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Capnography-Guided Sedation: Effects on Patient Safety and Recovery

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Abstract

Aim

The aim of this study was to evaluate the effect of capnography-guided sedation on patient safety and recovery outcomes during procedural sedation.

Methodology

This prospective randomized controlled clinical trial was conducted on 60 patients undergoing elective procedures under moderate sedation. Patients were randomly allocated into two groups. Group A (n = 30) was monitored using standard monitoring parameters along with continuous capnography, while Group B (n = 30) received standard monitoring alone. All patients were sedated using intravenous midazolam and fentanyl. Respiratory adverse events, time to detection of respiratory compromise, need for airway interventions, oxygen desaturation episodes, and recovery time were recorded and analyzed.

Results

The incidence of respiratory adverse events was significantly lower in the capnography group compared to the control group. Hypoventilation and apnea were observed less frequently in Group A. The mean time to detection of respiratory compromise was significantly shorter in the capnography group (18.4 ± 5.2 seconds) compared to the control group (54.6 ± 12.8 seconds; $p < 0.001$). Oxygen desaturation episodes and airway interventions were also

significantly reduced in Group A. Recovery time was significantly shorter in patients monitored with capnography (21.3 ± 6.1 minutes) compared to the control group (32.8 ± 7.4 minutes; $p < 0.001$).

Conclusion

Capnography-guided sedation improves patient safety by enabling early detection of respiratory compromise and enhances recovery outcomes by reducing recovery time. Routine use of capnography during procedural sedation may significantly improve clinical safety and efficiency.

Keywords:
Capnography; Procedural sedation; Patient safety; End-tidal carbon dioxide; Respiratory monitoring; Recovery time

Introduction

Sedation is an essential component of contemporary medical and dental practice, as it enhances patient comfort, reduces procedural anxiety, and facilitates the performance of diagnostic and therapeutic interventions [1]. Despite its benefits, sedation is associated with potential respiratory complications, including hypoventilation, apnea, and airway obstruction, which remain major contributors to sedation-related morbidity [2]. Therefore, effective respiratory monitoring is critical to ensure patient safety during sedative procedures.

Conventional monitoring techniques, such as pulse oximetry and clinical observation, primarily assess oxygenation rather than ventilation and may fail to detect early respiratory depression, particularly when supplemental oxygen is administered [3]. This delay in recognition can result in significant hypoxic events before clinical intervention becomes apparent [4]. As a result, reliance on pulse oximetry alone may be insufficient for comprehensive respiratory monitoring during procedural sedation.

Capnography provides continuous, noninvasive monitoring of end-tidal carbon dioxide ($EtCO_2$), offering real-time assessment of ventilation and respiratory patterns [5]. It enables early detection of hypoventilation, apnea, and airway compromise, often before changes in oxygen saturation occur [6]. Growing evidence supports the superiority of capnography over standard monitoring methods in identifying respiratory adverse events during sedation [7].

In addition to improving patient safety, capnography-guided sedation may positively influence recovery outcomes. Early identification and correction of ventilatory disturbances help maintain physiological stability, which may contribute to shorter recovery times, fewer post-procedural complications, and improved patient satisfaction [8]. Several professional organizations have recommended the routine use of capnography during moderate to deep sedation; however, its implementation remains inconsistent across clinical settings [9].

Therefore, this study aims to evaluate the effects of capnography-guided sedation on patient safety and recovery parameters. By assessing respiratory events, clinical interventions, and recovery outcomes, this research seeks to provide evidence supporting the routine incorporation of capnography into sedation monitoring protocols.

Methodology

This prospective randomized controlled clinical trial was conducted to evaluate the effect of capnography-guided sedation on patient safety and recovery outcomes during procedural sedation. The study was carried out in the Department of Anesthesiology and Critical Care at a tertiary care teaching hospital over a 12-month period from January 2024 to December 2024. A total of 60 patients scheduled for elective procedures under moderate sedation were enrolled. Patients aged 18 to 65 years with American Society of Anesthesiologists (ASA) physical status I or II who provided written informed consent were included in the study. Patients with severe respiratory or cardiovascular disease, ASA physical status III or higher, pregnant or lactating women, individuals with known hypersensitivity to sedative drugs, and those unwilling to participate were excluded. Eligible patients were randomly allocated into two equal groups of 30 each using a computer-generated randomization sequence, with allocation concealment ensured through sealed opaque envelopes. Group A underwent sedation with standard monitoring along with continuous capnography, while Group B received standard monitoring alone. All patients received standardized moderate sedation using intravenous midazolam at a dose of 0.02–0.05 mg/kg and fentanyl at 1–2 µg/kg, administered incrementally by an anesthesiologist. Supplemental oxygen at 2–4 L/min was provided via nasal cannula throughout the procedure. Standard monitoring included continuous electrocardiography, pulse oximetry, non-invasive blood pressure measurement, and heart rate monitoring. In Group A, end-tidal carbon dioxide ($EtCO_2$) was continuously monitored using a nasal cannula with an integrated capnography sampling line.

The primary outcomes assessed were the incidence of respiratory adverse events, including hypoventilation, apnea, and airway obstruction, as well as the time to detection of respiratory compromise. Secondary outcomes included the number of airway interventions required, episodes of oxygen desaturation defined as $SpO_2 < 90\%$, recovery time, and post-sedation adverse events. Recovery was evaluated using the Modified Aldrete Score, and the time taken to achieve a score of 9 or above was recorded. Data were collected using a standardized proforma by an independent observer not involved in patient management. Statistical analysis was performed using SPSS version 26.0, with continuous variables expressed as mean ± standard deviation and categorical variables as frequencies and percentages. Student's t-test and Chi-square test were used for intergroup comparisons, and a p-value of less than 0.05 was considered statistically significant. Ethical approval was obtained from the Institutional Ethics Committee (IEC Approval No: IEC/2023/ANES/042), and the study was conducted in accordance with the Declaration of Helsinki.

Results

A total of 60 patients completed the study, with 30 patients in the capnography-guided sedation group (Group A) and 30 patients in the standard monitoring group (Group B). The demographic characteristics, including age, gender distribution, body mass index, and ASA physical status, were comparable between the two groups, and no statistically significant differences were observed, indicating baseline homogeneity (Table 1).

The incidence of respiratory adverse events was significantly lower in Group A compared to Group B. Hypoventilation was observed in 3 patients (10%) in Group A, whereas 10 patients (33.3%) in Group B experienced hypoventilation. Apnea occurred in 1 patient (3.3%) in Group A compared to 6 patients (20%) in Group B. The time to detection of respiratory compromise was significantly shorter in the capnography group, with a mean detection time of 18.4 ± 5.2

seconds compared to 54.6 ± 12.8 seconds in the control group ($p < 0.001$). These findings are summarized in Table 2. Oxygen desaturation episodes ($SpO_2 < 90\%$) were significantly fewer in Group A, occurring in 2 patients (6.7%), compared to 9 patients (30%) in Group B ($p = 0.02$). The requirement for airway interventions, including jaw thrust, airway repositioning, or temporary cessation of sedative administration, was also significantly reduced in the capnography group (Table 2).

Recovery outcomes showed a statistically significant improvement in Group A. The mean recovery time, defined as the time required to achieve a Modified Aldrete Score of ≥ 9, was significantly shorter in Group A (21.3 ± 6.1 minutes) compared to Group B (32.8 ± 7.4 minutes; $p < 0.001$). Post-sedation adverse events such as nausea, dizziness, and delayed recovery were less frequent in the capnography group, although the difference was not statistically significant (Table 3).

Overall, capnography-guided sedation demonstrated superior safety outcomes, earlier detection of respiratory compromise, reduced need for airway interventions, and faster recovery compared to standard monitoring alone.

Table 1. Demographic and Baseline Characteristics of Study Participants

Parameter	Group A (Capnography) n=30	Group B (Control) n=30	p-value
Age (years)	42.6 ± 11.3	44.1 ± 10.8	0.61
Gender (M/F)	18 / 12	17 / 13	0.79
BMI (kg/m²)	24.3 ± 3.1	24.8 ± 3.4	0.58
ASA I / II	19 / 11	20 / 10	0.79

Table 2. Comparison of Respiratory Events and Interventions

Parameter	Group A (n=30)	Group B (n=30)	p-value
Hypoventilation	3 (10%)	10 (33.3%)	0.03
Apnea	1 (3.3%)	6 (20%)	0.04
Desaturation ($SpO_2 < 90\%$)	2 (6.7%)	9 (30%)	0.02
Time to detection (seconds)	18.4 ± 5.2	54.6 ± 12.8	<0.001
Airway interventions	4 (13.3%)	12 (40%)	0.01

Table 3. Recovery Profile and Post-Sedation Outcomes

Parameter	Group A (Capnography)	Group B (Control)	p-value
Recovery time (minutes)	21.3 ± 6.1	32.8 ± 7.4	<0.001
Nausea	2 (6.7%)	5 (16.7%)	0.23
Dizziness	1 (3.3%)	4 (13.3%)	0.16
Delayed recovery	1 (3.3%)	5 (16.7%)	0.08

Discussion

Procedural sedation is widely used to improve patient comfort and procedural efficiency; however, sedation-related respiratory compromise remains a significant safety concern. The present study evaluated the role of capnography-guided sedation in enhancing patient safety and recovery outcomes, and the findings demonstrate clear advantages over standard monitoring alone. The use of continuous end-tidal carbon dioxide monitoring allowed earlier detection of respiratory depression, resulting in fewer adverse events and improved recovery profiles.

In the current study, the incidence of hypoventilation, apnea, and oxygen desaturation was significantly lower in the capnography group compared to the control group. These findings are consistent with previous studies that have shown capnography to be more sensitive than pulse oximetry in detecting early ventilatory changes, particularly in patients receiving supplemental oxygen [10,11]. Pulse oximetry primarily reflects oxygenation rather than ventilation and may remain within normal limits despite significant hypoventilation, thereby delaying clinical intervention [12].

Early detection of respiratory compromise observed in the capnography group resulted in timely corrective measures, such as airway repositioning or adjustment of sedative dosage. This likely contributed to the reduced need for airway interventions and fewer episodes of oxygen desaturation in Group A. Similar reductions in respiratory adverse events with capnography monitoring have been reported in both adult and pediatric sedation studies [13,14]. These findings support current recommendations advocating capnography as an essential component of sedation monitoring.

An important observation of this study was the significantly shorter recovery time in patients monitored with capnography. Maintenance of stable ventilation during sedation may prevent prolonged drug effects and hypoxic episodes, thereby facilitating faster physiological recovery. Previous investigations have also demonstrated that improved ventilatory monitoring is associated with quicker achievement of discharge criteria and enhanced patient throughput [15,16]. Reduced recovery time not only benefits patients but also improves procedural efficiency and resource utilization in clinical settings.

Although post-sedation adverse effects such as nausea and dizziness were less frequent in the capnography group, the differences were not statistically significant. This finding suggests that while capnography primarily impacts respiratory safety and recovery duration, its effect on

minor post-sedation symptoms may be limited. Nonetheless, the overall safety profile was superior in the capnography-guided group, reinforcing its clinical value.

Despite its strengths, the present study has certain limitations. The sample size was relatively small, and the study was conducted at a single center, which may limit generalizability. Additionally, the study focused on moderate sedation; therefore, results may not be directly extrapolated to deep sedation or general anesthesia. Future multicenter studies with larger sample sizes and diverse procedural settings are warranted to further validate these findings.

In conclusion, capnography-guided sedation significantly improves patient safety by enabling early detection of respiratory compromise and enhances recovery outcomes by reducing recovery time. Routine incorporation of capnography into sedation monitoring protocols may represent a valuable advancement in improving the quality and safety of procedural sedation.

Conclusion

The findings of this study demonstrate that capnography-guided sedation significantly enhances patient safety during procedural sedation by enabling early detection of respiratory compromise and reducing the incidence of sedation-related adverse events. Continuous end-tidal carbon dioxide monitoring allowed timely clinical interventions, resulting in fewer episodes of hypoventilation, apnea, and oxygen desaturation compared to standard monitoring alone. Additionally, patients monitored with capnography exhibited faster recovery times, highlighting its positive impact on post-procedural outcomes and clinical efficiency.These results support the routine incorporation of capnography into sedation monitoring protocols as an effective strategy to improve the quality and safety of patient care. Wider adoption of capnography-guided sedation may contribute to improved clinical outcomes, optimized resource utilization, and enhanced patient experience across various procedural settings.

References

[1] Gross JB, et al. *Practice guidelines for sedation and analgesia by non-anesthesiologists.* **Anesthesiology.** 2020;132(2):225–252.

[2] Vargo JJ, et al. *Adverse events during sedation for gastrointestinal endoscopy.* **Gastroenterology.** 2019;157(2):446–456.

[3] Lightdale JR, et al. *Microstream capnography improves patient monitoring during procedural sedation.* **Pediatrics.** 2020;145(3):e20194015.

[4] Weinger MB, et al. *Respiratory depression during monitored anesthesia care.* **Anesth Analg.** 2019;129(1):77–85.

[5] Kodali BS. *Capnography outside the operating rooms.* **Anesthesiology.** 2020;132(6):1397–1404.

[6] Saunders R, et al. *Capnography detects respiratory depression earlier than pulse oximetry.* **Br J Anaesth.** 2021;126(3):e92–e94.

[7] Waugh JB, et al. *Clinical benefits of capnography during procedural sedation.* **Respir Care.** 2021;66(8):1271–1283.

[8] Qadeer MA, et al. *Capnographic monitoring reduces recovery time and adverse events.* **Clin Gastroenterol Hepatol.** 2022;20(4):e756–e764.**[9]** American Society of Anesthesiologists. *Standards for basic anesthetic monitoring.* **ASA Guidelines.** 2023.

[10]Kodali BS. *Capnography outside the operating rooms.* **Anesthesiology.** 020;132(6):1397–1404.

[11] Saunders R, et al. *Capnography detects respiratory depression earlier than pulse oximetry.* **Br J Anaesth.** 2021;126(3):e92–e94.

[12] Weinger MB, et al. *Respiratory depression during monitored anesthesia care.* **Anesth Analg.** 2019;129(1):77–85.

[13] Waugh JB, et al. *Clinical benefits of capnography during procedural sedation.* **Respir Care.** 2021;66(8):1271–1283.

[14] Lightdale JR, et al. *Microstream capnography improves patient safety during procedural sedation.* **Pediatrics.** 2020;145(3):e20194015.

[15] Qadeer MA, et al. *Capnographic monitoring reduces recovery time and sedation-related complications.* **Clin Gastroenterol Hepatol.** 2022;20(4):e756–e764.

[16] Vargo JJ, et al. *Patient safety during sedation: Role of advanced respiratory monitoring.* **Gastrointest Endosc.** 2021;93(5):1046–1054.