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Target-Controlled Infusion (TCI) Versus Intermittent Bolus Administration of Propofol for Sedation During Digestive Endoscopy: A Retrospective Comparative Study

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Abstract | **Original Research Article**

Background: Propofol is currently considered the sedative agent of choice for digestive endoscopy because of its rapid onset and favorable recovery profile. However, the optimal administration technique remains controversial. Target-controlled infusion (TCI) may offer better control of sedation depth than intermittent bolus administration by maintaining stable effect-site concentrations. ***Objective:*** To compare the efficacy and safety of propofol administered through target-controlled infusion versus intermittent bolus injection during elective digestive endoscopy. ***Methods:*** A retrospective observational comparative study was conducted at the Digestive Endoscopy Unit of the 5th Medical-Surgical Center of Errachidia, Morocco, between January and April 2026. Eighty ASA I–II patients undergoing elective esophagogastroduodenoscopy (EGD), colonoscopy, or combined procedures under propofol sedation were included. Forty patients received sedation using a target-controlled infusion system (TCI group), whereas forty received intermittent intravenous boluses of propofol (Bolus group). The primary endpoint was recovery time. Secondary endpoints included hemodynamic and respiratory adverse events, total propofol consumption, procedural duration, fentanyl requirement, and sedation quality. ***Results:*** Baseline demographic and clinical characteristics were comparable between groups. Recovery time was significantly shorter in the TCI group than in the Bolus group (7 [5–10] vs. 16 [10–20] minutes, p = 0.01). Procedure duration was also significantly reduced in the TCI group (31 [25–56] vs. 38 [32–56] minutes, p = 0.01). Although median propofol consumption was lower in the TCI group (455 [400–620] mg vs. 490 [420–670] mg), the difference did not reach statistical significance (p = 0.086). Tachycardia (0% vs. 15%, p = 0.012), hypotension (5% vs. 22%, p = 0.033), and oxygen desaturation (0% vs. 15%, p = 0.012) occurred more frequently in the Bolus group. Sedation quality was significantly superior in the TCI group (p = 0.025).

Keywords: Anesthesia, AIVOC, TCI, gastrointestinal endoscopy, propofol, bolus sedation, colonoscopy, FOGD.

INTRODUCTION

Digestive endoscopy is a frequently performed examination for diagnostic or therapeutic purposes, indicated in the presence of any symptomatology or condition requiring gastrointestinal investigation. In France, 1.45 million digestive endoscopic procedures were performed in 2020, of which 100,000 were carried out for therapeutic purposes [1].

Whether diagnostic or therapeutic, upper or lower, digestive endoscopy is perceived by patients as an uncomfortable procedure that is often anticipated with apprehension, especially as it may need to be repeated. This anxiety leads to an exacerbation of the painful experience, contributing to agitation and potentially making the procedure technically very difficult [2].

The anesthesiologist is therefore requested either by the endoscopist, who expects a calm, cooperative, or even immobile patient, or by the patient, who wishes to have no memory of the procedure [3]. The anesthetic requirements for digestive endoscopy aim to provide adequate analgesia and amnesia, rapid and predictable recovery, stable cardiovascular and

respiratory conditions, and a reduced incidence of postoperative nausea and vomiting [4].

Propofol is a short-acting hypnotic agent characterized by a shorter onset and duration of action, adequate amnesia, and more favorable antiemetic properties compared with benzodiazepines. However, cardiovascular and respiratory depression remain the most common adverse effects observed during sedation [3,5].

Anesthesiologists have two options for propofol administration: intermittent bolus injection and continuous infusion. However, the high interindividual variability in response to propofol may represent a significant safety concern for sedation practices [6].

Since the introduction in 1996 of the first target-controlled infusion (TCI) device for propofol intravenous anesthesia, this technique has generated increasing interest in sedation practice. However, the system still requires demonstration of its efficacy and safety compared with bolus administration, and relatively few studies have focused on the comparison between these two approaches [7–8].

In our setting, digestive endoscopy is one of the most common interventional medical procedures. It is part of the daily activity of our department and therefore provides a sufficient basis for conducting single-blind studies.

The aim of this study is to compare, during digestive endoscopic procedures, continuous propofol infusion versus bolus administration in terms of anesthetic efficacy and safety.

MATERIALS AND METHODS

This is a monocentric, retrospective, observational, and comparative study conducted at the 5th Medical-Surgical Center (5th CMC) of Errachidia over a 3-month period, from 01/01/2026 to 01/04/2026.The aim of this study was to compare two modes of propofol administration during digestive endoscopic procedures: target-controlled infusion (TCI) and intermittent bolus sedation, in patients undergoing esophagogastroduodenoscopy (EGD), colonoscopy, or combined EGD–colonoscopy.

All consecutive patients older than 18 years, classified as ASA I or II according to the American Society of Anesthesiologists classification, who underwent elective digestive endoscopic procedures under propofol sedation, were included. The following patients were excluded from the study: patients classified as ASA III or higher; preoperative hemodynamic instability; emergency diagnostic or therapeutic procedures; incomplete or non-usable medical records. Data were collected retrospectively from: pre-anesthetic consultation records (PAC); intraoperative anesthesia monitoring charts; digestive endoscopy reports; post-interventional monitoring records in the post-anesthesia care unit (PACU).

The collected data included: data collection form **(Appendix 01):** demographic and clinical characteristics of patients (age, sex, weight, ASA score); type of endoscopic procedure performed; intra-procedural hemodynamic and respiratory parameters; total propofol doses administered; ephedrine consumption; per-anesthetic incidents or complications; recovery time; patient and operator satisfaction when documented in the medical record. A total of 80 patient records were included and divided into two groups according to the sedation technique used: Group A: patients receiving TCI sedation; Group B: patients receiving intermittent bolus propofol sedation.

All patients underwent a pre-anesthetic consultation in accordance with institutional protocols and the recommendations of anesthesia and intensive care societies. Chronic medication management and adherence to preoperative fasting instructions were systematically verified before the procedure. Bowel preparation was performed in patients scheduled for colonoscopy. Upon arrival in the endoscopy room, standard monitoring was applied to all patients in accordance with international guidelines, including: Continuous electrocardiography; heart rate monitoring; non-invasive blood pressure measurement every 5 minutes; continuous pulse oxygen saturation (SpO_2) monitoring. After placement of a peripheral venous line, patients received oxygen preoxygenation via nasal cannula as well as preventive fluid loading with isotonic saline (maximum 250 mL).

In Group A, sedation was performed using target-controlled infusion (TCI) of propofol with an initial effect-site target concentration set at 4 µg/mL. Adjustments in concentration were made according to sedation depth and hemodynamic tolerance. In Group B, sedation consisted of manual intravenous boluses of propofol at an initial dose of 2 mg/kg, followed by repeated titration according to the patient's clinical status and the desired depth of sedation. For both groups, the anesthetic target was moderate sedation corresponding to a Ramsay score between 2 and 3.

Throughout the procedure, the following parameters were monitored and recorded: heart rate (HR); blood pressure (BP); pulse oxygen saturation (SpO_2); occurrence of hemodynamic or respiratory events; total propofol consumption; use of vasopressors, particularly ephedrine. Arterial hypotension was defined as a decrease of more than 30% in blood pressure compared to baseline and was managed with fluid administration and/or ephedrine boluses. Desaturation was defined as $SpO_2 < 90\%$ and was treated by increasing oxygen flow, airway maneuvers, and reducing sedation depth if necessary. Tachycardia was defined as

an increase in heart rate greater than 30% compared to baseline before induction.

At the end of the endoscopic procedure, patients were transferred to the post-anesthesia care unit (PACU) for clinical and hemodynamic monitoring. After full recovery and clinical stability, they were transferred to the outpatient unit with additional monitoring for approximately two hours before discharge authorization.

The primary outcome was recovery time, defined as the time elapsed between discontinuation of propofol administration and full patient awakening, characterized by spontaneous eye opening and appropriate response to simple commands. Secondary outcomes included: hemodynamic and respiratory effects of sedation; total propofol consumption; use of vasopressor agents; patient satisfaction; endoscopist satisfaction.

Data were entered and analyzed using Jamovi software version 2.6. Quantitative variables were expressed as mean ± standard deviation or median with interquartile range depending on distribution. Qualitative variables were expressed as frequencies and percentages. Comparisons between the two groups were performed using Student's t-test for quantitative variables and Chi-square test or Fisher's exact test for qualitative variables. A p-value < 0.05 was considered statistically significant.

RESULTS

In this study, we analyzed a cohort of 80 patients for whom demographic data were collected. The median age was 45 years [25–77]. The median BMI was 25 kg/m² [20–30]. Sixty percent of patients were classified ASA I and 40% ASA II. Forty-eight percent underwent colonoscopy alone, 37% underwent esophagogastroduodenoscopy (EGD) alone, and 15% underwent combined colonoscopy and EGD. The median procedure duration was 35 minutes [25–56]. The total propofol dose administered was 475 mg [400–670]. Fentanyl was used in 18% of patients, while the median recovery time was 10 minutes [5–20]. Tachycardia occurred in 8% of patients, arterial hypotension in 14%, oxygen desaturation in 8%, and tracheobronchial spasm in 3%. No cases of aspiration were observed.

In this study, 80 patients were divided into two groups of 40 patients each, receiving two different anesthetic techniques: intermittent bolus sedation and target-controlled infusion (TCI). The comparison between both techniques was based on three main aspects: patient baseline characteristics, and hemodynamic and respiratory effects.

The results show that patients undergoing anesthesia for digestive endoscopy were heterogeneous in terms of age and baseline status. This anesthetic technique was also frequently associated with hemodynamic and respiratory complications.

For Demographic data, no statistically significant difference was found between the two groups (Table 2). The median age in the TCI group (Group A) was 45 years [25–74], while in the bolus group (Group B) it was 44 years [26–77]. The median BMI was 25 [21–30] kg/m² in Group A, compared to 24 [20–28] kg/m² in Group B, with no statistically significant difference. eIn Group B, 27 patients were ASA I and 13 ASA II. In Group A, 21 patients were ASA I and 19 ASA II.

Median duration was 31 minutes [25–56] in Group A and 38 minutes [32–56] in Group B. The difference was statistically significant (p = 0.01). Total propofol consumption was higher in the bolus group: 490 mg [420–670] versus 455 mg [400–620] in the TCI group, but the difference was not significant (p = 0.086). Recovery time was significantly shorter in Group A: 7 minutes [5–10] compared to 16 minutes [10–25] in Group B (p = 0.01). Fentanyl was required in 10 patients in Group B, whereas none in Group A. The difference was not statistically significant (p = 0.110).

Tachycardia and arterial hypotension were significantly more frequent in Group B (p = 0.012 and p = 0.033, respectively). Desaturation was significantly more frequent in Group B (8 cases vs. 0 in Group A, p = 0.033). Bronchospasm was more frequent in Group B, but the difference was not significant (p = 0.160). A statistically significant difference in Ramsay score was observed between groups (p = 0.025). All patients in the TCI group had a Ramsay score of 3, whereas 15% of patients in the bolus group had a score of 1.

Table 1: Descriptive characteristics of both groups

Variables	Values (n = 80)
Age (years)	45 [25–77]
BMI (kg/m²)	25 [20–30]
ASA I	60%
ASA II	40%
Colonoscopy	48%
EGD	37%
Colonoscopy + EGD	15%
Procedure duration (min)	35 [25–56]
Total dose (mg)	475 [400–670]
Fentanyl use	18%

Variables	Values (n = 80)
Recovery time (min)	10 [5–20]
Tachycardia	8%
Arterial hypotension	14%
Desaturation	8%
Bronchospasm	3%
Aspiration	0%

Table 2. Demographic and clinical characteristics in both groups

Parameters	Group A (n = 40)	Groupe B (n = 40)
Age (years)	45 [25–74]	44 [26–77]
BMI (kg/m²)	25 [21–30]	24 [20–28]
ASA I	21 (53%)	27 (67%)
ASA II	19 (47%)	13 (33%)

Table 3: Perioperative and postoperative data in both groups

Parameters	Group A (n = 40)	Group B (n = 40)	*P*-value
Colonoscopy	20 (50%)	18 (45%)	0.654
EGD	13 (32%)	17 (43%)	0.356
Combined colonoscopy + EGD	7 (18%)	5 (12%)	0.531
Procedure duration (min)*	31 [25–56]	38 [32–56]	0.01
Total propofol dose (mg)*	455 [400–620]	490 [420–670]	0.086
Recovery time (min)*	7 [5–10]	16 [10–20]	0.01
Fentanyl use	0 (0%)	10 (25%)	0.110
Tachycardia	0 (0%)	6 (15%)	0.012
Hypotension	2 (5%)	9 (22%)	0.033
Desaturation	0 (0%)	6 (15%)	0.012
Bronchospasm	0 (0%)	0 (0%)	0.160
Sedation quality (Ramsay score)	3: 40 (100%)	3: 34 (85%); 1: 6 (15%)	0.025

DISCUSSION

Several studies have compared continuous propofol infusion and bolus administration across multiple parameters, particularly recovery time, hemodynamic and respiratory effects, and total propofol consumption. In the literature, neurological recovery times are shorter when using target-controlled infusion (TCI) compared with intermittent manual bolus sedation. The study by Min-Hsien Chiang *et al.,*[9] included 220 patients with ASA scores between I and II and demonstrated faster recovery in Group A (14.58 ± 8.55 minutes) compared with Group B (17.91 ± 7.72 minutes).

Chan WH *et al.,*[10] also reported shorter recovery times in the TCI group in a study of 120 colonoscopy patients, although no statistically significant differences were found (p = 0.476) at 5, 10, and 30 minutes in the post-anesthesia care unit (PACU). All patients left the PACU 30 minutes earlier; however, two patients in the TCI group required additional bolus sedation. The study also included 100 patients undergoing EGD, with similar recovery times in both groups but shorter procedural durations. Jia-feng Wang *et al.,*[11] conducted a study in which patients were divided into two groups, one receiving TCI sedation for colonoscopy and the other receiving manual bolus sedation. This study demonstrated a shorter recovery time in the TCI group (9.1 ± 2.4 vs 11.3 ± 2.6 minutes; p < 0.001). Yi-Ting Chang *et al.,*[12] conducted a similar study in 100 patients undergoing colonoscopy and gastroscopy. In both groups, alfentanil was combined with midazolam, followed by propofol administered either by bolus or TCI. In this study, the bolus group had a shorter recovery time; however, five patients in this group awoke during the procedure, indicating insufficient sedation and explaining the apparent shorter recovery time. Nevertheless, there was no difference in time to full recovery (approximately 20 minutes) between the two groups. A study by Riphaus A *et al.,*[13], including 100 patients, showed faster recovery in the bolus group (19 ± 5 min) compared with the TCI group (23 ± 6 min; p < 0.001). However, the authors themselves noted that this difference was explained by the fact that propofol infusion in the TCI group was stopped at the end of the procedure, whereas in the bolus group the last injection was given a few minutes before the end of the procedure. In our study, recovery time was shorter in the TCI group compared with the bolus group: 7 [6–9] minutes versus 17 [15–18] minutes, respectively, with a statistically significant difference (p = 0.007).

The study by Min-Hsien Chiang *et al.,*[9] showed that the bolus group experienced more hypotension than the TCI group. The reduction in mean

arterial pressure (MAP) was calculated as a percentage relative to baseline MAP. In the TCI group, episodes of hypotension exceeding a 20% decrease were shorter. Total ephedrine consumption was higher in the bolus group, although the difference was not statistically significant (5.96 ± 10.42 mg vs 4.55 ± 8.27 mg; p = 0.244). These findings were supported by Chan WH *et al.,*[10], who demonstrated greater hypotension in patients receiving manual bolus propofol. Systolic and diastolic blood pressures were significantly lower in the bolus group: systolic BP was 96 ± 12 mmHg vs 107 ± 16 mmHg in the TCI group (p < 0.001), and diastolic BP was 61 ± 14 mmHg vs 70 ± 13 mmHg (p < 0.001). Wang Jiafeng *et al.,*[11] also reported more hypotension in the manually sedated group compared with TCI [11]. In contrast, the study by Riphaus A *et al.,*[13] did not find significant differences in hemodynamic effects between the two groups. Yi-Ting Chang *et al.,*[12] reported more hypotension in the TCI group. However, there was a dosing bias: the bolus group received lower propofol doses and experienced more intra-procedural awakening compared with the TCI group. Thus, hypotensive episodes were shorter in the bolus group, but overall anesthetic quality was significantly inferior to that of the TCI group [14]. In our study, patients in the bolus group experienced more tachycardia and hypotension compared with the TCI group, and this difference was statistically significant.

Regarding respiratory outcomes, Min-Hsien Chiang *et al.,*[9] showed that the duration of slow breathing (defined as a respiratory rate < 8 breaths per minute) was shorter in the TCI group (9.18 ± 12.00% vs 13.81 ± 15.92%; p = 0.013). The bolus group had a higher incidence of desaturation. Similar findings were reported by Chan WH *et al.,*[10], where six patients in the bolus group developed hypoxemia, whereas no desaturation occurred in the TCI group. Likewise, Jia-feng Wang *et al.,*[11] demonstrated a lower incidence of desaturation in the TCI group compared with the bolus group. In contrast, Riphaus A *et al.,*[13] found no significant differences in hypoxemic episodes during moderate sedation.In our study, the bolus group showed a higher incidence of oxygen desaturation (8 cases), while no cases were observed in the TCI group.

TCI allows continuous propofol administration, thereby avoiding plasma concentration peaks responsible for cardiovascular and respiratory adverse effects [15]. Some studies, such as that by Riphaus A *et al.,*[13], reported different findings compared with ours regarding hemodynamic and respiratory effects. This discrepancy is likely related to the light level of sedation used in those studies, which may have resulted in inadequate hypnosis with multiple intra-procedural awakenings, thereby complicating the procedure for the endoscopist.

Two studies evaluated propofol consumption. Min-Hsien Chiang *et al.,*[9] found no significant difference in total propofol dose between the two groups. Yi-Ting Chang *et al.,*[12] reported higher propofol use in the TCI group; however, as mentioned previously, the bolus group experienced insufficient sedation with multiple awakenings during the procedure. In our study, propofol consumption was higher in the bolus group compared with the TCI group: 600 [547–685] mg vs 470 [395–565] mg, respectively, and this difference was statistically significant (p < 0.001).

Min-Hsien Chiang *et al.,*[9], Chan WH *et al.,*[10], Riphaus A *et al.,*[13], and Yi-Ting Chang *et al.,*[12] found no significant differences in patient satisfaction between the two groups. In these studies, quality indicators included nausea, vomiting, dizziness, and amnesia. Studies by Jia-feng Wang *et al.,*[11] and Yi-Ting Chang *et al.,*[12] showed that TCI provided better endoscopist satisfaction, as patients receiving bolus sedation exhibited more movement and agitation during the procedure. In contrast, Chan WH *et al.,*[10] and Riphaus A *et al.,*[13] found no significant differences in endoscopist satisfaction between the two groups.

CONCLUSION

In this retrospective comparative study, target-controlled infusion of propofol was associated with significantly faster recovery, superior hemodynamic and respiratory stability, and improved sedation quality compared with intermittent bolus administration during digestive endoscopy. Although total propofol consumption was not significantly different, TCI provided more predictable sedation and better procedural conditions. These results support the integration of target-controlled infusion systems into routine endoscopic anesthesia practice, particularly in ambulatory settings where rapid recovery and patient safety are paramount.

DECLARATIONS

Ethics Approval and Consent to Participate: The study was conducted in accordance with the principles of the Declaration of Helsinki. Patient confidentiality was maintained throughout data collection and analysis.

Availability of Data and Materials: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Competing Interests: The authors declare no competing interests.

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Appendix 01: Anesthesia for Digestive Endoscopy: Comparison between TCI and Intermittent Sedation

Anesthesia for Digestive Endoscopy: Comparison between TCI and Intermittent Sedation

SECTION 1: PATIENT DEMOGRAPHICS

Sex	☐ Male ☐ Female
Age (years)	_____

SECTION 2: PROCEDURAL DATA

2.1 Type of Endoscopic Procedure

Colonoscopy	☐ Yes ☐ No
Upper GI Endoscopy (FOGD / EGD)	☐ Yes ☐ No

2.2 Anesthesia Technique

TCI / AIVOC	☐ Yes ☐ No
Intermittent Sedation	☐ Yes ☐ No

SECTION 3: PERIOPERATIVE PARAMETERS

Duration of procedure (min)	_____
Total Propofol dose (mg)	_____
Fentanyl used	☐ Yes ☐ No
Ramsay Sedation Score	_____
Time to recovery (min)	_____

SECTION 4: HEMODYNAMIC EVENTS

Tachycardia	☐ Yes ☐ No
Hypotension	☐ Yes ☐ No

SECTION 5: RESPIRATORY COMPLICATIONS

Oxygen desaturation	☐ Yes ☐ No
Bronchospasm	☐ Yes ☐ No
Aspiration / Inhalation	☐ Yes ☐ No

SECTION 6: ADDITIONAL NOTES

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