Total Intravenous Anesthesia-Target Controlled Infusion for colorectal surgery. Remifentanil TCI vs sufentanil TCI

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Abstract

The aim of the study was to compare the effect of remifentanil and sufentanil administered for total intravenous anaesthesia (TIVA) using target-controlled infusion (TCI) on intraoperative hemodynamic response, tracheal intubation and extubation times in patients undergoing colorectal surgery.

Methods. Sixty patients undergoing open colorectal surgery for colorectal tumors or inflammatory diseases were randomized prospectively into one of two groups: remifentanil group R (n = 30) received TIVA-TCI with propofol and remifentanil and sufentanil group S (n = 30) received TIVA-TCI with propofol and sufentanil. Changes of mean arterial pressure (MAP) and heart rate (HR) were compared during induction and maintenance of anaesthesia. Response to tracheal intubation was assessed as episodes of hypertension, increased HR and bispectral index values, sweating, lacrimation, and coughing. The numbers of target plasma concentration (Cp) adjustments of opioids and propofol due to painful stimulation were recorded during surgery. Recovery time expressed as extubation time was also evaluated.

Results. MAP and HR, expressed as area under the curve (AUC), were not significantly different between groups during anesthesia and surgery. During induction of anesthesia, MAP values decrease from baseline, in both groups (p < 0.001). Intergroup comparison revealed that MAP decreased more in the remifentanil than sufentanil group (p = 0.027). HR decreased from baseline values only in the remifentanil group (p = 0.05). The number of target concentration adjustments for propofol and opioid was higher in the remifentanil group as compared with sufentanil group (p = 0.02 and p = 0.04). Hemodynamic responses to tracheal intubation and extubation times were not significantly different between the groups.

Conclusion. Both remifentanil and sufentanil TCI produced stable hemodynamic conditions during open colorectal surgery but sufentanil TCI was associated with less decrease in blood pressure and heart rate, and required fewer dose adjustments during anesthesia induction.

Keywords: remifentanil, sufentanil, target-controlled infusion, colorectal surgery, hemodynamics

Introduction

Total intravenous anaesthesia (TIVA) regimen with propofol and opioid is a useful anaesthetic technique, effectively controlling responses to tracheal intubation and intense surgical stimulation, while avoiding inhalational anaesthetics and allowing rapid emergence from anaesthesia [1]. Computer-assisted target controlled infusion (TCI) has been developed to rapidly achieve and maintain the target plasma or effect-site concentration of intravenous (i.v.) anaesthetics [2-4]. Therefore, TIVA-TCI allows more stable hemodynamic profile during surgery, prevents long-acting opioid-induced accumulation and allows rapid recovery from general anaesthesia.
Propofol has rapid onset and clearance and decreases postoperative nausea and vomiting. In addition, propofol affects the cardiovascular system predominantly by peripheral vasodilatation [5, 6]. Remifentanil is a potent short-acting opioid with rapid recovery and is relatively independent of dose, duration of infusion, or liver and kidney function. Thus, it can be administered in high doses during surgery, with little risk of respiratory depression and delayed postoperative recovery [7]. Remifentanil has a short context-sensitive half-life, which makes it particularly suitable for TCI administration [8]. Sufentanil is a more potent opioid than remifentanil and its analgesic effects last longer. Sufentanil has a longer context-sensitive half-life as compared with remifentanil, but TCI administration will prevent long-acting tissue accumulation and allows rapid recovery from anaesthesia [9, 10]. Both opioids reduce response to pain stimuli and dose-dependently reduce systemic blood pressure and heart rate [11-13].

Although the role of TIVA is well established in day-case surgery and in some major procedures such as neurosurgery, paediatric and cardiac surgery [14, 15], its role in major abdominal surgery is not yet established. There are studies that have investigated the influence of different anaesthetic drugs used in TIVA on hemodynamic profile during major abdominal surgery, but the results are not conclusive [16-20].

The aim of our study was to compare intraoperative hemodynamic effects, the response to tracheal intubation, and the extubation time during remifentanil and sufentanil TCI in patients undergoing colorectal surgery. Hemodynamic responses assessed as changes in mean arterial pressure (MAP) and heart rate (HR) during induction and maintenance of anaesthesia were the primary aim. Secondary aims were: response to tracheal intubation assessed as hemodynamic changes; somatic and autonomic responses; number of plasma concentration adjustments of anaesthetics as a response to painful stimulation during surgery; anaesthetic consumption; and total extubation time. We hypothesized that sufentanil TCI would provide better control of response to tracheal intubation and more stable hemodynamic values during surgery as compared with remifentanil TCI.

Methods

Ethical approval for this study (IRB no. 822/2013) was provided by the Ethical Committee of the “Iuliu Hațieganu” University of Medicine and Pharmacy, Cluj-Napoca, Romania. This study was performed between September 2013 and May 2014 at the Surgical Department of Regional Institute of Gastro-enterology-Hepatology “Prof. Dr. Octavian Fodor”, Cluj-Napoca, Romania.

After obtaining written informed consent, 60 American Society of Anesthesiologists (ASA) physical status I to III patients scheduled for colorectal surgery were allocated randomly into one of two study groups (30 patients each) by block randomization using a computer random-number generator: in group R (remifentanil group) patients were anesthetized using propofol and remifentanil TCI; group S (sufentanil group) patients were anaesthetized using propofol and sufentanil TCI.

Patients underwent open surgery for colorectal tumours or inflammatory diseases of colon and rectum. All patients were operated on by the same surgical team. Only patients older than 18 years old were included in the study. Those with a history of allergies to propofol, eggs, soya beans, those with chronic alcohol consumption, chronic use of benzodiazepines or drugs addiction were excluded from the study. We also excluded patients with obesity (BMI > 30 kg m$^{-2}$) and history of gastritis or peptic ulcers.

All patients received premedication with oral midazolam 7.5 mg before surgery. Upon arrival in the operating room, an 18-gauge peripheral venous cannula was inserted, and an infusion of Ringer’s lactate solution 500 ml was started. A second i.v. cannula was inserted for the administration of the anaesthetic drugs. Before induction of anaesthesia, all patients received 4 mg dexamethasone i.v. for postoperative nausea and vomiting (PONV) prophylaxis.

Routine monitoring was used intraoperatively: electrocardiogram (ECG), heart rate (HR), noninvasive arterial blood pressure (BP), pulse oximetry (SpO$_2$), capnography, and core temperature using a nasopharyngeal thermocouple probe. Depth of anaesthesia was monitored using bispectral index (BIS) (Vista; Aspect Medical System, Norwood MA, USA). Propofol, remifentanil and sufentanil were administered with Alaris Asena PK™ TCI pump (Cardinal Health, Alaris Products, Basingstoke, UK).

Propofol (Propofol Lipuro 1%, B. Braun Melsungen AG, Germany) was administered using Marsh model (plasma targeting concentration) in both group study. Anaesthesia was induced with an initial plasma target concentration (Cp) of 4 µg ml$^{-1}$ and propofol delivery rate was reduced to 500 ml h$^{-1}$ to minimize its hemodynamic impact. The propofol target plasma concentration was then adjusted in steps of 0.5-1 µg ml$^{-1}$ to maintain the targeted BIS value (40-55) during anaesthesia. The infusion of propofol was discontinued at the end of surgery before the last two surgical stitches. Opioid was infused in target plasma concentration using pharmacokinetics models Minto for remifentanil [8] and Gepts for sufentanil [10].
In the R group, remifentanil TCI (Ultiva™, GlaxoSmithKline, Uxbridge, UK) was used for intraoperative analgesia with an initial target Cp of 4 ng ml\(^{-1}\) at induction, and between 3-10 ng ml\(^{-1}\) during maintenance of anaesthesia. Remifentanil Cp was adjusted using increments of 1 ng ml\(^{-1}\) based on the patients’ analgesic needs assessed by changes in BP, HR, pupil size, sweating, laceration and coughing. Remifentanil infusion was terminated at the time of skin suturing before the last two surgical stitches.

In S group, sufentanil TCI (Sufentanil Torrex Pharma GmbH, Vienna, Austria) was used for intraoperative analgesia. Sufentanil infusion was started 1-2 minutes prior to the propofol infusion, while remifentanil infusion was started at the same time as the propofol infusion. The initial plasma concentration target Cp was set at 0.3 ng ml\(^{-1}\) at induction and between 0.2-1 ng ml\(^{-1}\) during maintenance of anaesthesia. After induction, sufentanil Cp was adjusted using increments of 0.1 ng ml\(^{-1}\) based on the patients’ analgesic needs assessed by the same parameters as in group R. At the anticipated end of surgery (abdominal closure), the sufentanil infusion was adjusted to provide an effect-site target concentration of 0.2 ng ml\(^{-1}\) at skin closure and tracheal extubation.

For facilitation of tracheal intubation, atracurium 0.5 to 0.6 mg kg\(^{-1}\) was administered, and additional 10 mg boluses were given during maintenance as necessary, according to train of four (TOF) stimulation of an ulnar nerve with TOF Watch SX (Organon Ltd. Dublin, Ireland). In all patients, the lungs were ventilated with 50% oxygen in air using pressure-controlled with end-tidal carbon dioxide partial pressure maintained between 35-45 mmHg. At the end of surgery, neuromuscular blockade was reversed with neostigmine 50 µg kg\(^{-1}\), given with atropine 20 µg kg\(^{-1}\).

In both groups, postoperative analgesia was achieved using i.v. morphine boluses of 4 mg with the aim of maintaining a pain score less than 3 on a 11-point numerical rating scale (NRS). In group R, a bolus of 0.15 mg kg\(^{-1}\) i.v. morphine was administered 40 min before the end of surgery for postoperative analgesia. In addition, in both groups, i.v. paracetamol 1 g and ketorolac 30 mg were administered every 8 h for the first 72 postoperative hrs; the first dose was administered 30 min before the end of surgery. PONV episodes were treated with i.v. ondansetron 4 mg as needed.

Endpoints:
The primary aim of the study was to compare the hemodynamic response evaluated as mean arterial pressure (MAP) and HR between remifentanil and sufentanil groups during induction and maintenance of anaesthesia.

MAP and HR were recorded: every minute during induction; 5 min after tracheal intubation and every 5 min until the end of surgery. Baseline (pre-induction) BP and HR were recorded after patients received 500 ml of Ringer solution. Hypotension was defined as a decrease in MAP by more than 20% from baseline value, and was treated with i.v. crystalloid solution and i.v. boluses of 5 mg ephedrine. In case of persistent hypotension (for more than 1 minute), the target concentration of anaesthetics was adjusted.

Secondary endpoints:
- Response to tracheal intubation assessed as: episodes of hypertension, changes in HR and BIS values, somatic responses (coughing, grimacing) and autonomic responses (sweating, lacrimation).
- Hypertension (defined as an increase in MAP by more than 20% from baseline value) and tachycardia (increase in HR of more than 10% above baseline values) were treated by adjusting the target concentration of opioids. Bradycardia was defined as a decrease in HR below 50 beats per minute for more than 1 minute, and was treated with atropine 0.5 mg i.v.; in case of persistent bradycardia despite atropine therapy, plasma concentration of opioids was decreased.
- The number of plasma concentration (Cp) adjustments of anaesthetics necessitated by painful stimulation during surgery (from skin incision until the end of surgery). This period was divided into 4 equal parts that represented 25, 50, 75%, duration of surgery. Target plasma and effect-site concentration of propofol, remifentanil and sufentanil were recorded every minute during induction and every 5 min until the end of surgery.
- Propofol and opioid consumption expressed as milligrams per hour.
- The extubation time, assessed by time between end of surgery and tracheal extubation.

Statistical analysis was performed using SPSS 16.0 for Windows (SPSS Inc., Chicago, Illinois, USA). Nominal data were described by frequency and percentage. Quantitative variables were described by mean and standard deviation or median and interquartile, as appropriate. Quantitative data were tested for normality using the Kolmogorov-Smirnov test and Mann-Whitney U test; Student’s t-test was used for comparison between groups, as appropriate. Between-group areas under curve (AUC) differences were assessed using the Mann-Whitney U test. The frequencies of nominal variables between groups were compared with a χ\(^2\) test. Two-way ANOVA for repeated measures (for MAP, HR) was used to analyze changes over time between groups. P value less than 0.05 was considered statistically significant.
Results

Patient characteristics and intraoperative data were summarized in Table 1. The two groups were similar with respect to age, weight, height, and sex. Duration of anesthesia and surgery did not differ between groups.

Table 1. Patient's characteristics and perioperative data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Remifentanil group (n = 30)</th>
<th>Sufentanil group (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)*</td>
<td>60.4 ± 11.1</td>
<td>61.4 ± 11.7</td>
</tr>
<tr>
<td>Weight (kg)*</td>
<td>79.8 ± 14.9</td>
<td>82.7 ± 13.8</td>
</tr>
<tr>
<td>Height (cm)*</td>
<td>169 ± 8.8</td>
<td>171.5 ± 7.8</td>
</tr>
<tr>
<td>BMI (kg m(^{-2}))*</td>
<td>27.9 ± 4.5</td>
<td>28.0 ± 3.9</td>
</tr>
<tr>
<td>Sex (male/female) †</td>
<td>19/11</td>
<td>20/10</td>
</tr>
<tr>
<td>ASA (I/II/III) ‡</td>
<td>7/17/6</td>
<td>8/16/6</td>
</tr>
<tr>
<td>Duration of surgery (min) †</td>
<td>134 (76-197)</td>
<td>136 (63-330)</td>
</tr>
<tr>
<td>Duration of anesthesia (min) †</td>
<td>157 (92-215)</td>
<td>161 (96-356)</td>
</tr>
<tr>
<td>Type of surgery ‡</td>
<td>Colectomy (Right/Left) 9/11</td>
<td>8/2</td>
</tr>
<tr>
<td></td>
<td>Colorectal resection 10</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Total colectomy 0</td>
<td>1</td>
</tr>
</tbody>
</table>

* Data expressed as mean ± SD. BMI = body mass index
† Data expressed as median and 25\(^{th}\) and 75\(^{th}\) percentiles
‡ Data expressed as number of patients

The hemodynamic parameters MAP and HR expressed as AUC were not significantly different between groups during induction and maintenance of anesthesia (p = 0.27 and p = 0.98, respectively). Two-way ANOVA for multiple comparisons of the time trend of MAP and HR between groups and within groups were assessed during induction. For within-group comparisons, MAP values decreased significantly from baseline values both in group R (p < 0.001) and group S (p < 0.001) (Fig. 1). HR followed the same decreasing trend as compared with the baseline values in group R (p = 0.05), but not in group S (Fig. 2). For between-group comparisons of MAP and HR, a significant decrease in MAP values was found in group R as compared to group S (p = 0.03).

We assessed the hemodynamic response to tracheal intubation immediately after intubation and the findings were summarized in Table 2. The hemodynamic response to tracheal intubation (changes in MAP and HR) were not significantly different between groups (p = 0.14).

Table 2. Response to orotracheal intubation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Remifentanil group (n = 30)</th>
<th>Sufentanil group (n = 30)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>0 (0%)</td>
<td>3 (10%)</td>
<td>0.2</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>2 (6.7%)</td>
<td>2 (6.7%)</td>
<td>1</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>1 (3.3%)</td>
<td>0 (0%)</td>
<td>1</td>
</tr>
<tr>
<td>Cough</td>
<td>1 (3.3%)</td>
<td>5 (16.7%)</td>
<td>0.2</td>
</tr>
<tr>
<td>Lacrimation</td>
<td>2 (6.7%)</td>
<td>5 (16.7%)</td>
<td>0.4</td>
</tr>
<tr>
<td>Increasing BIS</td>
<td>2 (6.7%)</td>
<td>0 (0%)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Data expressed as number of patient and percentages

Fig. 1. Trend of MAP at baseline, during induction and surgery. Surgery time was divided in 4 equal parts: 25, 50, 75% duration of surgery and at the end of surgery. Data expressed as mean ± SD. Within group comparisons during induction: *p < 0.001, significant MAP decrease vs baseline (in both groups). Between groups comparisons during induction: †p = 0.03, significant MAP decrease vs baseline in Remifentanil group.
was expressed as number of patients who experienced an episode of hypertension, tachycardia or bradycardia. There were no significant differences between groups regarding hemodynamic response.

Total propofol consumption during anaesthesia expressed as mg per hour was higher in group R than in group S (549.2 ± 156 mg/h vs 502.2 ± 148.5), but this difference did not reach statistical significance (p = 0.24) (Table 3). The mean effect-site concentration of propofol expressed as median and 25th and 75th percentiles was similar in both groups prior to tracheal intubation (p = 0.6), but at the end of surgery was higher in group R, 2 (1.6-2.5) µg ml⁻¹ as compared to group S, 1.2 (0.9-2) µg ml⁻¹ (p = 0.007) (Table 3). The mean effect-site concentration of opioids prior intubation, expressed as median and 25th-75th percentiles were 3.6 (3.3-4) ng ml⁻¹ for remifentanil and 0.2 (0.18-0.23) ng ml⁻¹ for sufentanil (Table 3).

The number of plasma concentration (Cp) adjustments of propofol and opioids due to painful stimulation was expressed as number of patients who experienced an episode of hypertension, tachycardia or bradycardia. There were no significant differences between groups regarding hemodynamic response.

**Table 3.** Intraoperative data: propofol consumption, target concentrations of propofol and opioids, number of anaesthetic concentration adjustment, time to extubation

<table>
<thead>
<tr>
<th></th>
<th>Remifentanil group (n = 30)</th>
<th>Sufentanil group (n = 30)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracheal intubation moment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ce propofol (µg ml⁻¹)</td>
<td>3.6 (3.1-3.8)</td>
<td>3.8 (3.2-4)</td>
<td>0.6</td>
</tr>
<tr>
<td>Ce opioid (ng ml⁻¹)</td>
<td>3.5 (3.3-4)</td>
<td>0.2 (0.18-0.25)</td>
<td>NA</td>
</tr>
<tr>
<td>End of surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ce propofol (µg ml⁻¹)</td>
<td>2 (1.6-2.5)</td>
<td>1.2 (0.9-2)</td>
<td>0.007</td>
</tr>
<tr>
<td>Ce opioid (ng ml⁻¹)</td>
<td>1.9 (1.3-2.2)</td>
<td>0.19 (0.17-0.21)</td>
<td>NA</td>
</tr>
<tr>
<td>Time to extubation (min)</td>
<td>10 (5.5-15)</td>
<td>13.5 (8.8-20)</td>
<td>0.13</td>
</tr>
<tr>
<td>No. of adjusting target concentration during surgery for:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propofol</td>
<td>8 (4-16.5)</td>
<td>5 (3.8-7.3)</td>
<td>0.02</td>
</tr>
<tr>
<td>Opioid</td>
<td>8 (4.8-18)</td>
<td>5 (4.8-2)</td>
<td>0.04</td>
</tr>
<tr>
<td>Propofol consumption per hour (mg/h) *</td>
<td>549.2 ± 156.1</td>
<td>502.2 ± 148.5</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Data expressed as median and 25th and 75th percentiles. * Propofol consumption expressed as mean ± SD. Ce, effect-site concentration
from skin incision until the end of surgery was assessed in both groups (Table 3). Propofol number of target concentration adjustments, expressed as median and 25th-75th percentiles was significantly higher in group R, n = 8 (4-16.5) as compared to the group S, n = 5 (3.8-7.3) (p = 0.02). The number of target concentration adjustments of opioids expressed as median and 25th-75th percentiles was also higher in group R, n = 8 (4.8-18) as compared with group S, n = 5 (4-8.2) (p = 0.04) (Table 3).

The extubation time, expressed as median and 25th-75th percentiles, was similar in the two groups, 10 (5.5-15) minutes in group R vs. 13.5 (8.8-20) minutes in group S (p = 0.13) (Table 3).

**Discussion**

Blood pressure and heart rate are the most widely used hemodynamic parameters during anaesthesia and surgery. Induction of anaesthesia and tracheal intubation may be associated with marked changes in cardiovascular variables, due to both the specific effects of anaesthetics drugs and the clinical status of the patients. TIVA with propofol and opioid can produce significant decreases in systemic blood pressure values, but the magnitude of this effect depends on the method and speed of delivery [21, 22]. Target-controlled infusions allow better control of plasma and brain concentration of these anaesthetics and may lead to reduced hemodynamic impact during surgery.

In our study there were no significant differences induced by remifentanil or sufentanil on MAP and HR evaluated as AUC during anaesthesia induction. However, MAP decreased significantly as compared to baseline values in both study groups, but was more pronounced in the remifentanil group.

Similar results to ours have been reported by other studies. Yegeaneth et al. [23] found that propofol-remifentanil TCI did not produce significant differences in MAP compared with propofol-sufentanil TCI in trauma patients undergoing non-emergent abdominal surgery. MAP decreased in both study groups compared with baseline values, but hypotension was more frequent in the sufentanil group. As compared to our study, Yegeaneth et al. [23] used Schnider pharmacological model for propofol administration, and effect-site concentration was set as target for both propofol and opioids. Similarly, Hu et al. [19] reported that propofol-remifentanil TCI and propofol with different target concentrations of remifentanil plus sufentanil produced similar reduction of MAP in patients undergoing abdominal surgery.

Yegeaneth et al. [23] reported that remifentanil TCI produced profound bradycardia during induction as compared with sufentanil, unlike Hu et al. [19] and our study. It is well known that tracheal intubation under light anaesthesia often causes hemodynamic responses that may be even more intense than skin incision. Opioids are widely used to control the neurovegetative response to tracheal intubation, and a linear relationship exists between opioid dose and cardiovascular response [16, 24]. There are several studies that compared the blunting of the hemodynamic response to tracheal intubation when using manual infusion or TCI of different opioids [16, 17, 19, 20, 25-29]. Several studies compared propofol and opioids TCI for hemodynamic response to tracheal intubation [19, 23] but unfortunately there were insufficient data to establish the optimal target controlled concentration for blunting this response.

In the present study, laryngoscopy and tracheal intubation were not followed by a significant increase or decrease in MAP and HR after remifentanil or sufentanil TCI. However, more patients in group S responded to tracheal intubation by increasing MAP. Similar finding have been reported by Yegeaneth et al. [23], who found no significant difference between remifentanil and sufentanil TCI on blood pressure increase after tracheal intubation; however, remifentanil produced more frequent hypotension in the first minutes after tracheal intubation. Also, HR was significantly reduced not only before but also after tracheal intubation.

Regarding the target concentration of propofol and opioids achieved before tracheal intubation, in our study these were similar to those used by Yegeaneth et al. [23]. Thus, effect-site concentration for propofol was 3.6-3.8 µg ml⁻¹ in our study and slightly higher in Yegeaneth et al. [23], 4.1-4.2 µg ml⁻¹. Sufentanil effect-site concentration was 0.2 ng ml⁻¹ in both studies, and remifentanil effect-site concentration was higher in our study (3.5 ng ml⁻¹ vs 2 ng ml⁻¹).

Hu et al. [19] showed that a combination of different target concentrations of remifentanil and sufentanil produced a lower increase of MAP and HR after tracheal intubation as compared to remifentanil TCI. As compared to our study, Hu et al. [19] used the same target concentration of propofol, but different target concentration for remifentanil (2-5 µg.ml⁻¹) and sufentanil (0.2-0.5 ng ml⁻¹).

In our study, we have assessed the number of plasma concentration (Cp) adjustments of propofol and opioids in response to surgical stimulation. Our findings indicated that the number of propofol Cp adjustment was higher in group R as compared with group S. Remifentanil Cp adjustment was done more frequently than for sufentanil in order to maintain hemodynamic stability. Despite the fact that the number of Cp adjust-
ments was higher in group R, hemodynamic impact of both opioids showed similar trend. Therefore, no significant differences in MAP and HR values were found between study groups during maintenance of anaesthesia. Hu et al. [19] have reported no significant differences in MAP and HR values when a combination of different target concentrations of sufentanil and remifentanil were used with propofol TCI.

It is well known that TCI of opioids may offer better control of anaesthesia emergence as compared to the continuous infusion during surgery [30, 31]. Remifentanil TCI allows rapid recovery from anaesthesia but with an immediate postoperative high pain levels and increased postoperative analgesic requirements [32]. Sufentanil TCI could provide an extubation concentration associated with good analgesia without delaying tracheal extubation or causing postoperative respiratory depression.

In our study, there were no significant differences in extubation time among study groups, although in group R, the extubation time was shorter. Similar results have been reported by Derrode et al. [33] who found that extubation time was not influenced by remifentanil or sufentanil TCI. The target sufentanil concentration at the time of extubation was set at 0.25 ng ml⁻¹ and was similar to our settings (0.2 ng ml⁻¹). Also, in both studies, a bolus dose of morphine was administered 30 minutes before the end of surgery to the remifentanil group. Martorano et al. [18], also reported that TIVA with propofol-remifentanil or sufentanil, administered as continuous infusion, did not influence awakening and extubation time, in neurological patients. An explanation for these findings was that sufentanil infusion was stopped sufficiently early before end of surgery to allow decrease in plasma concentration that ensures no respiratory depression.

Different results from ours have been reported by Hu et al. [19] and Bidgoli et al. [30], who found that remifentanil TCI provided shorter extubation time as compared to sufentanil TCI or combination of remifentanil-sufentanil TCI. One limitation of our study was the low number of patients included and the lack of a priori sample size calculation.

In conclusion, TCI propofol-remifentanil or propofol-sufentanil are safe, effective and produce stable hemodynamic conditions during open colorectal surgery, but TCI sufentanil was more effective during induction. However further study on a larger population is needed.

Conflict of interest
Nothing to declare

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### Anestezia totală întravenoasă – Target controlled infusion în chirurgia colorectală. Remifentanil TCI vs sufentanil TCI

#### Rezumat

**Obiectiv.** Scopul studiului este influența tipului de opioi, remifentanil vs sufentanil TCI, asupra profilului hemodinamic în chirurgia colorectală.

**Material și metodă.** 60 de pacienți ASA I-III supuși chirurgiei colorectale au fost randomizați în două loturi: lotul R (remifentanil) (n = 30) a inclus pacienți supuși TIVA-TCI cu propofol-remifentanil și lotul S (sufentanil) (n = 30) a inclus pacienți supuși TIVA-TCI cu propofol-sufentanil. Modificările tensiunii arteriale medii (TAM) și ale frecvenței cardiace (FC) au fost urmărite atât pe parcursul inducției cât și al menținerii anesteziei. Răspunsul la intubația orotraheală a fost evaluat prin modificările FC, TAM, indexului bispectral (BIS), transpirație, lăcimare și tuse. Pe parcursul menținerii anesteziei a fost înregistrat numărul de ajustări ale concentrației plasmatice (Cp) al propofolului și opioidului. Timpul de trezire apreciat a timpul scurs între sfârșitul intervenției chirurgicale și extubarea fost de asemenea evaluat.

**Rezultate.** TAM și FC, exprimate ca arie de sub curbă (AUC), nu au prezentat diferențe semnificative între grupuri pe parcursul anesteziei. În timpul inducției anesteziei, TAM a scăzut semnificativ față de valoarea de referință la ambele loturi de studiu (p < 0.001). Scăderea TAM a fost semnificativ mai mare în lotul R comparativ cu lotul S (p = 0.027). Scăderea FC a fost semnificativ mai mare față de valoarea de referință doar în grupul R (p = 0.05). Numărul de ajustări ale concentrației plasmatice a propofolului și opioidului a fost semnificativ mai mare în lotul R comparativ cu lotul S (p = 0.02 și respectiv 0.04). Răspunsul hemodinamic la intubația orotraheală și la extubare a fost similar în ambele loturi.

**Concluzie.** Remifentanil TCI și sufentanil TCI au asigurat o bună stabilitate hemodinamică în chirurgia colorectală, însă sufentanil TCI a fost asociat cu o scădere mai redusă a TAM și FC în cursul inducției anesteziei și a necesitat un număr mai mic de ajustări ale Cp pe tot parcursul anesteziei.

**Cuvinte cheie:** remifentanil, sufentanil, target controlled infusion, chirurgie colorectală, hemodinamică