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Sedation Related Complications in Gastrointestinal Interventions: A Single-Center Prospective Observational Study

Gastrointestinal Girişimlerde Sedasyonla İlişkili Komplikasyonlar: Tek Merkezli Prospektif Gözlemsel Çalışma

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ABSTRACT

Objective: While sedation is integral to modern gastrointestinal endoscopy, it is associated with a risk of cardiorespiratory complications. The primary objective of this study was to prospectively evaluate the safety profile and outcomes of sedation practices for gastrointestinal endoscopy. We aimed to quantify the incidence of specific cardiopulmonary adverse events and to identify the independent patient- and drug-related risk factors associated with these complications.

Methods: This prospective, single-center observational study included adult patients undergoing elective gastrointestinal procedures. Pre-procedural demographic and clinical data, including age, body mass index (BMI), American Society of Anesthesiologists score and Mallampati scores, were recorded. Intra-procedural data, including sedative agents, doses, and continuous cardiorespiratory monitoring, were collected. Binomial logistic regression models were used to determine the risk factors for complications.

Results: The overall complication rate was 69.6%, with hypotension (58%), hypertension (15%), and hypoxia (12%) being the most frequent adverse events. Multivariate analysis identified increasing age (OR=1.03, p<0.0001), higher BMI (OR=1.06, p=0.004), a Mallampati score of 3 (OR=1.98, p=0.004), and longer procedure duration (OR=1.03, p<0.0001) as independent predictors for any complication. Upper gastrointestinal procedures were associated with an increased risk of hypoxia (OR=2.12, p=0.05). Lidocaine administration at induction markedly reduced the overall complication rate (OR=0.03, p=0.01). Higher maintenance doses of propofol correlated with hypotension (OR=1.003, p=.005), whereas higher induction doses of midazolam increased the risk of hypoxia (OR=1.8, p=0.04) and apnea (OR=2.7, p=0.03). Prior COVID-19 vaccination was a protective factor against postoperative nausea and vomiting (PONV) (OR=0.003, p=0.03).

Conclusion: Although sedation for gastrointestinal endoscopy is generally safe, transient cardiorespiratory events are frequent, especially in older or obese patients, those with difficult airways, and during longer procedures. Intravenous lidocaine appeared to

ÖZ

Amaç: Sedasyon, modern gastrointestinal endoskopinin ayrılmaz bir parçası olsa da komplikasyon riski ile ilişkilidir. Bu çalışmanın temel amacı, gastrointestinal endoskopi için uygulanan sedasyonun güvenlik profilini ve sonuçlarını prospektif olarak değerlendirmektir. Spesifik kardiyopulmoner istenmeyen olayların insidans ölçmeyi ve bu komplikasyonlarla ilişkili bağımsız hasta ve ilaca bağlı risk faktörlerini tanımlamayı hedefledik.

Yöntem: Bu prospektif, tek merkezli, gözlemsel çalışmaya, elektif gastrointestinal işlem geçiren yetişkin hastalar dahil edildi. İşlem öncesi yaş, vücut kitle indeksi (VKİ), Amerikan Anestezistler Derneği (ASA) skoru ve Mallampati skoru gibi demografik ve klinik veriler kaydedildi. İşlem sırasında sedatif ajanlar, dozları ve sürekli kardiyorespiratuar monitörizasyon verileri toplandı. Komplikasyonlar için risk faktörlerini belirlemek amacıyla binomiyal lojistik regresyon modelleri kullanıldı.

Bulgular: Genel komplikasyon oranı %69,6 olup, en sık görülen komplikasyon hipotansiyon (%58), hipertansiyon (%15) ve hipoksiydi (%12). Çok değişkenli analizde artan yaş (OR=1,03; p<0,0001), daha yüksek VKİ (OR=1,06; p=0,004), Mallampati skoru 3 (OR= 1,98; p=0,004) ve daha uzun işlem süresi (OR=1,03; p<0,0001) herhangi bir komplikasyon için bağımsız belirleyiciler olarak tanımlandı Üst gastrointestinal girişimler hipoksi riskinde artış ile ilişkiliydi (OR=2,12; p=0,05). İndüksiyon sırasında lidokain uygulanması genel komplikasyon oranını belirgin biçimde azalttı (OR= 0,03; p=0,01). Daha yüksek idame propofol dozları hipotansiyon ile koreleydi (OR=1,003; p=0,005); buna karşılık, daha yüksek indüksiyon midazolam dozları hipoksi (OR=1,8; p=0,04) ve apne (OR=2,7; p=0,03) riskini artırdı. Önceden yapılmış COVID-19 aşılaması postoperatif bulantı ve kusmaya (POBK) karşı koruyucu bir faktör olarak belirlendi (OR=0,003; p=0,03).

Sonuç: Gastrointestinal endoskopi için sedasyon genellikle güvenli olsa da, özellikle yaşlı veya obez hastalarda, zor hava yoluna sahip olanlarda ve uzun süren işlemler sırasında geçici kardiyorespiratuar olaylar sıktır. İntravenöz lidokainin genel komplikasyonlara karşı koruyucu olduğu görülmüştür. Hasta güvenliğini artırmak için dik-

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be protective against overall complications. Careful pre-procedural assessment, individualized drug selection, and vigilant monitoring are crucial to enhance patient safety. The novel finding of a protective effect of COVID-19 vaccination against PONV warrants further investigation.

Keywords: Sedation, gastroentrology, complication

katli bir işlem öncesi değerlendirme, kişiselleştirilmiş ilaç seçimi ve yakın takip kritik öneme sahiptir. COVID-19 aşılamasının POBK 'a karşı koruyucu etkisine dair bu yeni bulgu, daha ileri araştırmaları gerektirmektedir.

Anahtar sözcükler: Sedasyon, gastroentroloji, komplikasyon

INTRODUCTION

The administration of sedation has become a cornerstone of modern gastrointestinal endoscopy, performed in the vast majority of cases across numerous countries (1,2). Its fundamental role is enhancing patient tolerance and satisfaction, transforming potentially distressing examinations into manageable experiences. Critically, sedation is not merely a tool for comfort; it is an enabling factor that facilitates the successful completion of many diagnostic and therapeutic interventions. For particularly prolonged or technically demanding procedures, such as endoscopic retrograde cholangiopancreatography (ERCP), endoscopic ultrasound (EUS)-guided interventions, or endoscopic submucosal dissection (ESD), the use of deep sedation is widely regarded as indispensable for ensuring procedural success and patient safety (3). Recognizing the increased complexity of such cases—which often correlates with longer procedure times, diminished technical success rates, and a higher risk of adverse events—the American Society for Gastrointestinal Endoscopy has recommended that sedation administered by a dedicated anesthesia provider should be considered for these complex endoscopic procedures (1).

However, this clinical necessity is counterbalanced by the inherent risks associated with all sedative agents and techniques. The provision of sedation introduces a potential for significant pulmonary complications, including but not limited to hypoventilation, respiratory depression leading to apnea, hypoxemia, as well as hemodynamic instability manifesting as hypotension or bradycardia (4). This paradox—the necessity of sedation for complex procedures versus its intrinsic risks—presents a significant clinical challenge.

Optimal sedation techniques for complex endoscopic procedures remain unclear (5, 6). There is a lack of global consensus regarding the choice of practitioners to administer sedation and the optimal sedation technique for endoscopic procedures. Many of the recommendations given in the guidelines are based on limited evidence, as the data published on sedation-associated complications are mostly retrospective (7-9).

In light of these literature gaps and the limitations associated with predominantly retrospective data, the primary objective of this study was to prospectively evaluate the outcomes and safety profile of anesthesiologist-administered sedation for gastrointestinal endoscopic procedures. Beyond aiming to sensitively capture transient physiological events often missed in retrospective audits, this study seeks to provide a unique contribution to the literature by comprehensively analyzing not only established demographic risk factors but also the impact of adjuvant agents like intravenous lidocaine and novel factors such as COVID-19 vaccination status on sedation-related complications. Accordingly, we aimed to quantify the incidence of specific cardiopulmonary adverse events and to identify independent risk factors associated with the development of each complication

MATERIAL and METHODS

This prospective, single-center observational study was conducted in the Interventional Gastroenterology Unit of Gazi University Faculty of Medicine. The Institutional Ethics Committee approved the protocol (23 December 2021; approval No. 238) and registered it at ClinicalTrials.gov (NCT05563727). Written informed consent was obtained from every participant prior to enrolment.

All adult patients (≥18 years) who underwent elective gastrointestinal procedures—diagnostic or therapeutic upper endoscopy, colonoscopy, ERCP, EUS, or ESD—were screened for inclusion between December 2021 and December 2022. Exclusion criteria were: refusal or inability to provide informed consent (e.g., cognitive impairment or language barrier), emergency procedures, known allergy to any sedatives, baseline peripheral oxygen saturation (SpO_2) < 90%, baseline systolic blood pressure (SBP) < 90 mmHg, or the need for tracheal intubation.

Before each procedure, a range of demographic and clinical variables were recorded. These included age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) physical status classification, pre-existing comorbidities, Mallampati airway score, smoking status, and history of COVID-19 infection or vaccination. The assessed comorbidities included cardiovascular (hypertension, coronary artery disease, congestive heart failure), endocrinological (diabetes mellitus, thyroid disorders), pulmonary (chronic obstructive pulmonary disease, asthma), neurological (history of cerebrovascular event), and renal (chronic kidney disease) conditions.

Upon arrival in the procedure room, patients underwent routine monitoring. All sedation procedures were managed by a primary anesthesiologist who was not involved in data collection. In keeping with the study's observational design, the choice of sedative agents (most frequently propofol, ketamine, lidocaine, fentanyl, and midazolam), administration technique, and dosing were left to the clinical discretion of the primary anesthesiologist.

A second, independent anesthesiologist, acting as an observer, was responsible for prospectively documenting all relevant data. This included the specific sedation technique, the cumulative doses of all administered anesthetic agents, and the total procedure time. In accordance with the standard sedation protocol at our institution, the depth of sedation was assessed at 5-minute intervals using the Modified Observer's Assessment of Alertness/Sedation (MOAA/S) scale. Throughout the procedure, the primary anesthesiologist titrated the sedative agents to maintain a deep sedation level, corresponding to a target MOAA/S score of 1–2, with the clinical goals of preventing patient movement, coughing, and gagging while preserving spontaneous ventilation.

Non-invasive blood pressure, heart rate, and SpO_2 were recorded at specific time points: baseline (T0), immediately post-induction (Tinduction), at 5-minute intervals thereafter (T5, T10, T15 etc.), and upon arrival in the post anesthesia care unit (PACU) (TPACU).

After the intervention, all patients were transferred to the PACU and observed by dedicated nursing staff. Patients were discharged upon achieving full recovery, defined as an Aldrete score of ≥9, and only after being assessed for at least 30 minutes following the cessation of sedative administration. The patient's final disposition—home, surgical ward, or intensive care unit—was also recorded.

Any complications that developed during the perioperative period until discharge were recorded, including hypotension, hypertension, bradycardia, hypoxia, apnea, bronchospasm, the need for inotropic support or atropine, agitation, and postoperative nausea and vomiting (PONV). Specific clinical criteria were established to define these adverse events. Hypotension was defined as a decrease in mean arterial pressure (MAP) to below 60 mmHg or a reduction of more than 20% from the patient's baseline value. Hypertension was defined as an increase in SBP of at least 20% from the patient's baseline values or a sustained SBP exceeding 160 mmHg. Bradycardia was defined as a heart rate that drops below 60 beats per minute, while hypoxia was defined as a SpO_2 level below 92%. Apnea was defined as the cessation of respiratory airflow for 20 seconds or longer.

Statistical Analyses

All statistical analyses were performed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the demographic variables and complications. Mean and standard deviation (SD) were reported for continuous variables, while percentages were provided for categorical variables. Binomial logistic regression models were established to determine the risk factors for complications according to demographic variables. The demographic variables considered in the analysis included gender, age, BMI, type of procedure (upper/lower GI system), ASA score, Mallampati score, procedure time, smoking status, history of COVID, vaccination status, presence of any comorbidity, type of comorbidity (neurological, cardiovascular, pulmonary, endocrinological, renal). Multiple regression analyses was utilized to evaluate the association between drug exposure and complications in which the cumulative doses of all sedative and analgesic agents administered during induction and maintenance were included *a priori* as independent variables using the enter method. Model fit was assessed with the Hosmer–Lemeshow test, and all models demonstrated adequate fit ($p>0.05$). Statistical significance was defined as $p<0.05$.

RESULTS

Demographic and Procedural Data

During the study period, 792 patients underwent gastrointestinal procedures and were assessed for eligibility to be included. Sixty-three patients could not be enrolled owing to the following reasons: 19 patients refused to participate, 46 did not meet the inclusion criteria (n=14: baseline SPO_2 sat < 90%, n=23: basal SBP < 90 mmHg, n=9: lack of written informed consent for various reasons), n=7: need for general anesthesia, technical failure occurred in 3 patients, and 24 patients were excluded because they presented for more than occasions during the study period. Patients' data were included in the statistical analysis only once in these cases. Eventually, 693 patients were analyzed (Figure 1).

Table I shows the baseline clinical and demographic characteristics of the investigated patients. Notably, the study included 55.7% men (n=307), and the mean age of the study population was 54.5 ± 15.1 years. Most patients were classified as ASA class II (62%, n=430). The most common underlying disease was hypertension in 30% of the patients (n=208). The most common procedure was endoscopy (26.4%), and the mean procedure time was 19.8 ± 15.3. 541 (78.1%) patients were discharged home, 151 (21.8%) were discharged to the ward, and one patient was sent to ICU.

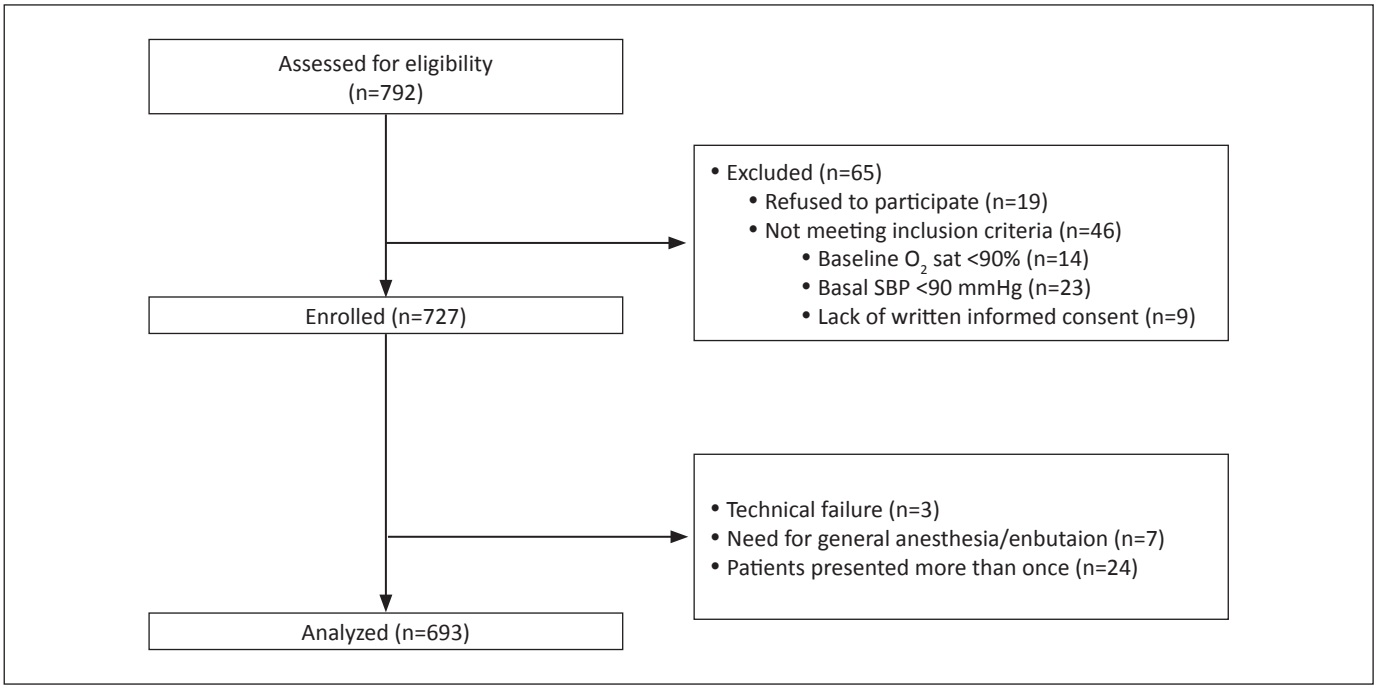

Figure 1. Flowchart of the study. **SBP:** Systolic blood pressure.

Table I. Patients' Clinical and Demographic Characteristics, Procedure Type

Male, n (%)	**307 (55.7)**
Age, mean±SD (years)	54.5 ± 15.1
BMI, mean±SD	26.6 ± 4.8
ASA Score, n (%)	
I	96 (13.9)
II	430 (62.0
III	152 (21.9
IV	15 (2.2)
Comorbidity, n (%)	
Hypertension	208 (30.0)
Endocrine Disease	165 (23.8)
Cardiac Disease	60 (8.7)
Respiratory Disease	45 (6.5)
Cerebrovascular Event	23 (3.3)
Renal Disease	22 (3.2)
Procedure, n (%)	
Upper GI Endoscopy	183 (26.4)
ERCP	154 (22.2)
Upper GI Endoscopy + Colonoscopy	144 (20.8)
Colonoscopy	95 (13.7)
EUS	86 (12.4)
ESD	31 (4.5)
Mallampati Score, n (%)	
1	194 (28.0)
2	365 (52.7)
3	124 (17.9)
4	10 (1.4)
Smoking, n (%)	162 (23.4)
History of COVID-19, n (%)	148 (21.4)
History of vaccination, n (%)	651 (93.9)
Type of vaccination, n (%)	
Biontech	283 (40.8)
Sinovac	130 (18.8)
Combined	238 (40.8)
Procedure time, mean± SD (min)	19.8 ± 15.3
Anesthesia induction time, mean± SD (min)	2.8 ± 1.8

BMI: Body mass index, **ASA:** American Society of Anesthesiology, **GI:** Gastrointestinal, **ERCP:** Endoscopic retrograde cholangiopancreatography, **EUS:** Endoscopic ultrasound, **ESD:** Endoscopic submucosal dissection

Drugs Data

Intravenous propofol was the most commonly used sedative agent for induction, accounting for 99.6% of cases (n=690), followed by ketamine (96.1%, n=666), midazolam (95.8%, n=664), fentanyl (89%, n=617), and lidocaine (81.8%, n=567). For propofol, the mean dose administered for induction was 70 ± 32.3 mg (range 10-220 mg), with a medication dosage of 0.9 ± 0.5 mg kg^{-1} (range 0.1-4.0 mg kg^{-1}). The mean dose of ketamine administered for induction was 24.3 ± 3.7 mg (range 10-50 mg), with a medication dosage of 0.3 ± 0.08 mg kg^{-1} (range 0.1-0.7 mg kg^{-1}). As for midazolam, the mean dose administered for induction was 1.1 ± 0.3 mg (range 1-3 mg), with a medication dosage of 0.01 ± 0.006 mg (range 0.01-0.05).

In terms of sedative agents used for maintenance, intravenous propofol was the most frequently administered agent, accounting for 91.6% (n=638). Ketamine, fentanyl, and lidocaine were administered on an as-needed basis, with ketamine used in 8.4% (n=58) and fentanyl in 3.8% (n=26). The mean total dose of propofol administered for maintenance was 104.7 ± 88.0 mg (range 10-800), with a medication dosage of 4.8 ± 3.7 mg kg^{-1} hr^{-1}. The mean total dose of ketamine administered for maintenance was 16.9 ± 11.6 mg (range 5-75). Additionally, the mean total dose of fentanyl administered for maintenance was 47.0 ± 16.6 µg (range 25-100). Midazolam (1 mg) and lidocaine (30 mg) were administered for maintenance of anesthesia in only two patients.

Cardiorespiratory Data

In most patients, sedation for gastrointestinal procedures did not significantly change cardiopulmonary function. The heart rate gradually decreased during the induction phase and throughout the procedure, reaching its lowest point at T50. In the post-procedure phase (TPACU), the heart rate slightly increased. Similarly, the MAP exhibited a decreasing trend during the procedure, although a slight increase was noted between T25 and T40. Oxygen saturation remained relatively stable throughout the procedure, showing only an insignificant decrease in the TPACU (Figure 2).

Complications

In the multivariate analyses, the risk of complication occurrence was predicted by the demographic variables we screened for. Age [OR=1.03 (95% CI, 1.02-1.05), p<0.0001], BMI [OR=1.06 (95% CI, 1.01-1.10), p=0.004], the Mallampati score, specifically a score of 3 compared to 1 [OR=1.98 (95% CI, 1.04-3.78), p=0.004] and procedure time [OR=1.03 (95% CI, 1.01-1.05), p<0.0001] were positively correlated with the occurrence of any complication. However, an endocrinological disorder was associated with a decreased risk [OR=0.42 (95% CI, 0.25-0.7), p=0.001].

The risk of developing hypertension was also assessed in relation to the screened variables. Body mass index showed a positive association, with an OR of 1.05 (95% CI, 1.01-1.10, p=0.02). Additionally, a higher Mallampati score (4 vs. 1) was significantly associated with an increased risk of hypertension, with an OR of 5.48 (95% CI, 1.32-22.7, p=0.01). Procedure time also demonstrated a positive correlation, with an OR of 1.01 (95% CI, 1.001-1.02, p=0.03).

The risk for occurrence of hypotension was predicted by the variables that we screened for: age [OR=1.03 (95% CI, 1.02-1.05), p<0.0001], ASA score (3 vs. 1) [OR=0.41 (95% CI, 0.2-0.8), p=0.01], ASA score (4 vs. 1) [OR=0.19 (95% CI, 0.05-0.74, p=0.01], procedure time [OR=1.02 (95% CI, 1.01-1.04), p<0.0001].

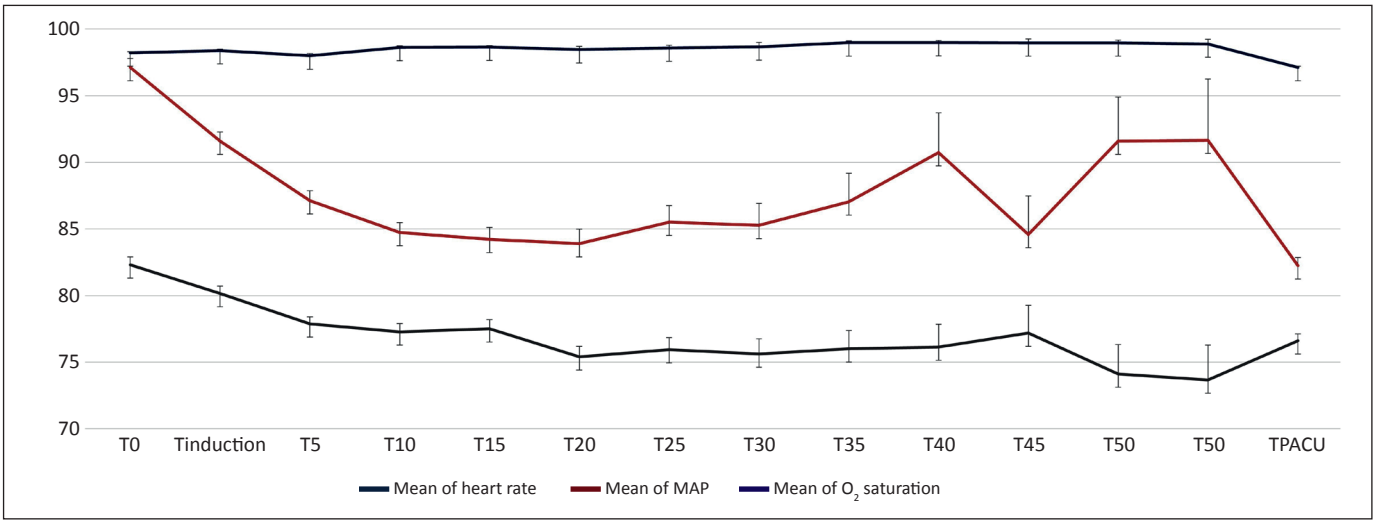

Figure 2. Heart rate, mean arterial presure and peripheral O_2 saturation of the patients. **MAP:** Mean arterial pressure.

Table II. Overall Complication Rates and Type of Sedation Related Adverse Events

	n (%)
Overall complication	**482 (69.6)**
Hypotension	402 (58)
Hypertension	104 (15)
Hypoxia	83 (12)
Inotrope administration	72 (10.4)
Apnea	32 (4.6)
Bradycardia	9 (1.3)
Bronchospasm	8 (1.2)
Nausea Vomiting	8 (1.2)
Agitation	3 (0.4)
Atropine administration	2 (0.3)

The risk of hypoxia increases in upper gastrointestinal procedures [OR=2.12 (95% CI, 0.99-4.5), p=0.05).

Two variables were identified as significant predictors of the occurrence of apnea. Procedure time showed a negative correlation, with an OR of 0.95 (95% CI, 0.91-0.99, p<0.004), indicating that longer procedure times were associated with a decreased risk. Additionally, the presence of any type of comorbidity increased the risk of apnea, with an OR of 6.02 (95% CI, 1.17-31.03, p<0.03).

No significant associations were observed between demographic values and the risks of bronchospasm, agitation, and bradycardia.

Interestingly, COVID-19 vaccination was identified as a negative risk factor [OR=0.003 (95% CI, 0.000-0.66), p=0.03] for PONV.

Logistic regression revealed that lidocaine administered at induction significantly reduced the odds of any complication [OR 0.35 (95% CI, 0.15–0.83); p=0.01], although each incremental dose slightly increased risk (OR=1.02 per mg; p = 0.006). Intra-operative ketamine quadrupled overall complication risk [OR = 4.53 (95% CI, 1.16–17.64), p=0.03] and tripled the need for inotropic support [OR = 3.02 (95% CI, 1.06–8.58, p=0.03). Higher maintenance propofol doses independently predicted overall complications (OR=1.004 per mg; p= 0.001) and hypotension (OR=1.003 per mg; p=0.005). Midazolam induction dose increased the odds of hypoxia [OR=1.90 (95% CI, 1.02–3.55); p=0.04] and apnea [OR=2.77 (95% CI,1.09–7.04); p=0.03], yet paradoxically protected against hypotension [OR 0.57 (95% CI, 0.35–0.92); p=0.02]. Fentanyl during maintenance was the strongest predictor of intra-operative hypertension [OR=16.72 (95% CI, 1.24–225.56); p=0.03]. Conversely, induction ketamine markedly reduced postoperative nausea and vomiting [OR=0.02 (95% CI, 0.00–0.78); p=0.03] and dose-dependently lowered bradycardia risk (OR=0.83 per mg; p=0.01). No other variables reached statistical significance. Drug-related complications are detailed in Table III.

DISCUSSION

This prospective, single-center observational study demonstrates that sedation for gastrointestinal endoscopy is accompanied by a substantial overall complication rate (69.6%), with hypotension (58%), hypertension, and hypoxia comprising the leading adverse events. Multivariable modeling identified increasing age, higher BMI, a Mallampati score of 3, and longer procedure duration as independent predictors of any complication. Pharmacological factors were equally important. Larger maintenance doses of propofol were associated with more hypotension and overall complications, whereas higher induction doses of midazolam increased the likelihood of hypoxia and apnoea. A novel and clinically relevant observation was the protective effect of prior COVID-19 vaccination against PONV.

Registry data typically report markedly lower adverse event rates compared to our findings. For instance, the National Anesthesia Clinical Outcomes database, which includes over 400,000 endoscopic procedures, cites an overall complication incidence of 1.09% and a serious-event rate of 0.34% (10). Likewise, an audit of 44,659 cases documented hemodynamic instability in 22.4%, dysrhythmia in 3.6%, desaturation in 1.4%, and PONV in 1.4% (11). This pronounced disparity is mainly attributable to methodological heterogeneity: our prospective, real-time data collection and deliberately stringent physiological thresholds enabled the identification of transient—yet clinically meaningful—episodes of hypotension, hypertension, or oxygen desaturation, which are frequently overlooked in retrospective databases. Although our study reported higher rates of hypotension, hypertension, or hypoxia compared to previous literature, the incidence of serious complications remained very low. These findings highlight the urgent need for harmonized, physiologically relevant definitions and standardized data-collection frameworks to allow valid and meaningful comparisons across studies.

The risk factors identified here are in accordance with previous studies. In 23,788 procedures, Gemma et al. demonstrated that advanced age, elevated BMI, higher ASA and Mallampati scores, inpatient status, prolonged interventions, and multidrug sedation heightened adverse-event risk (12). Specifically, patients aged ≥75 years experienced 46% more events than those <66 years; a BMI ≥27 kg m^{-2} conferred a 27% higher risk, while each one-point increase in ASA or Mal-

Table III. Types and Doses of Drugs and Their Relationship with Complications

Complication	Period	Drug use and Drug Dosages	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
									Lower	Upper
Overall complication	Induction	Lidocaine	-1.047	0.438	5.707	1	0.017	0.351	0.149	0.829
		Lidocaine dose	0.018	0.006	7.617	1	0.006	1.018	1.005	1.031
	Maintenance	Ketamine	1.510	0.694	4.729	1	0.030	4.525	1.161	17.642
		Propofol dose	0.004	0.001	11.356	1	0.001	1.004	1.002	1.007
Hypertension	Induction	N/A	-	-	-	-	-	-	-	-
	Maintenance	Fentanyl	2.817	1.328	4.501	1	0.034	16.719	1.239	225.557
Hypoxia	Induction	Midozolam dose	0.641	0.320	4.026	1	0.045	1.899	1.015	3.554
	Maintenance	N/A	-	-	-	-	-	-	-	-
Bronchospasm	Induction	N/A	-	-	-	-	-	-	-	-
	Maintenance	N/A	-	-	-	-	-	-	-	-
Apnea	Induction	Midozolam dose	1.019	0.475	4.601	1	0.032	2.772	1.092	7.036
	Maintenance	N/A	-	-	-	-	-	-	-	-
Agitation	Induction	N/A	-	-	-	-	-	-	-	-
	Maintenance	N/A	-	-	-	-	-	-	-	-
PONV	Induction	Ketamine	-4.173	2.000	4.353	1	0.037	0.015	0.000	0.777
	Maintenance	N/A	-	-	-	-	-	-	-	-
Bradycardia	Induction	Ketamine dose	-0.185	0.073	6.442	1	0.011	0.831	0.721	0.959
	Maintenance	N/A	-	-	-	-	-	-	-	-
Atropine requirement	Induction	N/A	-	-	-	-	-	-	-	-
	Maintenance	N/A	-	-	-	-	-	-	-	-
Hypotension	Induction	Midozolam dose	-0.565	0.246	5.253	1	0.022	0.568	0.351	0.921
	Maintenance	Propofol dose	0.003	0.001	7.914	1	0.005	1.003	1.001	1.005
Inotrope requirement	Induction	N/A	-	-	-	-	-	-	-	-
	Maintenance	Ketamine	1.106	.533	4.311	1	0.038	3.021	1.064	8.580

lampati score raised the risk by 42% and 16%, respectively (12). In our study, we also found that a lengthy and urgent procedure such as ERCP, performed under combined sedation techniques, carries a significantly higher risk than a brief diagnostic endoscopy conducted in a young, healthy patient using propofol alone. These findings emphasize the importance of a comprehensive, individualized pre-procedural assessment to guide the selection of anesthetic techniques, determine the required level of monitoring, and plan appropriate post-procedural care.

Hemodynamic fluctuations—particularly hypotension and hypertension—were the most frequent complications observed in our study. Hypotension increased in parallel with advanced age, higher ASA scores and longer procedure times. We attribute its high incidence to the absence of objective depth-of-anesthesia monitoring and the rigid threshold adopted for defining hypotension. Consequently, hypotension emerged as the leading adverse event. In frail, geriatric patients undergoing prolonged procedures, maintenance drug doses should, therefore, be titrated downwards under depth-of-anesthesia guidance to minimize vasodilatory and negative inotropic effects. By contrast, hypertension occurred predominantly in patients with a BMI ≥ 30 kg m^{-2} or Mallampati class IV airways, a pattern likely related to repeated upper-airway instrumentation, sympathetic surges, and the requirement for deeper anesthesia to permit endoscope passage. A deeper induction followed by judicious intra-operative antihypertensive titration appears prudent in such individuals. Although a meta-analysis of 16 trials showed that electroencephalogram based depth monitoring lowers total drug use, it did not consistently reduce hypoxia or hypotension (13). Hemodynamic instability is multifactorial—affected by comorbidities, sympathetic blockade, and hypovolae-

mia—so bispectral index monitoring should be viewed as one component of a broader multimodal strategy rather than a stand-alone safeguard.

Respiratory complications during gastrointestinal endoscopy—including hypoxia and apnoea—result from several inter-related mechanisms: drug-induced depression of central ventilatory drive by sedatives and opioids, upper-airway obstruction caused by loss of pharyngeal muscle tone, and the technical challenges of a "shared airway." Reported desaturation rates in the literature vary from 0.06% to 1.36%, depending on the definition used and the sampling strategy employed (11,14,15). In our cohort, hypoxemia occurred more frequently during upper gastrointestinal procedures, particularly in patients with significant comorbidities, a pattern that mirrors previous findings. We attribute this higher incidence to the necessity of sharing the airway with the endoscopist, which reduces the anaesthesiologist's ability to apply airway maneuvers promptly. Conversely, hypoxemia was less common in longer procedures than in shorter ones, a finding we ascribe to the fact that most episodes of hypoxia and apnoea occur during induction when sedative agents are administered rapidly as bolus doses.

Our finding that COVID-19 vaccination appears to protect against PONV after gastrointestinal endoscopy is, to our knowledge, unprecedented. Although nausea and vomiting are vaccine side effects, vaccination can reduce the incidence and severity of persistent post-viral gastrointestinal symptoms (16,17). Hence, our data generate a novel hypothesis that the immune modulation associated with vaccination might confer resilience against procedure-induced emetogenic stimuli. This association warrants confirmation in prospective, adequately powered trials that control for the timing of vaccination, given the possibility that vaccine-related nausea occurring very close to the procedure could confound PONV assessment.

In our study, three drugs exerted distinct and clinically meaningful effects on procedure-related complications. First, intravenous lidocaine was linked to a lower overall complication rate. Beyond its well-known analgesic action, lidocaine dampens sympathetic surges and cough reflexes during upper-gastrointestinal instrumentation, blunts visceral pain during lower-gastrointestinal endoscopy, and reduces propofol requirements; each of these effects can translate into fewer episodes of apnoea and hemodynamic instability (18). Second, ketamine use correlated with a smaller incidence of PONV. This finding accords with thoracic surgery data showing that ketamine's opioid-sparing profile and relative hemodynamic stability lessen emetogenic stimuli (19). Although ketamine itself can provoke dysphoria or emergence delirium, its anti-emetic benefit may be particularly valuable in patients who are at high baseline risk for PONV or who require substantial opioid analgesia. Finally, midazolam displayed a clear dose-dependent association with hypoxemia and apnoea. Because midazolam can depress ventilatory drive—an effect amplified by co-administered opioids—dose reduction or avoidance should be considered in frail, elderly, or respiratory-compromised individuals (15).

Key strengths of this study are its prospective design, clear physiologic criteria for adverse events, and the parallel assessment of patient and drug factors. The main drawbacks are that it was done at a single center, we lacked depth-of-anesthesia or target-controlled infusion monitoring. These limitations mean our results should be viewed cautiously and confirmed in larger, multicentre studies.

CONCLUSION

Sedation for gastrointestinal endoscopy is generally safe, but strict monitoring often reveals shifts in blood pressure, heart rate, and breathing. These problems are more likely in older or obese patients, those with a difficult airway, during longer procedures, or when specific drug doses are used. In contrast, COVID-19 vaccination and intravenous lidocaine seem to lower the risk. Best practice starts with a careful pre-procedure assessment, thoughtful drug choice and dosing, continuous airway and hemodynamic monitoring, and early use of oxygen supports.

AUTHOR CONTRIBUTIONS

Conception or design of the work: SE, NCE
Data collection: SE, NCE
Data analysis and interpretation: SE
Drafting the article: SE
Critical revision of the article: GI, MC
The author (SE, NCE, GI, MC) reviewed the results and approved the final version of the manuscript.

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