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Target-Controlled Infusion of Propofol in Training Anesthesiology Residents in Colonoscopy Sedation: A Prospective Randomized Crossover Trial

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Background: Propofol is widely used in sedation for colonoscopy, but its adverse effects on cardiovascular and respiratory systems are still concerning. The present study investigated whether target controlled infusion (TCI) of propofol could provide a better sedation quality than manually controlled infusion (MCI) in training inexperienced anesthesiology residents.





Material/Methods: Eighteen training residents were allocated into 2 groups receiving TCI and MCI training in their first month in the endoscopy center, while receiving MCI and TCI training instead in their second month. The last 2 patients at the end of each month were included to analyze the sedation quality of TCI and MCI techniques by comparing satisfaction of endoscopist and patients based on the visual analogue scale (VAS). Heart rate (HR), mean blood pressure (MAP), SpO₂, and recovery time were also compared as the secondary outcomes.

Results: The demographic data were similarly distributed among the TCI and MCI patients. Endoscopist's satisfaction score in the TCI group was significantly higher than in the MCI group, 81.3±7.2 versus 74.2±9.5 (P=0.003), but the patients' satisfaction score was similar between the 2 groups. More stable hemodynamic status was obtained in the TCI group, manifested as higher lowest MAP and lower highest MAP than in the MCI group. Lowest SpO₂ in the TCI group was significantly higher than in the MCI group. Patients in the TCI group recovered earlier than in the MCI group.

Conclusions: TCI is a more effective and safer technique for anesthesiology residents in sedation for colonoscopy.

MeSH Keywords: **Colonoscopy • Conscious Sedation • Propofol**

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Background

Colonoscopy has been widely performed to screen colorectal diseases. Most of the procedures are performed under sedation and/or analgesia due to the discomfort or pain, [1,2] and adequate sedation may improve the quality of colonoscopy [3,4]. Sedation for endoscopy can be classified into minimal, moderate, and deep sedation, depending on the different types of procedures, and moderate sedation level is regarded as the minimal requirement for colonoscopy [5,6].

Propofol sedation with or without opioid agents is one of the most acceptable strategies for sedation in colonoscopy in anesthesiologists or non-anesthesiologist physicians, because of the rapid onset of action and the short-term effect [7–9]. However, the adverse effects on cardiovascular and respiratory systems remain the main limitation of its use in sedation for endoscopy [10,11]. Intermittent bolus and continuous infusion are both alternatives for administration of propofol; however, the great variation in individual responses to propofol may be an important concern regarding the safety of colonoscopy sedation [12]. Target-controlled infusion (TCI) is an automatically adjusted system for intravenous anesthetics based on the predicted pharmacokinetics models using parameters such as age, sex, and body mass index. Compared with manually-controlled infusion (MCI) of propofol, TCI was demonstrated to provide faster recovery time and more stable hemodynamic and respiratory status [13,14].

Training of sedation for endoscopy is crucial to maintain patient safety for both anesthesiologists and non-anesthesiologist staffs. The present study aimed at comparing the sedation outcome with TCI or MCI techniques in training anesthesiology residents.

Material and Methods

Study design

This was a prospective, randomized, crossover study including 18 training residents in anesthesiology from 2011 to 2012. All residents were in their second year of the 3-year resident training program in Shanghai city. Before coming to the endoscopy center, all of them received the general anesthesia training for orthopedic surgery and general surgery, with full understanding of intravenous anesthesia and inhalational anesthesia. They were also taught theoretical and practical lessons in TCI and MCI for endoscopy sedation. The 18 residents were randomly allocated to receive TCI or MCI training based on computer-generated numbers (n=9 for each group). During the first month of their stay in the endoscopy center, TCI-training residents used TCI technique while MCI-training

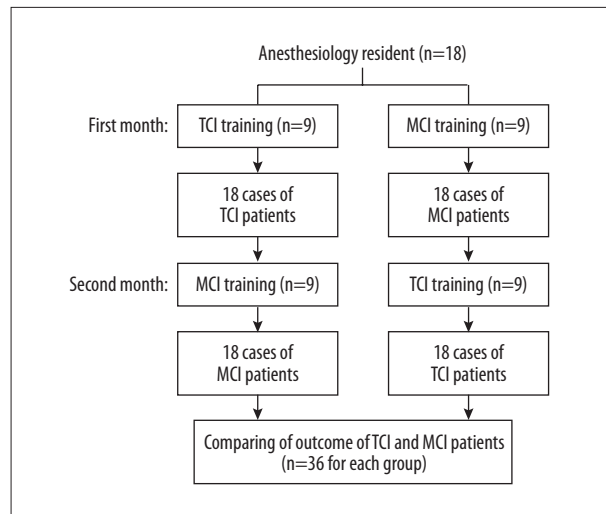


Figure 1. Flow chart of the study protocol. TCI – target controlled infusion; MCI – manually controlled infusion.

residents used MCI technique for colonoscopy sedation. At the end of that month, the data of the last 2 patients undergoing colonoscopy were collected as an examination. During the second month, TCI-training residents used MCI technique while MCI-training residents used TCI technique for colonoscopy sedation. At the end of the second month, the data of the last 2 patients undergoing colonoscopy test were collected as an examination. Finally, the outcomes of the patients chosen at the end of each month were compared to assess the training results (Figure 1). All procedures were supervised by the senior attending anesthesiologists. The inclusion criteria of the patients included: patients meeting the indications of elective colonoscopy based on the endoscopist; age ≥ 18 years; and American Society of Anesthesiologist (ASA) physical status 1 or 2. The exclusion criteria included: morbid obesity (BMI ≥ 30 kg/m²); predicted difficult airway; hypertension; known cardiac diseases; acute or chronic hepatic and renal dysfunction; long-term use of anesthetics or opioids; and patients undergoing invasive procedures under colonoscopy. The same endoscopist, who was blinded of the grouping, performed all colonoscopy procedures. The local Ethics Committee approved the protocol of the study and all patients provided their written informed consent.

Sedation protocol

All patients routinely underwent overnight fasting and bowel preparation. After arrival in the operating room, the patients were monitored with the electrocardiogram, pulse oximetry (SpO₂), and non-invasive blood pressure. Oxygen at 2 L/min was inhaled through a nasal cannula. Both the TCI system and conventional microinfusion pump were connected to the peripheral venous line with propofol on them to achieve blinding for endoscopist and patients. For sedation induction, fentanyl

Table 1. Demographic data of the patients.

Groups	TCI (n=36)	MCI (n=36)	P value
Age (years)	42.6±7.6	40.2±6.9	0.154
Gender (M/F)	21/15	23/13	0.809
Height (cm)	169.9±7.0	170.4±7.1	0.974
Weight (kg)	65.5±9.6	66.2±10.9	0.872
BMI (kg/m ²)	22.6±2.3	22.7±2.5	0.844
ASA score (1/2)	23/13	26/10	0.614
Baseline heart rate (bpm)	73.1±7.0	75.3±8.6	0.196
Baseline blood pressure (mmHg)	84.4±9.3	88.5±8.7	0.154
Procedure time (min)	27.3±8.9	27.5±7.8	0.977

TCI – target controlled infusion; MCI – manually controlled infusion; M – male; F – female; BMI – body mass index; ASA – American Society of Anesthesiologist physical score.

(2 µg/kg) (Renfu, Yichang, China) was slowly administered and propofol (AstraZeneca, Milan, Italy) was then administered, according to the grouping. In the TCI group, propofol was infused through the Module DPS TCI system (Fresenius Kabi, Bad Homburg, German) using the Marsh model. The primary plasma concentration was set as 3.0 µg/ml and an adjustment of 0.2 µg/ml was made upon the patients' response based on the Observer's Assessment of Alertness/Sedation (OAAS) Score [15]. In the MCI group, propofol was injected at a bolus of 1.5 mg/kg and then continuously infused at 6 mg/kg/h using the conventional continuous microinfusion pump (Smiths Medical, Hangzhou, China). A bolus of 0.5 mg/kg propofol was injected as required. After colonoscopy, the patients were awakened and discharged after a Modified Aldrete Score System ≥9 was achieved.

Data collection and outcomes

The sedation quality was assessed as the satisfactory score of the endoscopist and patients on a 100-mm visual analogue scale (VAS). Intraoperative heart rate (HR), SpO₂, and blood pressure (BP) was recorded every 3 min. The respiratory and cardiovascular stability was assessed by the highest and lowest HR and mean blood pressure (MAP), as well as the lowest SpO₂. Severe adverse effect was defined as a SpO₂ lower than 90%, an HR lower than 50 bpm, or a MAP lower than 55 mmHg. The recovery time was also recorded as the time from termination of propofol infusion to the full recovery of orientation.

Statistical analysis

All statistical analyses were performed with IBM SPSS Statistics Version 20.0 (Armonk, NY). The continuous data are expressed as mean ±SD and compared with Student's *t* test for normally distributed data. Enumeration data was compared using

the chi-square test. A *P*<0.05 was considered as statistically significant.

Results

All patients successfully underwent smooth procedures and no severe adverse events occurred. All procedures were performed with an OAAS score not higher than 2. The demographic data of the patients are listed in Table 1. There were no significant differences between the 2 groups regarding age, sex, height, weight, BMI, ASA score, baseline level of heart rate and pressure, and procedure time.

The satisfactory score of the endoscopist was significantly higher in the TCI group than in the MCI group, 81.3±7.2 versus 74.2±9.5 (*P*=0.003). Patient satisfaction was similar between the 2 groups, 77.2±6.7 versus 76.8±7.8 (*P*=0.808). The lowest and highest HR were similar between the 2 groups (*P*=0.204 and 0.196, respectively), but the lowest MAP was significantly higher (*P*=0.001), while the highest MAP was significantly lower in TCI groups (*P*=0.009). Moreover, the lowest SpO₂ in the MCI group was significantly lower than in the TCI group (95.6±3.0% versus 97.4±2.0%) (*P*=0.008). Patients in the TCI group had a shorter recovery time than in the MCI group (9.1±2.4 versus 11.3±2.6) (*P*<0.001) (Table 2).

Discussion

Our present study demonstrated that TCI showed a better sedation result in training residents of anesthesiology as manifested by the satisfactory score in the endoscopist. Propofol administered by TCI resulted in more stable hemodynamic and respiratory status than that by MCI. Meanwhile, TCI also provided a quicker recovery than MCI.

Table 2. Quality and safety assessment of colonoscopy sedation.

Groups	TCI (n=36)	MCI (n=36)	P value
VAS score of endoscopist	81.3±7.2	74.2±9.5	0.003
VAS score of patients	77.2±6.7	76.8±7.8	0.808
Lowest HR (bpm)	66.3±4.9	64.5±7.2	0.204
Highest HR (bpm)	85.1±7.0	87.3±8.6	0.196
Lowest MAP (mmHg)	72.9±6.6	67.7±7.8	0.001
Highest MAP (mmHg)	95.4±6.5	100.3±8.5	0.009
Lowest SpO ₂ (%)	97.4±2.0	95.6±3.0	0.008
Recovery time (min)	9.1±2.4	11.3±2.6	<0.001

TCI – target controlled infusion; MCI – manually controlled infusion; VAS – visual analogue scale; HR – heart rate; MAP – mean blood pressure.

Satisfaction of the endoscopist and patients was chosen as the primary outcome to evaluate the sedation quality, because they were blinded to the grouping without any idea how propofol was administered. In some studies satisfaction of the senior anesthesiologists were also included as the study outcome [16,17]. However, in our opinions, it was really hard to have the senior anesthesiologist blinded to the grouping, and the risk of bias would be high to analyze the satisfaction data from the senior anesthesiologists. Although the patient satisfaction was similar using TCI and MCI techniques, the endoscopist satisfaction suggested that TCI sedation might make colonoscopy easier to perform. Moreover, based on the predicted pharmacokinetic model, TCI promoted earlier recovery after termination of propofol infusion than MCI.

Cardiovascular or respiratory compromise is the main concern of propofol use for endoscopy sedation, especially when administered by inexperienced training residents and non-anesthesiologist staff [8,18]. Nevertheless, propofol has been widely accepted as an ideal agent for endoscopy sedation among anesthesiologist or non-anesthesiologist staff because of the rapid onset of action and short recovery time [19–21]. It is necessary to keep a balance between adequate sedation depth and minimized adverse effects. However, the peak plasma concentration of propofol might be twice the concentration 10

min after a bolus injection and the concentration of propofol might be slowly but constantly increased after continuous infusion [22]. Therefore, the unstable plasma concentration of propofol resulted from MCI technique may be one the causes of its adverse effects on cardiovascular and respiratory systems. Some important parameters are not taken into account during MCI, such as age, sex, and BMI, which may lead to significant changes in pharmacokinetics of propofol. Therefore, we need to tailor the dose of propofol to specific individuals based on the clinical experience, which might be difficult for inexperienced training residents. Fortunately, TCI can provide relatively stable plasma concentrations as required, so as to reduce the incidence of adverse events.

Conclusions

Given the fact that training residents of anesthesiology were less experienced in colonoscopy sedation, propofol TCI is an ideal infusion mode for them to improve sedation quality and promote stable cardiovascular and respiratory status.

Completing interests

The authors declare that they have no competing interests.

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