adverse event was defined as an event requiring intervention such as administration of intravenous fluids or intravenous medications, placement of an oral airway device, or provision of ventilatory assistance.

Primary Data Analysis

Data are reported using descriptive statistics (Microsoft Excel; Microsoft Corporation, Redmond, WA). Categoric data are presented as frequency and percentage of frequency of occurrence. Continuous data are presented as medians, with ranges and interquartile ranges (IQR). Ninety-five percent confidence intervals (CIs) are reported where appropriate.

RESULTS

Characteristics of Study Patients

This study was conducted during an 8-month period in which 114 patients had procedural sedation and analgesia with ketofol for painful procedures in the ED. Patient demographics and comorbid conditions are listed in Table 1. Supplemental oxygen was used for 110 patients (97%). No patient was hypoxic before procedural sedation and analgesia. The majority of procedures performed were orthopedic (Table 2).

Main Results

The median dose of ketofol administered was 0.75 mg/kg each of propofol and ketamine (range 0.20 to 2.05 mg/kg; IQR 0.6 to 1.0 mg/kg). Of the 114 procedures performed, 110 (96.5%) were completed successfully, with no adjunctive medications required. Three patients (2.6%) required additional doses of propofol alone to complete the intended procedure. For 1 patient (0.9%), the intended procedure (shoulder reduction) was not successfully performed because of muscular rigidity despite the use of 1.3 mg/kg each of ketamine and propofol and an additional 1.4 mg/kg of propofol alone (Table 3).

Vital sign changes are summarized in Table 4, with most patients experiencing modest increases in pulse rate and blood pressure. No patient became hypotensive or had evidence of poor perfusion. Eight patients (7%) had minor adverse events (Table 3); the most common were 3 airway malalignments (2.6%; 95% CI 0.6% to 7.5%), requiring simple repositioning of the airway with jaw thrust or chin lift. Two patients (1.8%;

Table 3. Ketofol procedural sedation and analgesia adverse events (n=114 ketofol procedural sedation and analgesia events).

Age/Sex, Weight (kg)	Coexisting Medical Conditions	Procedure	Ketofol Components (mg/kg)		Preprocedural Medications	Adversity	Adjunctive Medication or Intervention
			Ketamine	Propofol			
PSA requiring adjunctive medications							
51/Female (70.0)	None	Incision and drainage	1.5	1.5	None	Suboptimal relaxation	Propofol 50 mg IV
22/Male (79.4)	None	Shoulder dislocation	1.0	1.0	Nitrous gas	Suboptimal relaxation	Propofol 40 mg IV
54/Female (49.0)	HTN	Wrist fracture	2.1	2.1	None	Suboptimal relaxation	Propofol 50 mg IV
45/Male (94.8)	None	Shoulder dislocation	1.3	1.3	None	Rigidity	Propofol 120 mg IV
Minor PSA adverse events							
72/Female (49.9)	HTN, DM	Shoulder dislocation	1.4	1.4	MS 5 mg IV	Airway malalignment	Airway positioning
25/Female (70.3)	None	Incision and drainage	0.7	0.7	Ativan 1 mg SL	Vocal, minor rigidity	None
53/Female (56.7)	None	Wrist fracture	0.9	0.9	None	Unpleasant emergence	None
49/Male (52.2)	None	Knee manipulation	0.9	0.9	None	Held arm up	None
70/Male (89.8)	HTN	Hip dislocation	1.1	1.1	None	Airway malalignment	Airway positioning
50/Male (86.2)	Bipolar disorder	Incision and drainage	0.8	0.8	MS 5 mg IV	Mild dysphoria	Decreased stimulation
16/Female (61.2)	None	Patellar dislocation	0.6	0.6	None	Airway malalignment	Airway positioning
68/Male (77.1)	Alcohol abuse	Shoulder dislocation	0.9	0.9	None	Atrial fibrillation (2 min)	None
Significant PSA adverse events							
29/Male (89.8)	None	Wrist fracture	0.8	0.8	None	Apnea, hypoxia	BVM × 2 min; 100% O_2
88/Male (84.0)	HTN, pacemaker, seizures	Hip dislocation	0.6	0.6	MS 4 mg IV	Hypoxia	Airway positioning, 100% O_2
15/Male (72.1)	Alcohol intoxication	Ankle fracture/dislocation	0.7	0.7	None	Apnea, hypoxia	Stimulation
55/Male (79.8)	Atrial fibrillation	Cardioversion	0.4	0.4	None	Unpleasant emergence	Midazolam 2 mg IV

BVM, Bag-valve-mask; *HTN,* hypertension; *MS,* morphine sulfate; *PSA,* procedural sedation and analgesia.

Table 4. Vital sign changes (n=114 ketofol procedural sedation and analgesia events).

Vital Sign Changes	Results
Pulse rate, median change, beats/min (range; IQR)	+6 (−20 to 65; 0 to 16)
Systolic blood pressure, median change, mm Hg (range; IQR)	+17.5 (−10 to 73; 5 to 26)
Diastolic blood pressure, median change, mm Hg (range; IQR)	+9 (−16 to 34; 2 to 17)
Mean arterial blood pressure, median change, mm Hg (range; IQR)	+13.2 (−11 to 41; 4 to 19)
Oxygen saturation, number of patients experiencing a decrease, No. (%)	33 (29)
Median decrease in oxygen saturation (n=33), % (range; IQR)	−2 (1 to 14; 1 to 3)

95% CI 0.2% to 6.2%) had mild dysphoria requiring no intervention. There were no cases of vomiting or aspiration.

Significant adverse events are also described in Table 3. Three patients (2.6%; 95% CI 0.6% to 7.5%) became hypoxic, with 1 patient (0.9%; 95% CI 0.02% to 4.8%) requiring assisted ventilation with bag-valve-mask for 2 minutes (lowest oxygen saturation 86%). One patient (0.9%; 95% CI 0.02% to 4.8%) developed an unpleasant emergence reaction consisting of agitation; he was treated with midazolam 0.025 mg/kg intravenously, with prompt resolution of the event. No patients were intubated. No sequelae were identified, and all patients were discharged in good condition.

Median recovery time was 15.0 minutes (range 5 to 45 minutes; IQR 12 to 19 minutes). Eighty-three percent of patients recovered in 20 minutes or sooner. Ninety-six percent of patients recovered within 30 minutes.

Median satisfaction scores (0=unsatisfied; 10=completely satisfied) for physicians was 10 (range 2 to 10; IQR 10 to 10), for nurses was 10 (range 3 to 10; IQR 9 to 10), and for patients was 10 (range 5 to 10; IQR 10 to 10).

Preprocedural analgesia was documented in 43 patients (38%). Forty patients received intravenous morphine sulfate, with the median total amount given equal to 0.073 mg/kg (range 0.024 to 0.236 mg/kg; IQR 0.056 to 0.120 mg/kg). One patient received fentanyl 0.38 μg/kg intravenously. One pediatric patient received codeine phosphate at 1.5 mg/kg orally 3.5 hours before procedural sedation and analgesia. Two patients received inhaled nitrous oxide.

LIMITATIONS

Ketofol was not directly compared with other known procedural sedation and analgesia regimens; thus, it is impossible to comment on its superiority over other regimens in ED practice. The small size of this study limits the ability to offer firm conclusions about the safety of ketofol as a procedural sedation and analgesia agent.

Selection bias may exist in this series because only procedural sedation and analgesia events using ketofol were recorded and the decision to use ketofol was at the discretion of the treating physician. However, the number of patients receiving propofol or ketamine alone outside of the study was relatively small, and we believe the groups to be similar overall.

The reliance on oxygen saturation instead of capnography may have led to underreporting of respiratory depression. Capnography is known to be one of the earliest indicators of respiratory depression,[20] and preoxygenation of patients has been shown to preserve oxygen saturation in the presence of hypoventilation.[21] All cases of hypoxia in our study occurred among patients who did receive supplemental oxygen.

The dose and timing of sedative administration, as well as the administration of preprocedural analgesics, was intentionally not standardized. Although this strengthens the study in terms of generalizability to actual practice, it also introduces variability because premedication with narcotics and rapid administration of larger doses of propofol are associated with increased frequency and severity of respiratory complications.[22,23]

DISCUSSION

The use of propofol and ketamine as single agents for procedural sedation and analgesia in the ED has grown in popularity, but the unwanted effects of each drug alone have limited their adoption in select populations. This study represents a novel application of the combination of 2 well-known medications whose characteristics appear to be complimentary. Our study shows ketofol to be an effective and apparently safe ED procedural sedation and analgesia regimen. The mixture of ketamine and propofol into a single syringe in a 1-to-1 ratio offers a simple, practical approach to medication preparation and use. This series used ketofol on patients of all ages and with a broad range of acute and chronic comorbid conditions with a high degree of satisfaction, thus highlighting its versatility in the ED setting.

The addition of ketamine to propofol is thought to counteract the cardiorespiratory depression that occurs when propofol is used alone, whereas propofol blunts the psychomemetric and nauseant effects of ketamine. Ketamine provides an analgesic effect that is absent when propofol is used alone, which, for some clinicians, may represent a further advantage. Using ketamine and propofol in combination allows sedation to be achieved with lower total doses of each drug, resulting in favorable adverse event and recovery time profiles.

Short recovery time is a valuable attribute of a procedural sedation and analgesia regimen in the ED environment. The median recovery time of 15 minutes in our study is comparable to that of other procedural sedation and analgesia regimens noted for their rapid recovery times. Only 4% of patients showed a recovery time longer than 30 minutes. Studies of propofol sedation report recovery times from 15±11 minutes[24] to 23±11 minutes.[25] Mean recovery times from etomidate have been reported between 12.6±10 minutes[26] and 17.0±10.1 minutes.[27] Studies of fentanyl/midazolam combination have shown recovery times from 28.5 minutes[28] to 113.7±36.9 minutes.[29] Median recovery times ranging from 25 minutes[30]

to 58 minutes[31] have been reported when intravenous ketamine is used alone.

In this study, adverse effects with ketofol were uncommon and had no apparent relationship to drug dosages or to the use of preprocedural medications. There were no cases of hypotension, bradycardia, vomiting, or laryngospasm. At discharge, no patient demonstrated sequelae from any adverse event.

Of the 3 patients experiencing hypoxia, all received supplemental oxygen before and during the procedure, 1 received narcotic analgesics before the procedure, and 1 patient was acutely intoxicated with alcohol while undergoing procedural sedation and analgesia. No patient required intubation. The rate of hypoxia in our study is comparable to that of reports in the literature of sedation with propofol alone that showed that hypoxia occurred in 5% of patients and bag-valve-mask assist was required in 0.8%.[32] The incidence of hypoxia with etomidate has been shown to be 4%, with bag-valve-mask ventilation required in 3% of cases.[27] The incidence of respiratory depression using fentanyl and midazolam has been reported to be 19%.[33] Studies of ketamine sedation report apnea and hypoxia to be rare, usually occurring with rapid intravenous administration.[12,13]

Emergence reactions and vomiting are considered to be significant adverse effects of ketamine usage, occurring more often in adults than children.[34] In a study of 1,022 pediatric patients, Green et al[13] reported emesis in 6.7%, mild emergence in 17.6%, and moderate to severe agitation in 1.6% of patients. Chudnofsky et al[35] described emergence phenomena in up to 50% of adults. In our study, all 3 cases of emergence phenomena occurred in adults, and of these, only 1 was treated with midazolam. According to the expected rate of occurrence of emergence phenomena in adults described in the literature, our results suggest that ketofol may be associated with a lower rate of unpleasant emergence than ketamine alone.

As with most procedural sedation and analgesia regimens, ketofol was not 100% effective, which may reflect variations in the dosing between physicians, as well as individual variability in sedative response. In the 4 cases of inadequate sedation in our series, additional propofol alone enabled successful completion of the intended procedure in all but 1 patient (shoulder reduction). This single patient exhibited muscular rigidity, a known effect of ketamine,[34] resulting in the abandonment of procedural sedation and analgesia with ketofol. This patient subsequently had procedural sedation and analgesia with fentanyl and midazolam and successful completion of the intended procedure. Two other patients exhibited muscular rigidity that did not interfere with the successful completion of the necessary procedures (incision and drainage, knee manipulation).

Further research with larger samples comparing ketofol to other common procedural sedation and analgesia agents could further document the safety, efficacy, and effectiveness of ketamine and propofol combination for procedural sedation and analgesia in the ED setting. Different ratios of ketamine and propofol (eg, propofol 70%:ketamine 30%) may provide safe, deep sedation with cardiorespiratory stability, greater relaxation, and lower incidences of emergence phenomena.

We found the combination of ketamine and propofol in a single syringe to be easy to use and highly effective as a procedural sedation and analgesia agent in the ED setting, which is reflected in the high degree of satisfaction recorded by physicians, nurses, and patients. The relatively small size of our study precludes conclusions about safety and the incidence of rare adverse effects. As with all procedural sedation and analgesia regimens, adverse effects are possible, and thus, appropriate monitoring and the ability to intervene with cardiorespiratory support remain essential.

The authors gratefully acknowledge the contributions of Alec H. Ritchie, MD, and Samuel J. Gutman, MD, in the editing of this manuscript.

Supervising editor: Steven M. Green, MD

Author contributions: EVW and GA conceived the study. EVW performed background literature review, designed the study, tabulated data, and provided statistical analyses. GA supervised conduct of trial and data collection. EVW and GA drafted article. GA takes responsibility for the paper as a whole.

Funding and support: The authors report this study did not receive any outside funding or support.

Publication dates: Received for publication April 28, 2006. Revisions received July 10, 2006, and July 27, 2006. Accepted for publication August 7, 2006. Available online October 23, 2006.

Reprints not available from the authors.

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