

Original article

Adverse Effects of Ketamine on Procedural Sedation and Analgesia in PACU

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ABSTRACT

Background: Ketamine provides dissociative sedation and analgesia while generally preserving spontaneous ventilation, but cardiovascular, gastrointestinal, psychoperceptual, and respiratory adverse events may occur during recovery. **Objective:** To determine the frequency and pattern of adverse events observed after ketamine-based procedural sedation and analgesia. **Methods:** This descriptive observational study included 94 patients aged over 16 years with American Society of Anesthesiologists physical status I or II who received ketamine at Ghurki Trust Teaching Hospital, Lahore, from September to October 2024. Clinical and recovery variables were summarized as frequencies and percentages with Wilson 95% confidence intervals. **Results:** Any adverse event was recorded in 52/94 patients (55.3%; 95% CI 45.3–65.0). Hypertension occurred in 40 (42.6%), tachycardia in 29 (30.9%), vomiting in 18 (19.1%), nausea in 16 (17.0%), emergence reactions in 12 (12.8%), and hypersalivation in 10 (10.6%). Hypoxia occurred in four (4.3%), respiratory depression in two (2.1%), and apnea in one patient (1.1%); no laryngospasm was recorded. Adequate sedation was achieved in 88 (93.6%) and the procedure was completed successfully in 90 patients (95.7%). **Conclusion:** Adverse events were frequent but were predominantly cardiovascular or gastrointestinal; recorded respiratory events were uncommon. Standardized monitoring and prospective evaluation of dose- and patient-related factors are warranted. **Keywords:** Ketamine, Procedural sedation, Adverse events, Post-anesthesia care unit, Patient safety.

EDITORIAL INFORMATION

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Ethical Approval: Faculty of Allied Health Sciences, The University of Lahore, Lahore, Pakistan.

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INTRODUCTION

Procedural sedation and analgesia is an essential component of perioperative and emergency care, allowing painful or anxiety-provoking diagnostic and therapeutic procedures to be performed while minimizing distress, pain, and unwanted movement. Effective sedation requires achieving an appropriate depth without compromising ventilation, oxygenation, circulation, or protective responses. Safe practice therefore depends on careful pre-procedural assessment, appropriate drug selection, continuous physiological monitoring, immediate availability of airway-rescue equipment, and observation until recovery criteria are fulfilled (1–4). Particular attention to the recovery period is important because respiratory, cardiovascular, and behavioral complications may emerge after completion of the procedure.

Procedural sedation exists on a continuum from minimal anxiolysis to deep sedation and dissociation. Patients may unintentionally progress to a deeper level following repeated doses, rapid intravenous administration, or concomitant use of opioids or other sedatives. Consequently, sedative safety should not be assessed solely by procedural completion but also by the frequency, severity, and management of adverse events during recovery. The post-anesthesia care unit (PACU) provides structured observation during this transition, where residual drug effects, pain, nausea, agitation, altered consciousness, hemodynamic changes, or respiratory compromise may become apparent. Monitoring these outcomes is important for discharge planning, staffing, escalation of care, and overall patient safety (2–4,23,24).

Ketamine, a phencyclidine derivative acting predominantly as a non-competitive N-methyl-D-aspartate receptor antagonist, produces dose-dependent dissociation with analgesia, amnesia, and sedation (5–9). Unlike several other sedative agents, ketamine frequently preserves spontaneous ventilation and cardiovascular tone, contributing to its widespread use for painful procedures, trauma care, emergency interventions, and anesthesia in resource-diverse clinical settings. Following intravenous administration, its rapid penetration into the central nervous system produces a prompt clinical effect, while redistribution and hepatic metabolism contribute to recovery. However, sedation duration and recovery may vary according to dose, route, age, physiological reserve, repeated administration, and concurrent medication (6–9).

Although ketamine generally maintains respiratory drive, preservation of airway reflexes is not absolute. Airway obstruction, excessive secretions, vomiting, hypoxia, apnea, and laryngospasm may occur and require timely recognition and intervention (2–4,6,10–13). Ketamine also has a characteristic cardiovascular and neurobehavioral adverse-event profile. Sympathetic stimulation may result in transient tachycardia and hypertension, while nausea, vomiting, hypersalivation, dizziness, dysphoria, agitation, vivid dreams, and hallucinations may complicate recovery (6–10,14,15). Cardiovascular changes are usually transient in otherwise healthy individuals but may be clinically important among patients with hypertension, ischemic heart disease, or limited cardiovascular reserve. Emergence reactions may similarly increase supervision requirements, delay discharge, and negatively affect the recovery experience.

Respiratory events, although less frequently reported than cardiovascular or gastrointestinal effects, are particularly important because of their potential severity. Hypoxia may arise from hypoventilation, transient apnea, airway obstruction, secretions, laryngospasm, procedural factors, or co-administered medications. Importantly, the absence of rare respiratory events in smaller studies should not be interpreted as absence of risk, because estimates are strongly influenced by sample size, surveillance intensity, and definitions used for adverse events (10–13,23,24).

Previous adult reviews and emergency-department studies generally support ketamine as an effective procedural-sedation agent, although reported adverse-event rates vary considerably (10,11,16–20). Differences in patient populations, dosage regimens, routes of administration, observation periods, and outcome definitions limit direct comparison across studies. For example, transient blood-pressure changes may be classified as adverse events in some studies but recorded only when intervention is required in others. Similarly, hypoxia may be defined using different oxygen-saturation thresholds or durations. Standardized reporting of individual outcomes, denominators, interventions, and confidence intervals has therefore been recommended to improve comparability and interpretation of sedation research (11,23,24).

Evidence from low- and middle-income settings remains particularly relevant because patient characteristics, procedural profiles, monitoring resources, recovery staffing, and documentation practices may differ from those of large international centers. Ketamine is especially useful in such settings because of its versatility and relative preservation of spontaneous ventilation and cardiovascular function; however, these advantages should not reduce vigilance during recovery (9,15). In Pakistan, evidence describing ketamine-associated adverse events following procedural sedation, particularly within teaching-hospital PACU settings, remains limited. Local data are needed to establish the pattern of cardiovascular, gastrointestinal, emergence, secretory, and respiratory events encountered during routine practice.

Therefore, this study aimed to determine the frequency and pattern of adverse events among patients receiving ketamine for procedural sedation and analgesia and to describe the proportions achieving adequate sedation and successful procedural completion.

MATERIALS AND METHODS

A descriptive observational study was conducted at Ghurki Trust Teaching Hospital, Lahore, from September to October 2024. Using purposive sampling, 94 patients older than 16 years with American Society of Anesthesiologists physical status I or II who received ketamine for procedural sedation and analgesia were included; patients with significant psychiatric illness, a documented contraindication to

ketamine, or refusal to participate were excluded. Demographic characteristics, ketamine administration details, route, vital signs, Ramsay Sedation Scale assessments, pain scores, procedural completion, and recovery events were recorded on the study form. The Ramsay scale was used as the recorded sedation measure (21). Prespecified events were hypertension, tachycardia, nausea, vomiting, emergence reaction, hypersalivation, respiratory depression, hypoxia, apnea, and laryngospasm. Categories were not mutually exclusive. Data were analyzed in IBM SPSS Statistics version 27.0. Categorical variables were summarized as n (%); Wilson 95% confidence intervals were calculated for principal proportions, with the patient as the denominator. Reporting was guided by STROBE and standardized procedural-sedation outcome principles (22–24). Ethical approval was obtained from the Institutional Review Board (IRB)/Ethics Review Committee of the University of Lahore prior to the commencement of the study (Ref. No.: DRC/DHPT021/04/24). The research was conducted in accordance with the ethical principles of the Declaration of Helsinki and its subsequent amendments.

RESULTS

All 94 enrolled patients were included in the descriptive analysis. Men comprised 56 participants (59.6%), compared with 38 women (40.4%), giving a male-to-female ratio of approximately 1.5:1. The absolute difference between the proportions of men and women was 19.2 percentage points. The 31–50-year category was the most frequently represented age group.

Table 1. Participant characteristics

Characteristic	n	%
Male	56	59.6
Female	38	40.4

At least one adverse event was recorded in 52 of 94 patients, corresponding to a prevalence of 55.3% (95% CI 45.3–65.0). The confidence interval indicates that, within the precision of this sample, the underlying proportion experiencing any recorded event could plausibly range from approximately 45% to 65%. Because the event categories were not mutually exclusive, the frequencies in Table 2 represent individual recorded outcomes and should not be added to estimate the number of affected patients.

Table 2. Adverse events observed after ketamine sedation

Adverse event	n	%	95% CI
Hypertension	40	42.6	33.0–52.6
Tachycardia	29	30.9	22.4–40.8
Vomiting	18	19.1	12.5–28.3
Nausea	16	17.0	10.8–25.9
Emergence reaction	12	12.8	7.5–21.0
Hypersalivation	10	10.6	5.9–18.5
Hypoxia	4	4.3	1.7–10.4
Respiratory depression	2	2.1	0.6–7.4
Apnea	1	1.1	0.2–5.8
Laryngospasm	0	0.0	0.0–3.9

Cardiovascular observations formed the largest component of the event profile. Hypertension was recorded in 40 patients (42.6%; 95% CI 33.0–52.6), making it the most frequent individual event. Tachycardia occurred in 29 patients (30.9%; 95% CI 22.4–40.8). Hypertension was therefore observed in 11 more patients than tachycardia and its point estimate was 11.7 percentage points higher. Together, these findings show that increases in blood pressure and heart rate were the principal physiological observations during the monitored period. Gastrointestinal events were the next most prominent group. Vomiting occurred in 18 patients (19.1%; 95% CI 12.5–28.3), while nausea was documented in 16 (17.0%; 95% CI 10.8–25.9). Their similar point estimates and overlapping confidence intervals indicate comparable frequencies in this sample. Emergence reactions affected 12 patients (12.8%; 95% CI 7.5–21.0), and hypersalivation was recorded in 10 (10.6%; 95% CI 5.9–18.5). Thus, each of these recovery-related events affected approximately one in every eight to ten participants.

Respiratory outcomes were substantially less frequent than cardiovascular or gastrointestinal events. Hypoxia was observed in four patients (4.3%; 95% CI 1.7–10.4), respiratory depression in two (2.1%; 95% CI 0.6–7.4), and apnea in one (1.1%; 95% CI 0.2–5.8). No laryngospasm was recorded; however,

the upper limit of the 95% confidence interval was 3.9%, reflecting the uncertainty associated with estimating rare events in a sample of 94 patients.

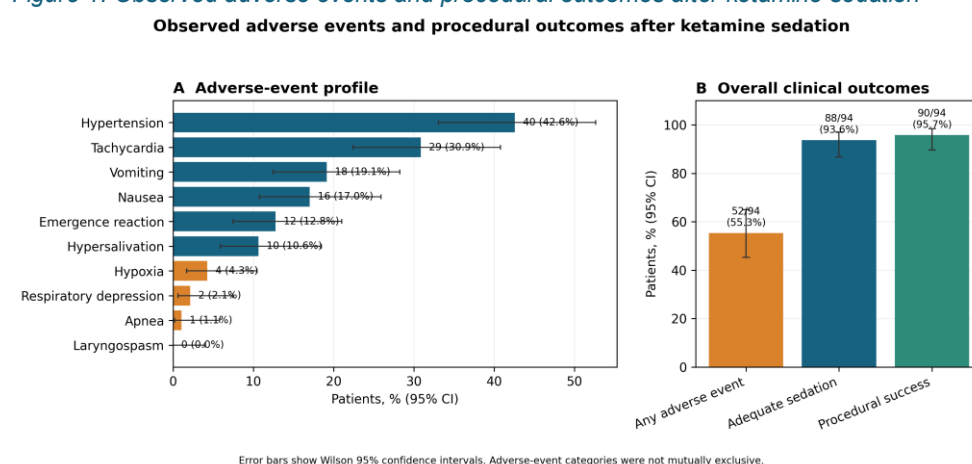
Table 3. Overall sedation and procedural outcomes

Outcome	n	%	95% CI
Any adverse event	52	55.3	45.3–65.0
Adequate sedation	88	93.6	86.8–97.0
Procedural success	90	95.7	89.6–98.3

Adequate sedation was documented in 88 of 94 patients (93.6%; 95% CI 86.8–97.0), leaving six patients (6.4%) without the recorded adequate-sedation outcome. Procedural success was reported in 90 patients (95.7%; 95% CI 89.6–98.3), while four procedures (4.3%) did not meet the recorded success outcome. Procedural success was 2.1 percentage points higher than the adequate-sedation proportion.

The occurrence of any adverse event did not preclude a high overall rate of procedural completion. The point estimate for adequate sedation exceeded that for any adverse event by 38.3 percentage points, and procedural success exceeded it by 40.4 percentage points. These marginal comparisons describe the overall pattern of the aggregate outcomes; they do not identify whether the same patients contributed to each outcome category.

Figure 1. Observed adverse events and procedural outcomes after ketamine sedation



Hypertension and tachycardia occupied the highest range, vomiting and nausea formed an intermediate gastrointestinal cluster, and emergence reaction and hypersalivation each remained close to 10%. Individual respiratory-event estimates were below 5%, although their comparatively wide confidence intervals reflect the small number of events. In parallel, adequate sedation and procedural completion both exceeded 90%, compared with 55.3% for the composite any-adverse-event outcome.

DISCUSSION

This study found that just over half of patients had at least one recorded event after ketamine-based procedural sedation, while adequate sedation and procedural completion were documented in more than nine of every ten patients. The event profile was dominated by hypertension and tachycardia, followed by nausea, vomiting, emergence reactions, and hypersalivation. Hypoxia, respiratory depression, and apnea were uncommon in this sample, and no laryngospasm was recorded.

The predominance of cardiovascular observations is biologically plausible because ketamine commonly increases sympathetic tone, heart rate, and arterial pressure (6–9). These changes may be short-lived, but their clinical importance depends on baseline cardiovascular status, magnitude, duration, and need for treatment. The present results therefore support physiological monitoring but cannot determine whether each recorded change was clinically consequential because event severity and treatment were not available in the aggregate data.

The gastrointestinal and emergence-event pattern is consistent with adult reviews and prospective procedural-sedation series, although published estimates vary across settings (10,11,14,16–20). Differences may reflect dose, administration route, adjunct medication, procedure type, age distribution,

and outcome definitions. Recovery agitation and perceptual effects are recognized features of ketamine, particularly in adults, while nausea and vomiting may delay discharge or require antiemetic therapy (10,14,15).

The low number of respiratory events is compatible with ketamine's tendency to preserve spontaneous ventilation, but it should not be interpreted as absence of risk. Respiratory depression, apnea, and laryngospasm have been reported, and procedural-sedation guidance requires continuous observation and readiness for airway intervention regardless of the agent used (2–4,10–13,24). With only 94 participants, this study was not powered to characterize rare serious events.

A strength of the study is its description of routine practice in a Pakistani teaching-hospital recovery setting, where locally generated data are limited. Its main limitations are the single-center design, purposive sampling, small sample, exclusion of ASA III–IV patients, absence of a comparison group, and limited reporting of dose, route, co-medication, event thresholds, severity, and timing. No adjusted analysis was performed, so the estimates should be interpreted as descriptive rather than causal. Larger prospective multicenter studies should use standardized event definitions and report dose, temporal sequence, interventions, recovery time, and patient-level risk estimates.

CONCLUSION

Among 94 patients receiving ketamine for procedural sedation and analgesia, adverse events were commonly recorded and were predominantly cardiovascular or gastrointestinal, whereas documented respiratory events were uncommon. Adequate sedation and procedural completion were achieved in most patients. These findings support structured monitoring and cautious interpretation of ketamine safety, particularly because event severity, dosing relationships, and rare complications could not be fully evaluated in this descriptive study.

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