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A Double-Blind Comparison of Low-Dose Intravenous Ketamine and Methohexital in Adults

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Two ultralight general anesthetic techniques, one using low-dose ketamine and the other using methohexital as the primary anesthetic agent, were compared for efficacy, safety, and psychomotor recovery in a double-blind fashion for use during third molar surgery. Low-dose intravenous ketamine as the primary anesthetic following premedication with fentanyl and midazolam, and in conjunction with nitrous oxide, appeared to produce less hypoxia, hypercarbia, and apnea than when methohexital was used. No significant differences were noted in heart rate or blood pressure between the techniques. The ketamine technique was universally preferred by the surgeons and anesthesiologists because of superior patient cooperation and airway management. No unpleasant psychomimetic side effects of significance were noted with the use of ketamine. Postoperative recovery took slightly longer in the ketamine group, with patients being judged fit for discharge approximately 10 to 15 minutes later than the patients who received methohexital.

The search continues for an ideal ultralight general anesthetic technique for outpatient oral surgery. An ideal anesthetic must be safe as well as efficacious. Major goals include patient cooperation and compliance, amnesia, short recovery time, and few drug-related side effects.

Several ultralight anesthetic techniques are currently in use. None, however, is ideal. Perhaps the most widely used technique is the combination of a preanesthetic narcotic and benzodiazepine, followed by a short-acting anesthetic. Fentanyl and midazolam (or diazepam) are often combined with sodium methohexital to deliver ultralight anesthesia (the "Brevital bump" technique). The safety of combining three such respiratory depressants is far from ideal. Apneic episodes, hypercarbia, and oxyhemoglobin desaturation sometimes necessitate aggressive airway management and supplemental ventilation.

Although fentanyl and midazolam can produce undesirable respiratory compromise, they offer favorable properties for ultralight anesthesia. Fentanyl provides analgesia for patient comfort and cooperation during local anesthetic injections and the procedure. Midazolam offers antianxiety, sedative, and muscle-relaxing properties as well as excellent amnesia, all desirable effects. Methohexital is an ultrashort-acting barbiturate with a steep dose-response profile that produces a general anesthetic state with rapid onset and recovery, thus lending itself well to the outpatient setting. Like all potent anesthetic agents, however, it may produce respiratory depression and apnea and, in addition, may promote an "irritable" airway due to its lack of analgesic properties or effect on the spino-lemiscothalamic pathways. This is particularly significant in smokers who may already have irritable

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airways and excessive secretions. The "Brevital cough" is well known and sometimes very annoying to the surgeon. Furthermore, operating conditions are not always favorable with methohexital anesthetics and many surgeons have experienced the frustration of struggling with uncooperative patients.

Dissociative anesthetics such as ketamine hydrochloride (Ketalar or Ketajet), introduced in the early 1970s, produce a functional and electrodissociation between thalamoneocortical and limbic systems.[1,2] As an ultralight anesthetic, ketamine potentially offers many advantages over methohexital. It produces a dissociative state that manifests as amnesia, unconsciousness, and catalepsy (eyes remain open with slow nystagmus while corneal and light reflexes remain intact).[3] Analgesia, especially somatic, is obtained with subanesthetic doses.[4,5] Furthermore, improved patient cooperation might be anticipated during anesthesia because patients are often immobilized with Ketamine.

Unlike methohexital, ketamine does not tend to produce respiratory depression unless high doses are administered rapidly by intravenous (IV) infusion. Under normal conditions, pulmonary compliance increases and airway resistance decreases, which may be beneficial in patients with reactive airway disease.[3] Ketamine has a dose-related central sympathomimetic action that increases cardiac index without altering stroke index. The sum effect is that systemic vascular resistance remains unaltered.

The undesirable side effects of ketamine most noted are excessive salivation and hallucinations during drug emergence. Emergent reactions can vary from alterations in mood state and body image to extracorporal experiences or even frank delirium.[3] Previous studies have demonstrated that these effects are dose-related.[3,6-8] It is interesting that when a benzodiazepine (ie, midazolam > diazepam) is used with low-dose ketamine, psychic emergent reactions are eliminated.[9-11] Additionally, glycopyrrolate, atropine, or other anticholinergics, when combined with ketamine, reduce oral and tracheal secretions. Glycopyrrolate is the preferred antisialogogue because it has few related cardiac side effects (ie, tachycardia).[12] Other effects of ketamine include a slight increase in blood glucose and cerebrospinal fluid (CSF) pressure (issues generally of minimal concern in an outpatient oral surgery population) and dizziness, extreme tiredness, and blurred vision.[3]

When used in combination with fentanyl, midazolam, and glycopyrrolate, low-dose IV ketamine may offer a safer and more efficacious ultralight anesthetic than the current standard, methohexital.

The purpose of this study was to compare two ultralight general anesthetic techniques, one using ketamine and the other using methohexital as the primary anesthetic agent, for safety, efficacy, recovery, and side effects in a randomized double-blind prospective manner.

Materials and Methods

Two groups of 20 adult patients were administered glycopyrrolate, fentanyl, midazolam, 30% N_2O, and either methohexital (M) or low-dose ketamine (K) in a randomized double-blind fashion.

American Society of Anesthesiologists (ASA) I or II health status patients who required the removal of two or more third molars (at least one requiring bone removal), and who requested general anesthesia, were accepted into the study. Psychiatric illness, illicit street drug use, and alcohol abuse were exclusion criteria. Patients were accepted into the study after signing a consent form that was previously approved by the Committee for Human Investigation at the UNC School of Dentistry. Patients ranged in age from 17 to 36 with the mean age in group M being 25.5 ± 5 years and in group K 25.6 ± 3.7 years. Mean weights were similar between groups (M = 69.19 kg; K = 69.43 kg). The female:male ratio was 3:2 and similar between groups (M = 60:40; and K = 65:35).

All patients underwent a thorough history and physical examination preoperatively. Alertness-psychomotor and Digit Symbol Substitution Test (DSST) ratings were recorded to provide baseline reference data.

Patients were seated in the surgical operatory and an intravenous line was introduced into their nondominant hand. Lactated Ringer's solution was delivered at maintenance rates. Nellcor oximeter, Hewlett-Packard defibrillator, Ohmeda 5200 CO_2 monitor, and Dinamap vital signs monitor no. 1846 (Critikon Inc, Tampa, FL) were placed to record baseline oxyhemoglobin saturation, electrocardiogram, end-tidal CO_2 (P_{ETCO_2}), and vital signs (heart rate, blood pressure, respiratory rate), respectively. All patients received 0.2-mg glycopyrrolate intravenously and 1 minute later received 50-μg fentanyl intravenously. Following the administration of fentanyl, 30% nitrous oxide/70% oxygen was introduced. If minimal clinical effects were noted after 1 minute, an additional 50 μg of fentanyl was administered. Patients who experienced significant central nervous system (CNS) effects after the first dose of fentanyl, however, only received an additional 25 μg. One minute following the administration of fentanyl, 2 mg of midazolam was given intravenously. Following a 2-minute observation period, additional 1-mg increments of midazolam were titrated every 2 minutes until the desired level of clinical sedation was achieved (ie, ptosis, drowsiness, or slurred speech). One minute following the administration of the last dose of midazolam, the patient was given 0.1 mL/kg test drug, which contained either 1 mg/kg methohexital (10 mg/mL) or 0.5 mg/kg ketamine (5 mg/mL). The anesthesiologist and surgeons were unaware of the test drug used under double-blind conditions.

One minute following administration of the test drug, local anesthetic (2% xylocaine, 1:100,000 epinephrine) was injected as appropriate for the surgical procedure. Additional boluses of test drug were given in 2- to 3-mL increments as necessary to maintain intraoperative patient compliance.

Surgery time was limited to a minimum of 15 minutes and a maximum of 45 minutes to avoid confounding variables related to surgery. At the completion of surgery, nitrous oxide was terminated and the patient was given 100% oxygen by nasal hood.

Patients were prescribed acetaminophen with codeine for postoperative pain and those patients allergic to codeine were prescribed acetaminophen with hydrocodone.

To evaluate and compare the safety of the two techniques, vital signs, oxyhemoglobin saturation and P_{ETCO_2} were recorded every 5 minutes intraoperatively. Any incidence of oxyhemoglobin desaturation below 92%, elevation of P_{ETCO_2} greater than 25% above baseline (hypercarbia), or apnea was recorded. An apneic episode was defined as no respiratory effort for at least 30 seconds as monitored by capnography. In addition, an airway management score was devised in which the anesthetist, who was blinded to the drugs used, rated the need for and extent of airway management required during the procedure. Each patient was rated on a scale of 0 (required intubation), 1 (constant airway support needed), 2 (frequent airway maneuvers needed), 3 (occasional moderate airway positioning needed), 4 (occasional mild airway repositioning), and 5 (no airway support needed).

Overall efficacy of the technique was evaluated using a global anesthetic evaluation score, a patient cooperation score, and amnesia testing. Patient cooperation and global evaluation were rated independently by the surgeon and anesthetist postoperatively. Patient cooperation scores ranged from 0 (being very uncooperative) to 9 (very cooperative) (Fig 1). Global efficacy of the anesthetic was rated as either poor (0), fair (1), good (2), very good (3), or excellent (4). Global efficacy was also rated in a similar fashion by the patient 60 minutes postoperatively and again 24 hours postoperatively.

Amnesia was evaluated by asking the patient to recall four events at 60 minutes and again 24 hours postoperatively. These events were IV placement, local anesthesia administration, tooth removal, and transport to the recovery room.

Patient Cooperation

Did the patient's movements during local anesthesia or extractions interfere with or delay treatment?

______ No interfering movement (0)
______ Minor movements, positioning remained appropriate (1)
______ Minor movements, patient had to be repositioned (2)
______ Movements grossly interfered with procedure (3)

To what extent did the patient verbalize discomfort?

______ Not at all (0)
______ Some verbalization, did not indicate pain or discomfort (1)
______ Some verbalization indicating pain or discomfort (2)
______ Complained frequently during the procedure (3)

Did the patient show nonverbal signs of discomfort during the procedure?

______ Not at all (0)
______ Slight discomfort, occasional grimaces (1)
______ Moderate discomfort, feet/hands tensed, tears in eyes (2)
______ Marked discomfort apparent frequently (3)

Cooperation Score (sum) ______________

FIGURE 1. Patient cooperation scores evaluated independently by the surgeon and anesthesiologist for each patient. Note that lower scores correlate with better patient cooperation.

Recovery was evaluated from the completion of surgery until the patient was discharged home. All patients were discharged at 1 hour postoperatively. Patient recovery was evaluated using alertness scales recorded every 10 minutes (Fig 2), psychomotor scales every 15 minutes (Fig 3), and DSST neurologic testing performed every 15 minutes postoperatively. All values were compared with preoperatively recorded baseline data.

Side effects were recorded intraoperatively, during the immediate postoperative recovery period, at 24 hours, and 1 week postoperatively by telephone interview. Any undesirable emergent phenomena, unusual behavior, or abnormal neurologic (ie, dreams or changes in cognitive function) or physical symptoms were noted.

Wilcoxin two sample tests (t test) and Kruskal Wallis tests (χ^2) were applied to the data to compare significance between groups. Significance was considered present when $P \leq .05$.

To minimize technique variables, three surgeons were involved in treating all 40 patients. The anesthesiologists (the authors) administered all medications and monitored all the patients throughout the procedure.

Responsiveness	Expression	Eyes	Composite Score
_____ Responds readily to name spoken in normal tone	_____ Normal	_____ Clear, no ptosis	_____ (5) alert
_____ Responds lethargically to name spoken in normal tone	_____ Mild relaxation	_____ Glazed or mild ptosis <½ the eye	_____ (4)
_____ Responds only after name called loudly and repeatedly	_____ Marked relaxation (slack jaw)	_____ Glazed and marked ptosis >½ the eye	_____ (3)
_____ Responds only after prodding and shaking			_____ (2)
_____ Does not respond			_____ (1)

Alertness Score _____

FIGURE 2. Alertness scale used to reflect patient recovery.

Results

The operative time ranged from 15 minutes to 45 minutes, with mean operative times for group M being 24.5 minutes and group K being 22.1 minutes. Group M patients received an average of .05 mg/kg midazolam (3.5 mg) and group K patients received an average of .06 mg/kg (4.2 mg).

Safety

Vital signs. Mean preoperative and intraoperative heart rate, systolic and diastolic blood pressure, and respiratory rate for each group appear in Table 1. There was no significant difference in preoperative or intraoperative values when M and K groups were compared (Figs 4 to 6).

End-tidal CO_2 (P_{ETCO_2}). Group M P_{ETCO_2} preoperatively was 40.4 ± 3.2 (range, 32 to 46) versus 39.7 ± 2.81 (34 to 46) for group K. This difference was not statistically significant by Wilcoxin *t* test ($P = .34$). P_{ETCO_2} at 5 minutes ($P = .13$) and at the end of surgery also were not statistically different between groups ($P = .15$). However, P_{ETCO_2} recorded intraoperatively at 10 and 15 minutes were significantly different (10 minutes, $P = .03$; 15 minutes, $P = .005$). Methohexital patients had significantly higher end-tidal CO_2 at both 10 and 15 minutes intraoperatively (Table 2).

Hypercarbia. Hypercarbia was defined as an P_{ETCO_2} greater than 25% over baseline. Fourteen of 20 methohexital patients had hypercarbic periods,

	Normal	Abnormal	Not Attempted Due to Excessive Sedation
1. Sits for 10 seconds	_____	_____	_____
2. Stands with support for 10 seconds	_____	_____	_____
3. Stands without support for 10 seconds	_____	_____	_____
4. Walks with support for 6 ft	_____	_____	_____
5. Walks without support for 6 ft	_____	_____	_____
6. Line-walks for 6 ft	_____	_____	_____

Psychomotor Recovery Score _____

FIGURE 3. Psychomotor scale used to reflect recovery.

Table 1. Mean and SD for Preoperative and Intraoperative Blood Pressure and Heart Rate

	Methohexital ($\bar{x}$ ± SD) n = 20	Ketamine ($\bar{x}$ ± SD) n = 20
I. Blood pressure		
Systolic		
Mean preop	120.35 ± 12.35	127.8 ± 14.5
Mean intraop		
5 Min	139.65 ± 15.72	140.6 ± 17.17
10 Min	133.70 ± 15.82	140.69 ± 15.85
15 Min	130.59 ± 14.06	142.38 ± 18.60
End	135.85 ± 18.27	141.35 ± 15.08
Diastolic		
Mean preop	71.1 ± 13.17	73.15 ± 11.9
Mean intraop		
5 Min	82.13 ± 12.68	77.25 ± 12.71
10 Min	71.10 ± 14.09	73.05 ± 14.11
15 Min	71.94 ± 14.95	73.88 ± 11.87
End	72.65 ± 14.95	75.10 ± 12.02
II. Heart rate		
Mean preop	74.1 ± 14.78	77.0 ± 18.22
Mean intraop		
5 Min	115 ± 16.11	116.9 ± 26.98
10 Min	105.85 ± 22.27	119.05 ± 24.63
15 Min	107.25 ± 22.48	114.67 ± 24.32
End	108.11 ± 19.07	116 ± 24.52
III. Respiratory rate		
Mean preop	16.45 ± 3.65	15.05 ± 2.5
Mean intraop		
5 Min	12.4 ± 4.41	14.80 ± 5.56
10 Min	14.45 ± 3.98	16.26 ± 5.49
15 Min	14.76 ± 3.83	16.88 ± 4.72
End	15.84 ± 3.11	16.70 ± 4.92

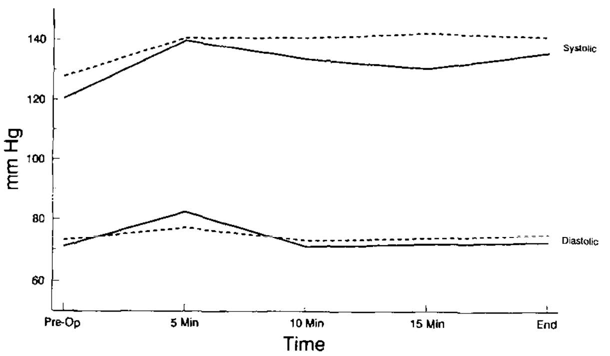

FIGURE 4. Preoperative and intraoperative mean systolic and mean diastolic blood pressure for all methohexital and ketamine patients (n = 20). No statistical difference was noted between the two groups. ———, Methohexital; ---, ketamine.

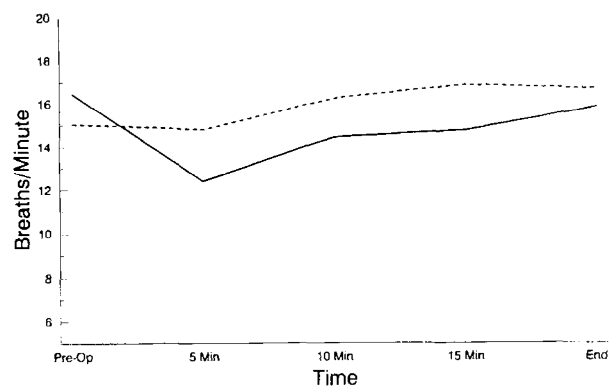

FIGURE 6. Preoperative and intraoperative mean respiratory rate for methohexital (n = 20) and ketamine patients. ———, Methohexital; ---, ketamine.

totalling 113 of 497 operating minutes (22.7%). This compared to 8 of 20 ketamine patients who experienced hypercarbia for 53 of 442 total operative minutes or 11.9%.

Apnea. Nineteen of 20 (95%) group M patients had apneic episodes. Only 7 of 20 (35%) K patients experienced the same. This difference was highly significant (χ^2 = 15.82, $P < .001$).

Oxyhemoglobin saturation. There were no reported desaturations below 92% in the K group patients. Three methohexital patients, however, experienced a total of four desaturations of varying duration.

Airway management ratings. Group M mean airway management ratings were 2.45 ± 1.14 (range, 1 to 4) compared with 4.25 ± 0.79 (range, 2 to 5) for group K patients. This difference was highly significant ($P < .001$).

Efficacy

The efficacy of the anesthetic was reflected by patient cooperation scores and the global anesthesia evaluations. Surgeons and anesthesiologists did not show statistically significant differences between their ratings. Table 3 shows that patient cooperation was ranked much higher (statistically significant) during ketamine anesthesia by both surgeons and anesthesiologists (surgeons, P = .003; anesthesiologists, P = .001). Similarly, global efficacy was ranked higher for ketamine anesthesia (surgeons, P = .001; anesthesiologists, P = .005). The patients did not note any difference between their evaluations of the two anesthetic techniques (P = .806 at 60 minutes; P = .876 at 24 hours).

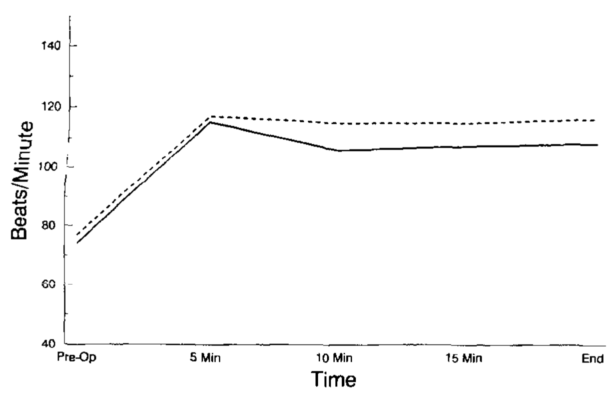

FIGURE 5. Preoperative and intraoperative mean heart rate for methohexital and ketamine patients. No statistical difference was noted between groups. ———, Methohexital; ---, ketamine.

Amnesia was assessed by events recalled. Table 4 summarizes these findings. Interestingly, 15% of methohexital patients and 5% of ketamine patients said they did not remember the intravenous line being placed before the administration of any drugs. Twenty-five percent of methohexital patients and 40% of ketamine patients recalled the transport to the recovery room. Neither group had significant recall of local anesthetic administration or extraction of teeth.

Recovery

No differences in preoperative alertness or psychomotor recovery were noted between the K and M groups. Using a psychomotor scale rating of 4 as the criteria for discharge (ie, patient can walk nor-

Table 2. Preoperative and Intraoperative Mean and SD P_{ETCO_2}

Mean P_{ETCO_2}	Methohexital ($\bar{x}$ ± SD) n = 20	Ketamine ($\bar{x}$ ± SD) n = 20	P Value
Preop	40.4 ± 3.2	39.7 ± 2.81	P = .34
5 Min	49.3 ± 5.21	46.9 ± 4.67	P = .13
10 Min	48.9 ± 5.51	45.58 ± 4.48	P = .03*
15 Min	48.6 ± 4.73	45.3 ± 4.94	P = .005*
End	45.26 ± 4.01	43.5 ± 5.09	P = .15

* Significantly different by Wilcoxin t test ($P < .05$).

Table 3. Mean and SD Patient Cooperation Ratings and Global Efficacy Ratings As Evaluated by Anesthesiologists and Surgeons

	Ketamine ($\bar{x} \pm SD$) n = 20	Methohexital ($\bar{x} \pm SD$) n = 20	*P* Values
Patient cooperation scores			
(Cooperation α 1/score)			
Surgeon ratings	1.05 ± 1.47	3.2 ± 2.48	$P = .003$*
Anesthesiologist ratings	1.40 ± 1.47	3.95 ± 2.74	$P = .001$*
Global efficacy scores			
(Efficacy score)			
Surgeon ratings	3.6 ± .6	2.5 ± 1.19	$P = .001$*
Anesthesiologist ratings	3.5 ± .69	2.15 ± 1.09	$P < .001$*

* Significant statistical difference (Wilcoxin *t* test) between K and M groups.

mally with support for 6 ft), Figure 7 shows methohexital patients were fit to discharge at an average of about 15 minutes postoperatively versus ketamine patients, who were dischargeable at an average of about 30 minutes. Figure 8 illustrates that alertness recovery paralleled return of psychomotor skills. Without exception, all patients were fit for discharge by 60 minutes.

Based on DSST scores, methohexital patients returned to baseline psychomotor function between 30 and 45 minutes (Fig 9). This was not the case with ketamine patients, in whom performance did not return to baseline by 60 minutes postoperatively.

The majority of side effects in both groups were seen only at 60 minutes postoperatively. As anticipated, drowsiness and tiredness were commonly experienced, but not noted to be different between groups. Incoordination, reported only at 60 minutes postoperatively, was noted by two methohexital patients (10%) and seven ketamine patients (35%). Side effects occasionally experienced by patients at 24 hours were nausea, vomiting, and drowsiness; however, differences between groups were not significant.

Postoperatively, hallucinations or dreams were not reported by any ketamine patients. Two methohexital patients, however, experienced horrifying dreams 24 hours postoperatively, recalling vivid details. Intraoperatively, six ketamine patients (30%) recalled strange thoughts and dreams, none of which were considered unpleasant or distressing. This was not observed in the M group.

Table 4. Percentage of Events Recalled by Each Group of Patients

	% Yes	
	Methohexital	Ketamine
IV being placed	85	95
Local anesthesia administered	5	0
Teeth being extracted	0	0
Transported to recovery	25	40

Discussion

Our findings suggest that low-dose intravenous ketamine used in combination with selected preanesthetic drugs provides an effective ultralight general anesthetic. Ketamine is safe, perhaps safer than methohexital. No incidence of oxyhemoglobin desaturation occurred in any patient in the ketamine group, while four desaturations occurred in the methohexital group. P_{ETCO_2} was significantly lower with ketamine at 10 and 15 minutes intraoperatively and group K patients spent significantly less time in the hypercarbic range. Furthermore, apneic episodes were far less frequent when ketamine was used. This finding is consistent with previous reports.[2,3] The fact that group K patients received a slightly higher midazolam dose than group M patients (group K = .06 mg/kg; group M = .05 mg/kg) makes these observations even more significant.

One might have also expected 5-minute intraoperative P_{ETCO_2} levels to be lower in K group patients; however, this was not observed. Perhaps the

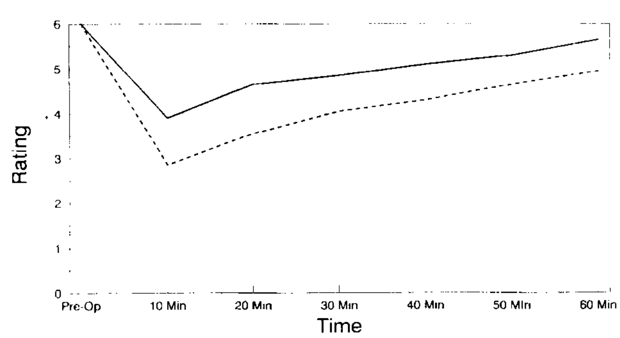

FIGURE 7. Mean psychomotor recovery ratings preoperatively and postoperatively for methohexital and ketamine patients. Methohexital patients are fit for discharge about 15 minutes sooner than ketamine patients. ———, Methohexital; - - -, ketamine. *Fit for discharge.

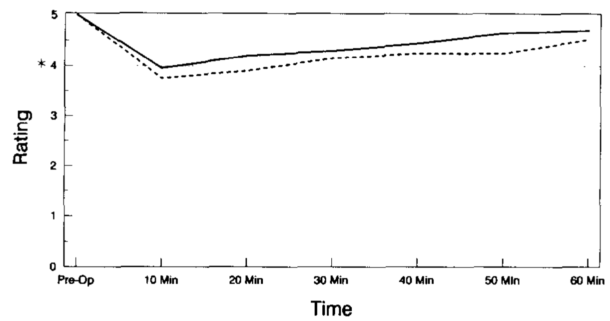

FIGURE 8. Mean alertness recovery ratings preoperatively and postoperatively for methohexital and ketamine patients. Methohexital patients are fit for discharge about 15 minutes sooner than ketamine patients. *Fit for discharge.

respiratory depressant effect of midazolam peaks at around this time and any ketamine-induced respiratory stimulation was masked. This may also explain why respiratory rates were not different between groups. Additionally, coughing episodes, occasionally observed when using methohexital, were not noted with the administration of low-dose ketamine.

Ketamine has been noted for its potential to cause tachycardia and hypertension, perhaps making its combined use with local anesthetics containing vasoconstrictors unfavorable. It is interesting, therefore, that blood pressure and heart rate were not significantly different between groups. Perhaps the low doses used in this study account for this observation.[3] Also, the cardiovascular stimulating effects of ketamine may have been reduced by adjunctive use of the benzodiazepine.[8-10]

Ketamine was clearly the preferred technique to surgeons, largely because of better intraoperative patient compliance. Coughing, struggling patients were not encountered. Anesthesiologists also consistently ranked K group patients more cooperative, most likely because airway management problems were less frequently encountered. Efficacy

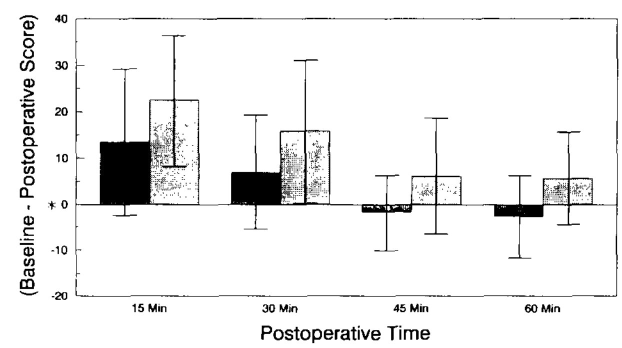

FIGURE 9. Mean differences in DSST scores between baseline (0) and 15-minute postoperative intervals for methohexital and ketamine patients. Methohexital patients reached their preoperative baseline scores approximately 40 minutes postoperatively; however, ketamine patients did not return to baseline within the 1-hour postoperative follow-up. *Baseline preoperative DSST score. ■, Methohexital; ▨, ketamine.

was ranked significantly higher for ketamine anesthetics by both surgeons and anesthesiologists.

It does mean, however, that care must be taken to avoid corneal damage. Patients rated the anesthetic techniques as being equally effective and pleasant. This provides evidence that the use of ketamine did not produce any unpleasant or negative effects in patients that would preclude its use. It should be noted that ketamine patients occasionally keep their eyes open under anesthesia. This does not mean, however, that they are awake.

Methohexital may be the drug of choice if rapid patient recovery is a principal criterion. Most clinicians would agree that patients should be able to walk with assistance before they are fit for discharge. In our series, methohexital patients were ready for discharge 10 to 15 minutes before ketamine patients. This difference may be significant for office oral surgery where space and staff are limited. Many practitioners and outpatient surgical centers, however, feel that a patient should be observed for at least 1 hour before discharge. All patients in both groups were deemed fit for discharge in 1 hour.

The type and incidence of side effects reported by patients were most interesting. No ketamine patients experienced hallucinations or emergent drug phenomena. We relate this observation to the use of the low doses and the adjunctive use of a benzodiazepine. The amnesic effect of midazolam may be very effective in eliminating emergent reactions in adults. Tucker[6] and others[3,9,11,13] have reported similar findings. It was interesting that 30% of K group patients had strange thoughts or dreams during the procedure. Details, however, were sketchy in all of these patients. One patient, a 20-year-old woman, described one of these dreams. She recalled "orange-colored teeth marching around in front of an amusement park, like an enchanted story." Another patient reported, "I knew I was dreaming but could not remember what." Of the six ketamine patients who experienced intraoperative thoughts, none of them had dreams postoperatively. For this reason, and because of their inability to remember details, none were frightened or concerned by the experience. Frightening postoperative dreams were reported by two methohexital patients. Both patients reported that dreams awakened them from sleep and persisted for the entire night. These dreams occurred within 48 hours of their anesthetic.

Excess salivation was not an observed or reported side effect in either group of patients. Glycopyrrolate, in our study, effectively controlled secretions without the cardiac effects of other anticholinergic medications.[9] Because atropine has been shown to increase the frequency of psychic emergent phenomena when used with ketamine, glycopyrrolate seems to be the premedicant of choice to control salivation.[14,15]

In conclusion, the untoward side effects—salivation, tachycardia, hypertension, and emergent hallucinogenic phenomena—that limited ketamine's efficacy when used previously at higher doses and often alone, were not experienced in this study. Low-dose ketamine, used in combination with carefully selected preanesthetic drugs, appears to be safe and efficacious. Low-dose ketamine has become our preferred technique for ultralight anesthesia in many patients, particularly for uncooperative patients or those with reactive airways.

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