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Influence of intraoperative opioid on postoperative pain and pulmonary function after laparoscopic gastric banding: remifentanil TCI *vs* sufentanil TCI in morbid obesity†

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Background. Choice of opioid may influence postoperative pain, recovery, and respiratory homeostasis in morbid obesity. The aim of this study was to compare the effects of target-controlled infusions (TCIs) of remifentanil or sufentanil on postoperative analgesia, recovery, and pulmonary function after laparoscopic gastric banding.

Methods. Forty morbidly obese patients undergoing laparoscopic gastric banding received BIS-guided desflurane anaesthesia combined with remifentanil TCI (Group R) or sufentanil TCI (Group S). Intraoperative haemodynamic stability, BIS controllability, and immediate recovery in the operating room were measured. Pulmonary function, modified Aldrete score, modified Observers Assessment of Alertness and Sedation score, blood gas analysis, and visual analogue score for pain and postoperative nausea and vomiting were measured on admission to the post-anaesthesia care unit and 30, 60, 120 min afterwards. After operation, patients received patient-controlled analgesia with morphine.

Results. During the first two postoperative hours, cumulative morphine consumption was higher in the remifentanil group compared with the sufentanil group, but was equal values after that time. Recovery profiles and spirometry showed no significant differences. During maintenance, remifentanil gave a better haemodynamic stability.

Conclusions. As few differences occurred in the postoperative period, the theoretical advantage of remifentanil over the longer acting sufentanil can be questioned when using TCI technology.

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A rational choice of drugs is crucial when aiming at optimal emergence and recovery after surgery in morbidly obese patients as many have poor physical status due to co-morbidity.[1] Inhaled anaesthetics with low blood gas solubility, such as sevoflurane and desflurane, have been found to be beneficial when used in this at-risk population.

Conflicting findings in recovery profiles have been shown after anaesthesia with sevoflurane or desflurane in morbidly obese patients.[2–5] These studies were performed with a background of different opioids and different administration modes and may account for these variable recovery effects. The selection of opioid and its mode of administration may influence postoperative pain, morphine consumption, haemodynamics, and respiratory homeostasis.[6]

The application of remifentanil may give a more objective assessment of recovery given its short half-life.[7] Additionally, it has been proven that target-controlled infusion (TCI) administration of opioids offers better control of emergence.[8 9] The pharmacological properties of sufentanil could delay recovery and produce respiratory depression.

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The aim of our study was to compare pain and recovery profiles in morbidly obese patients who received BIS-guided desflurane for maintenance of anaesthesia in combination with remifentanil TCI or sufentanil TCI. The primary endpoint was postoperative analgesia and morphine consumption. Our hypothesis was that morphine consumption would be higher in those receiving remifentanil.

The quality of recovery, which was defined as achieving optimal alertness as soon as possible, maintaining stable respiratory function and haemodynamics with the absence of postoperative nausea and vomiting (PONV), was the secondary endpoint.

Methods

After Institutional Ethics Committee (Ghent University Hospital, Ghent, Belgium) approval, written informed consent was obtained from 40 morbidly obese patients (BMI>35 kg m^{-2}), aged 18–70 yr (ASA I–II), undergoing laparoscopic gastric banding. Exclusion criteria included diagnosed obstructive sleep apnoea syndrome, re-do surgery, history of drug abuse, use of β-blockers, significant cardiopulmonary disease, renal failure (serum creatinine>120 μmol $litre^{-1}$), abnormal liver enzymes (transaminases>1.5× normal values), or history of allergy to anaesthetics. All patients were operated on by the same team of surgeons, using the same surgical technique (Swedish Adjustable Gastric Band, Obtech Medical, Baar, Switzerland). Four 10 mm trochars and one 5 mm trochar were placed on a line 10 cm parallel to the costal border bilaterally on the mid-clavicular line and anterior axillary line and paramedian of the umbilicus. None of the surgical sites was infiltrated with local anaesthetics. In all patients, CO_2 insufflation was initiated at 20 cm H_2O and afterwards decreased to 15–17 cm H_2O. The gastric band was fixed to the cardia using tunnelling sutures in order to prevent slippage. The injection port was manually sutured after elongating the incision of one of the 10 mm trochar sites.

After demonstration of correct usage during the pre-anaesthetic visit, baseline measurements of forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), peak expiratory flow rate (PEF), and mid-expiratory flow rate (MEF_{25-75}) were performed using a bedside spirometer (Spiropro, SensorMedics, Bilthoven, The Netherlands) in envelope mode[10] by the same blinded anaesthesiologist throughout the study. Spirometry was standardized with each patient in a 30° head-up position.

One hour before surgery, all patients received ranitidine 150 mg p.o. Midazolam (2 mg) was given i.v. before placement of a catheter in the left radial artery, approximately 10 min before induction. Patients were pre-oxygenated by mask for 5 min in the supine position with oxygen 10 litre min^{-1}.

Heart rate (HR), invasive arterial pressure, Sp_{O_2}, capnography, inspiratory, and end-tidal anaesthetic drug concentrations were measured continuously using an S5 monitor (Datex-Ohmeda, Helsinki, Finland). BIS (version 4.0) was derived from the frontal EEG (At-Fpzt) and calculated by the A-2000 BIS Monitor using a BIS-XP Sensor (Aspect Medical Systems, Inc., Newton, MA, USA). The smoothening time of the BIS monitor was set at 15 s. All data were continuously recorded, using the RUGLOOP data manager.

Patients were randomly allocated to one of the two groups. In the remifentanil group (Group R), the remifentanil infusion was started 2.5 min before induction via a computer-assisted continuous infusion device (RUGLOOP II ©, Demed, Temse, Belgium) to an initial target plasma concentration of 4 ng ml^{-1} using a three-compartment model.[11 12] In the sufentanil group (Group S), the sufentanil infusion was started 2.5 min before induction via a computer-assisted continuous infusion device (RUGLOOP II©, Demed) to an initial target effect-site concentration of 0.2 ng ml^{-1} using a three-compartment model.[13]

Anaesthesia was induced with a bolus of propofol, administered at 300 ml h^{-1} until loss of consciousness (LOC). BIS and the amount of propofol used were recorded. At LOC, rocuronium 0.9 mg kg^{-1} of ideal body weight (IBW) was administered while applying cricoid pressure. The trachea was intubated 60 s later. The lungs were ventilated with a mixture of oxygen/air ($F_{I_{O_2}}$=0.5) using an ADU ventilator (GE Healthcare, Helsinki, Finland). Tidal volume was set at 10 ml kg^{-1} IBW with 5–8 cm H_2O PEEP and peak airway pressure was kept below 35 cm H_2O. Respiratory frequency was adjusted to achieve an end-tidal CO_2 pressure of 4.0–4.6 kPa. If required, $F_{I_{O_2}}$was adjusted to maintain oxygen saturation above 95%.

After tracheal intubation, all patients received a prophylactic antibiotic dose of cefazoline 2 g i.v., propacetamol 4 g i.v. followed by 2 g every 6 h, and diclofenac 150 mg i.v.

All patients received desflurane. Initial fresh gas flow (FGF) was 6 litre min^{-1} with the vaporizer set at 6 vol% (=F_D desflurane). After 2.5 min, the FGF was lowered to 2 litre min^{-1} and the F_D desflurane was targeted to maintain a BIS value between 45 and 55. If the BIS value was <45 for >30 s, the F_D desflurane was decreased by 25%. If BIS values exceeded 55 for >30 s, an 'inhalation bolus of desflurane' was administered.[3] The remifentanil and sufentanil administration was adjusted according to haemodynamic measurements.[8] A baseline arterial pressure and HR were taken 5 min after tracheal intubation.

Inadequate analgesia was defined as: rise in systolic arterial pressure (SAP)>15 mm Hg above baseline, HR>90 beats min^{-1} in the absence of hypovolaemia, autonomic signs (e.g. sweating, salivation, and flushing) and somatic signs (e.g. movement, swallowing). If any of the above were present, the opioid target concentration was increased by 25%.

A level of excessive analgesia was defined as: mean arterial pressure (MAP) below 60 mm Hg or HR below 50 beats min^{-1}. In this case, the opioid target concentration was decreased by 25%.

After each change in infusion rate, there was a lockout period of 2.5. If requested by the surgeon, an additional bolus of rocuronium (25% of the initial dose) was given. If more than three consecutive adjustments were needed to bring arterial pressure or heartbeat within limits, i.v. rescue medication was used: urapidil 12.5 mg, phenylephrine 0.1 mg, or atropine 0.5 mg as appropriate.

For surgery, all patients were positioned in the semi-recumbent position after having received a crystalloid loading dose 10 ml kg^{-1} IBW. In persistent hypotension in the sitting position, a bolus of phenylephrine, 0.1 mg i.v., was given rather than changing the opioid dosage. Sufentanil administration was stopped at the exsufflation of the pneumoperitoneum. Remifentanil in Group R and desflurane in both groups were stopped at completion of dressing. Residual muscle relaxation was assessed by double burst stimulation and reversed with atropine 10 μg kg^{-1} and neostigmine 35 μg kg^{-1}.

After stopping all drug delivery, FGF was set at 6 litre $min^{-1}$with an $F_{I_{O_2}}$ of 50%. Two minutes after the drug discontinuation, ventilation was stopped and manual-breathing support was installed (one breath every 15 s until return of spontaneous ventilation. If E'_{CO_2} became higher than 60 mm Hg, manual-breathing support was increased until $E'_{CO_2}$was below 50 mm Hg). The anaesthesia time was defined as the time period between LOC and the moment of drug discontinuation. Recovery times, from stopping desflurane, were recorded for spontaneous breathing, opening eyes, extubation, free airway, and orientation (saying name, date, and location on request).

In the post-anaesthetic care unit (PACU), patients were placed in a 30° back-up Fowler position, breathing room air. Supplementary oxygen (6 litre min^{-1}) was only given via a facemask if oxygen saturation decreased below 92%. The withholding of oxygen was for study purposes and is not a standard practice. For postoperative analgesia, all patients received a patient-controlled analgesia (PCA) device (Pain Management Provider, Abbott Ireland, Finisklin sligo, Ireland) in 1 mg bolus mode with a lock-out of 8 min. A loading dose of 0.15 mg kg^{-1} IBW was given at the first analgesic request of the patient in the PACU. The time from stopping desflurane to delivery of a loading dose was defined as time to loading dose. Total amount of demands and deliveries and the cumulative morphine consumption, given as a loading dose and by PCA, were recorded for 24 h. Patients were instructed to achieve maximal comfort in order to breathe and cough without substantial pain.

Intermediate recovery was assessed by a blinded observer on PACU admission and after 30, 60, and 120 min. This included modified Aldrete score,[14] a modified Observer's Assessment of Alertness/Sedation (OAA/S) scale (0=asleep, not arousable; 1=asleep but arousable; 2=drowsy; 3=awake but calm; and 4=awake, very aware),[15] a 10 cm visual analogue scale (VAS),[16] (with 0=no pain and 10=worst pain) at rest and after spirometry, incidence of PONV, and oxygen saturation (Sirecust 1261, Siemens, Erlangen, Germany). Additionally, the consumption of ondansetron (Zofran®, GlaxoSmithKline, San Polo di Torille, Parma, Italy) during PACU stay was recorded. Patients were discharged from the PACU after 120 min if possible (Aldrete score≥8).

Spirometry was repeated in the PACU on admission, and 30, 60, and 120 min afterwards. Before each test, an arterial blood sample was drawn for pH, P_{CO_2}, P_{O_2}, and oxygen saturation.

Postoperative morphine consumption was used to calculate the statistical power. Power analysis was based on previous data,[17] comparing the cumulative 24 h morphine dose when using sufentanil TCI or remifentanil TCI which reached significance ($P<0.05$) with 15 patients in each group. On the basis of these data, statistical difference between groups could be predicted with a β-risk of 80% at an α-level of 0.05 when including 17 patients per group. Twenty patients per group were randomized to compensate for possible dropouts.

For all data sets, Gaussian distribution was tested using the Kolomogorov–Smirnov test. Between groups, continuous data were analysed using independent samples *t*-test or Mann–Whitney test, where appropriate. Categorical data were analysed using Fisher's exact test. All statistical tests were performed using SPSS v. 11.0 (SPSS Inc., Chicago, IL, USA). Within groups, statistics were done using ANOVA statistics. Significance level was set at 5% unless otherwise reported.

To assess the differences between groups in MAP, HR, and BIS at specific time points, case time was synchronized forwards from LOC until 5000 s and backwards from return of consciousness (ROC) until 2000 s. At every 10 s time point during maintenance, the 95% confidence intervals (CIs) for the difference between the mean values (Group S–Group R) were calculated. Significance is reached when zero is not included in the 95% CI.

Results

Forty patients were enrolled. The PCA data of one patient in Group R were excluded due to extravenous infusion on the ward. The patient characteristics (Table 1) and maintenance characteristics and immediate recovery (Table 2) showed no significant differences between groups.

Detailed analysis of the difference between mean values and 95% CI (Fig. 1) shows that MAP and HR were significantly lower in Group R compared with Group S after three distinctive stimuli: intubation, pneumoperitoneum, and skin closure. For BIS, significantly higher values at intubation were recorded in Group R compared with Group S. Lower BIS values in Group R compared with Group S were observed at skin closure.

The percentage of case time with systolic blood pressure >15 mm Hg above baseline and HR above

Table 1 Patient characteristics. Data are median (range), mean (SD) or number of patients

	Group R ($n=20$)	Group S ($n=20$)	*P*-value
Age (yr)	36 (20–57)	41 (19–57)	0.54
Actual weight (kg)	115 (19)	116 (15)	0.80
Ideal weight (kg)	62 (5)	64 (5)	0.44
Height (cm)	166 (8)	170 (7)	0.11
BMI (kg m^{-2})	41 (4)	40 (3)	0.28
Smokers (no/yes)	15/5	14/6	0.38
Sex ratio (M/F)	4/16	2/18	0.72

Table 2 Induction, maintenance, and recovery characteristics. (Total time = from injection of propofol until stopping desflurane; recovery time = from the moment of stopping desflurane.) Data are means (SD)

	Group R	Group S	*P*-value
Total time (min)	99 (17)	109 (19)	0.09
BIS at LOC	60 (9)	60 (9)	0.95
Used propofol for induction (mg)	117 (24)	129 (23)	0.11
Recovery time to spont. resp. (s)	279 (141)	207 (147)	0.12
Recovery time to opening eyes (s)	309 (155)	321 (183)	0.82
Recovery time to extubation (s)	385 (159)	375 (193)	0.86
Recovery time to orientation (s)	450 (166)	466 (190)	0.78
Recovery time to free airway (s)	406 (151)	386 (198)	0.72
Time-weighted mean opioid dose ($\mu g\ kg^{-1}min^{-1}$)	0.125 (0.026)	0.006 (0.001)	
Mean consumption of desflurane ($ml\ kg^{-1}min^{-1}$)	0.0048 (0.0011)	0.0050 (0.0010)	0.67
Time-weighted mean rocuronium dose ($\mu g\ kg^{-1}min^{-1}$)	5.53 (1.15)	5.44 (1.35)	0.81
BIS at end	46 (6)	47 (7)	0.52
Plasma concentration at end ($\mu g\ ml^{-1}ng\ ml^{-1}$)	4.8 (1.5)	0.14 (0.05)	
Effect-site concentration at end ($\mu g\ ml^{-1}ng\ ml^{-1}$)	4.8 (1.5)	0.16 (0.05)	
End-tidal desflurane at stop pneumoperitoneum (vol%)	3.3 (1.1)	3.6 (1.0)	0.33
End-tidal desflurane at end (vol%)	3.4 (0.9)	3.8 (0.6)	0.12
Plasma concentration at breathing ($\mu g\ ml^{-1}ng\ ml^{-1}$)	1.7 (0.7)	0.13 (0.04)	
Effect-site concentration at breathing ($\mu g\ ml^{-1}ng\ ml^{-1}$)	2.3 (SD1.1)	0.14 (0.05)	
End-tidal desflurane at breathing (vol%)	0.9 (0.3)	1.0 (0.8)	0.48

90 beats min^{-1} was significantly lower in Group R compared with Group S (Table 3). Episodes of severe hypertension (MAP>130 mm Hg) lasted a short time in both groups, but were significantly shorter in Group R. Two patients in Group R needed urapidil with a median dosage (min–max) of 12.5 mg (0–12.5 mg) compared with 10 in Group S of 12.5 mg (10–60 mg) ($P=0.01$). Episodes of hypotension (MAP<60 mm Hg) were rare. Eleven patients in Group R and 12 in Group S needed phenylephrine with a median dosage (min–max) of 0.2 (0.1–0.6) mg and 0.2 (0.1–0.6) mg, respectively ($P=0.75$). Episodes of bradycardia (beats min^{-1}<50) were similar between groups. BIS was kept similarly accurate within the target of 40–60 in both groups.

(Figures showing the individual predicted plasma and effect-site concentrations of remifentanil and sufentanil, the individual measured inspired and end-tidal concentration of desflurane for both groups, and the individual BIS, HR, SAP, and MAP between both groups *vs* time are available on the on-line version of this article).

After operation, the modified Aldrete scores and OAA/S scores from both groups showed no statistical difference between groups. The incidence of PONV on admission was 45% in Group R and 25% in Group S ($P=0.19$). The incidence after 120 min decreased to 5% in Group R and 10% in Group S ($P=0.55$). Fourteen patients in Group R required ondansetron compared with nine in Group S ($P=0.08$). Average (SD) ondansetron consumption in Group R was 4.4 mg (3.4) compared with 2.2 mg (2.7) in Group S ($P=0.03$).

The VAS pain scores at rest and after spirometry showed no differences between the groups. However, a significant increase in VAS pain scores after spirometry compared with at rest was observed in Group S (Table 4). The cumulative morphine consumption (Fig. 2) was significantly higher at 30, 60, and 120 min in Group R. Afterwards no significant difference was noticed in cumulative morphine consumption between both groups. The time to first analgesic request was significantly shorter in Group R compared with Group S: 29 min (15) *vs* 70 min (50), respectively ($P=0.002$). The total amount of demands and deliveries were not different between groups.

In the PACU, HR was similar in both groups, but MAP was higher in Group R at admission compared with Group S (Table 5). Analysis of arterial pH, P_{CO_2}, P_{O_2}, and oxygen saturation showed a significantly lower pH at admission in Group S, due to higher Pa_{CO_2}. In both groups, all measured spirometry showed a significant decrease to about 65% of preoperative values and gradually returned to about 75% 120 min after PACU admission (Fig. 3). No between-group differences were found.

Discussion

This prospective, single-blinded, randomized study partially confirmed our primary hypothesis that intraoperative remifentanil TCI will result in higher morphine consumption than sufentanil TCI for postoperative pain after laparoscopic gastric banding. Remifentanil resulted in better intraoperative haemodynamic stability, but recovery and respiratory function were similar to sufentanil.

For sufentanil, we targeted the effect-site to minimize equilibration time between plasma concentration and effect-site concentration. For remifentanil, however, we targeted a plasma concentration. At the time of the study, the manufacturer of remifentanil did not allow, advise, nor advocate the use of remifentanil effect-site steering in high-risk patients. We believe that this administration mode is acceptable as shown by the good nociceptive

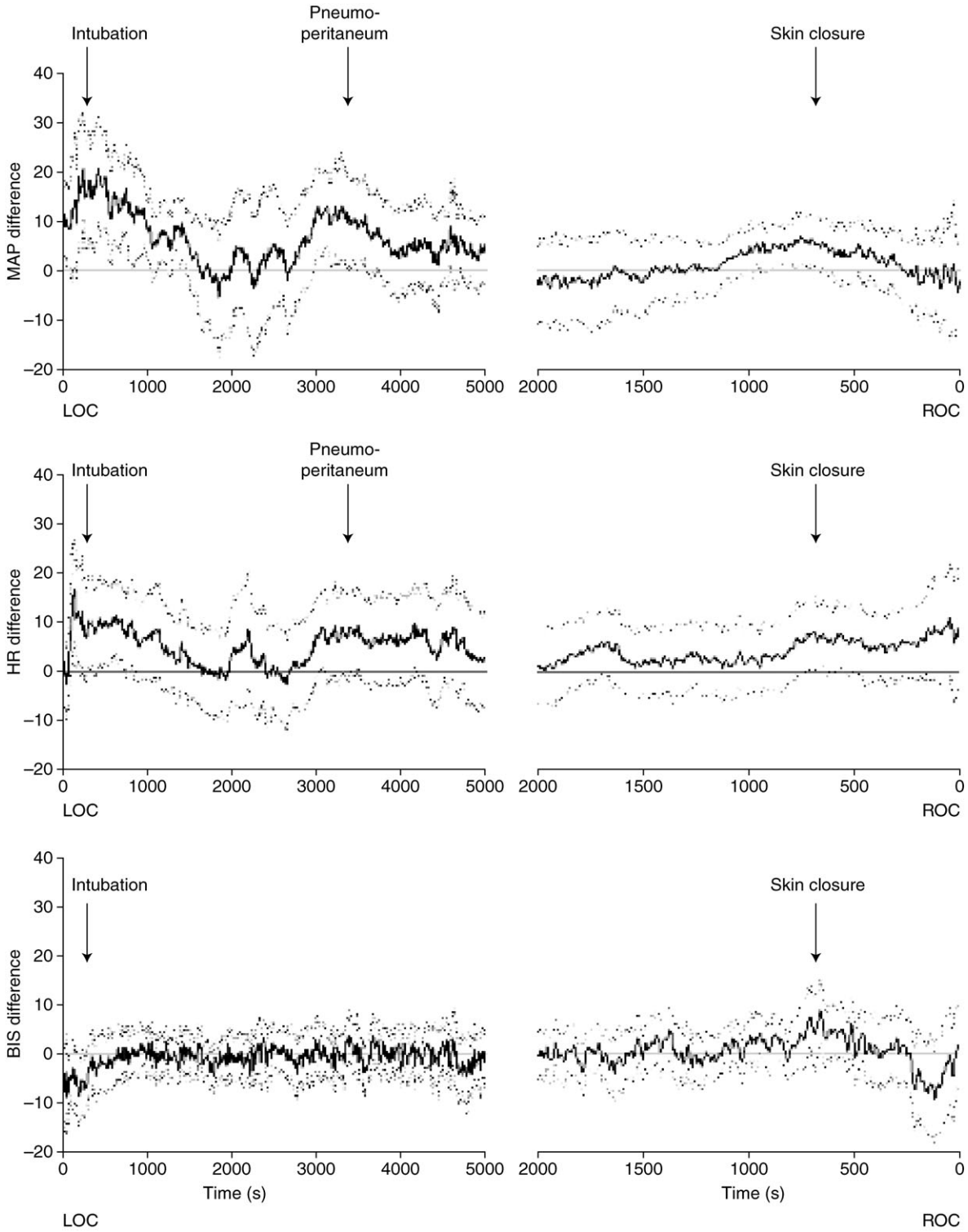

Fig 1 Time-synchronized analysis of the differences between mean values of MAP, HR, and BIS between groups (from LOC until ROC). The difference between means (Group S−Group R) is plotted as a straight line; the upper and lower CI are plotted as dotted lines. Significance is reached when zero is not included in the 95% CI.

blockade and better intraoperative haemodynamic control in Group R compared with Group S.

The VAS pain scores and cumulative morphine consumption are in contrast with the findings of Derrode and colleagues[17] who found higher VAS pain during the first 2 h and a persistent higher morphine consumption in a remifentanil TCI group compared with sufentanil TCI after major open abdominal surgery in non-obese patients.

Table 3 Haemodynamic and hypnotic stability during maintenance of anaesthesia (from starting propofol to stopping desflurane). Data are means (SD). *$P<0.05$ between groups

	Group R	Group S	*P*-value
Percentage of time baseline systolic pressure+15 mm Hg	9 (8)*	17 (10)*	0.01
Percentage of time with MAP<60 mm Hg	7 (7)	6 (8)	0.74
Percentage of time with MAP>130 mm Hg	0.5 (1.8)*	1.3 (2.0)*	0.02
Percentage of time with tachycardia	7 (11)*	15 (21)*	0.03
Percentage of time with bradycardia	4.3 (11)	2 (4)	0.37
Percentage of time BIS between 40 and 60	72 (21)	72 (18)	0.99
Percentage of time BIS lower than 40	26 (21)	26 (17)	0.95
Percentage of time BIS higher than 60	2.4 (2.9)	2.0 (1.4)	0.65

Table 4 VAS pain scores (0–10 cm) in rest and post-spirometry in the two groups on admission at PACU and 30, 60, and 120 min afterwards. Data are mean (SD). *$P<0.05$ within group comparison

	Group R		Group S	
	At rest	Post-spirometry	At rest	Post-spirometry
VAS on admission	4.3 (1.7)	4.5 (1.6)	3.3 (2.2)*	3.8 (2.3)*
VAS after 30 min	4.5 (1.8)	5.0 (2.1)	4.4 (2.2)*	4.8 (2.4)*
VAS after 60 min	3.9 (1.8)	4.2 (2.0)	4.0 (1.9)*	4.3 (2.0)*
VAS after 120 min	2.4 (2.0)	2.7 (1.6)	2.8 (1.4)*	3.4 (1.8)*

Table 5 MAP, HR, breaths per minute, arterial blood gas analysis, and pulse oximetry on admission at PACU and 30, 60, and 120 min afterwards. Patients were breathing room air. Data are means (SD). *$P<0.05$ between groups

	Admission	After 30 min	After 60 min	After 120 min
MAP (mm Hg)				
Group R	105 (12)*	99 (13)	96 (16)	91 (15)
Group S	96 (11)*	93 (11)	94 (10)	96 (12)
HR				
Group R	89 (15)	80 (14)	79 (15)	80 (14)
Group S	85 (15)	78 (12)	76 (13)	78 (13)
Breaths per minute				
Group R	17.3 (6.8)	17.9 (4.4)*	17.3 (5.2)	17.0 (5.0)
Group S	15.2 (4.5)	14.7 (4.9)*	15.9 (5.4)	15.5 (4.8)
pH				
Group R	7.38 (0.02)*	7.39 (0.02)	7.38 (0.03)	7.37 (0.02)
Group S	7.35 (0.03)*	7.37 (0.03)	7.37 (0.03)	7.38 (0.03)
Pa_{CO_2} (kPa)				
Group R	5.29 (0.6)	5.26 (0.3)	5.33 (0.5)	5.42 (0.5)
Group S	5.68 (0.8)	5.42 (0.5)	5.46 (0.5)	5.46 (0.5)
Pa_{O_2} (kPa)				
Group R	11.6 (3.3)	11.1 (2.1)	10.7 (2.1)	11.4 (3.3)
Group S	10.7 (2.2)	11.6 (2.5)	11.1 (2.3)	10.9 (13.5)
Saturation (%)				
Group R	95.4 (3.4)	95.8 (2.1)	95.1 (2.9)	95.5 (1.6)
Group S	94.3 (2.6)	95.4 (3.3)	95.1 (2.3)	95.2 (1.6)
Sp_{O_2}(%)				
Group R	96.3 (2.1)	96.5 (2.2)	96.5 (2.3)	96.2 (2.4)
Group S	95.5 (2.3)	95.7 (2.3)	95.9 (1.8)	95.9 (2.0)

The initial higher morphine consumption in Group R can be explained by the differences in the opioid pharmacokinetics. Unlike the study of Derrode and colleagues, our patients only underwent laparoscopic surgery and we gave multimodal analgesia. Acetaminophen is known to reduce morphine consumption, particularly after abdominal surgery, as does diclofenac.[18] This could explain why morphine requirements and VAS scores became similar during the first 2 h at rest and after spirometry independent of the opiate selected during surgery. The significant difference in VAS pain scores at rest compared with after spirometry in the sufentanil group can be explained by the gap between the time of morphine request and onset of its analgesic effect. More accurate timing of morphine administration should be considered even when using sufentanil and has to be defined in further studies.

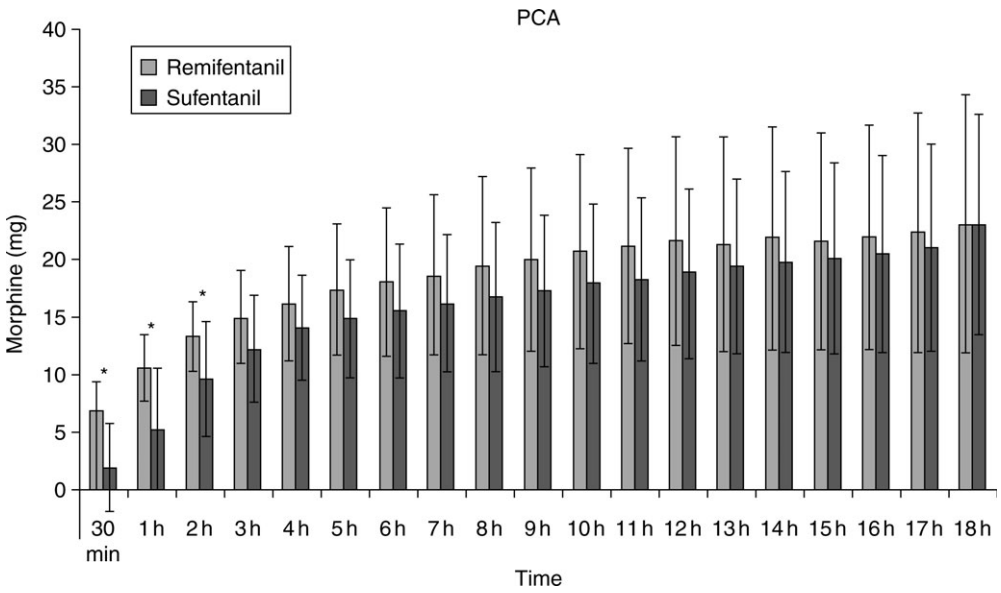

Fig 2 Cumulative morphine consumption (mg) starting from the stopping of desflurane until 18 h afterwards in Group R and Group S. Data are means (SD). *$P<0.05$ between groups.

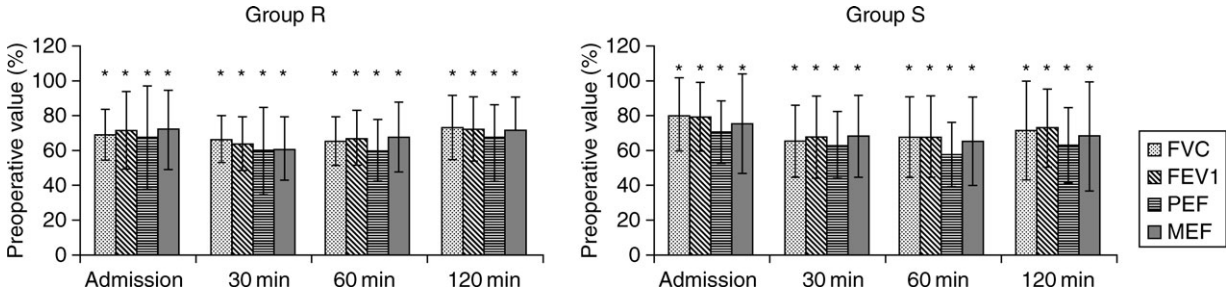

Fig 3 FVC, FEV_1, PEF, and mean expiratory flow 25–75% (MEF) expressed as a percentage of the preoperative value in Group R and Group S. Data are means (SD). *$P<0.05$ compared with the respective preoperative value.

The intraoperative management of both hypnotic and analgesic components of anaesthesia may influence emergence and recovery after surgery in morbidly obese patients. In our study, we aimed at comparing the influence of opioid selection on intraoperative stability and recovery under equal hypnotic conditions. The potency ratio of remifentanil to sufentanil[19] is around 20, and we started our delivery at this to achieve an initial equipotent opioid administration. Desflurane was successfully guided by BIS, and similar end-tidal concentrations were reached in both groups. The pharmacokinetic and dynamic properties of remifentanil allow it to suppress moments of surgical stress and raised arterial pressure more rapidly than sufentanil[20 21] due to a quicker equilibration between plasma concentration and effect-site concentration.[22 23] The increase in HR and arterial pressure in Group S at three specific stimuli during maintenance confirms the difference in surgical stress blockade. We did not increase the opioid target concentration in anticipation of a strong nociceptive stimulus. Alternatively, one could target a higher initial sufentanil concentration to avoid these haemodynamic fluctuations.[19] On the basis of our study results, when using sufentanil TCI in morbidly obese patients, we would advise a starting effect-site target of 0.4 ng ml^{-1} with increases of up to 0.65 ng ml^{-1} during surgery. Thirty minutes before the end of surgery, the effect-site target should be decreased in order to obtain spontaneous breathing with satisfactory analgesia as discussed later.

We expected to find longer and more variable recovery times when using sufentanil due to its slower pharmacological profile. In contrast to these intuitive expectations, immediate recovery in the operating room was similar in both groups. Spontaneous breathing returned at an average calculated effect-site concentration of 2.3 and 0.14 ng.ml^{-1} for remifentanil and sufentanil, respectively. The clinician should aim to reach these targets at the end of surgery to minimize immediate recovery times. Our findings correlate well with the sufentanil plasma concentration measured during spontaneous ventilation of 0.13 ng ml^{-1}.[24] In this study, sufentanil TCI was stopped at pneumoperitoneum exsufflation and the return to spontaneous breathing took 49.6 (17.5) min, compared with 29 (4.4) min in our study using desflurane instead of propofol.

A previous study[25] of pulmonary function and pain after laparoscopic gastroplasty in morbidly obese patients using sufentanil and isoflurane intraoperatively and analgesia with acetaminophen and PCA piritramide found that FVC, FEV_1, and PEF decreased to about 45–50% of preoperative values 4 h after surgery and took 3 days to return to about 75%. Our quicker return of pulmonary function could be explained by the use of desflurane, the multimodal analgesia, and the experience of our surgical team. The avoidance of 100% oxygen at extubation and the sitting position in the PACU can prevent atelectasis.[26] Our spirometric data rejected the hypothesis of opioid-dependent depression of respiratory functions. Small statistical differences were found, but are without clinical relevance. Other measures of recovery (OAAS, modified Aldrete score, and PONV) were similar between groups.

This study was performed in healthy morbidly obese patients undergoing laparoscopic gastric banding. There is a trend to perform laparoscopic or open gastric bypasses in patients with higher risks. Whether our findings apply to these subgroups of morbidly obese patients need further studies.

In conclusion, when comparing the influence of perioperative opioid on postoperative pain and pulmonary function after laparoscopic gastric banding in morbidly obese patients, we found that remifentanil TCI resulted in higher morphine consumption than sufentanil TCI only during the initial management of postoperative pain after laparoscopic gastric banding. Remifentanil resulted in better intraoperative haemodynamic stability, and similar recovery and respiratory function compared with sufentanil. An initial higher sufentanil target concentration, decreased accurately at the end of the surgical procedure to allow spontaneous ventilation combined with optimal timing of morphine administration could minimize the differences between groups. As such, the use of sufentanil TCI might be considered as an alternative for remifentanil TCI during well-defined surgical procedures in morbidly obese patients.

Supplementary material

Supplementary material is available at *British Journal of Anaesthesia* online.

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