ORIGINAL ARTICLE

Fentanyl Efficacy in Anesthesia for Morbidly Obese Patients Undergoing Laparoscopic Sleeve Gastrectomy: A Prospective Randomized Trial of Dosage Calculations Based on Lean Body Mass (1 mcg/kg versus 2 mcg/kg)

Thanyarat Prommahachai, MD[1], Nampetch Tongsiri, RN[2], Akom Prommahachai, MD[3]

[1] Division of Anesthesiology, Udon Thani Hospital, Udon Thani, Thailand; [2] Division of Anesthetic Nurse, Udon Thani Hospital, Udon Thani, Thailand; [3] Division of Orthopedics, Udon Thani Hospital, Udon Thani, Thailand

Background: Fentanyl is a potent opioid analgesic commonly used in anesthesia for bariatric surgery due to its high efficacy. However, the appropriate fentanyl dosage for morbidly obese patients remains inconclusive.

Objective: To compare the efficacy of two fentanyl dosages at 2 mcg/kg versus 1 mcg/kg administered during induction before intubation in morbidly obese patients undergoing laparoscopic sleeve gastrectomy.

Materials and Methods: A prospective, randomized, single-blinded trial was conducted between November 2024 and July 2025. Adults, aged 18 years and older, with morbid obesity scheduled for laparoscopic sleeve gastrectomy under general anesthesia were randomized, one to one, to receive either 2 mcg/kg or 1 mcg/kg intravenous (IV) fentanyl during induction. Following intubation, all patients received 25 mcg IV fentanyl every 30 minutes. Outcomes included pain scores assessed by the visual analog scale (VAS) in the post-anesthesia care unit (PACU) and at 24 hours, intraoperative hemodynamic parameters, and postoperative blood sugar.

Results: Forty participants were enrolled. VAS scores at PACU showed no difference between groups. At 24 hours, however, the median VAS was significantly higher in the 2 mcg/kg group compared with the 1 mcg/kg group at 28 (IQR 19.87 to 50) versus 16.2 (IQR 0 to 26.6) (p=0.0059). Intraoperative analysis revealed that the 2 mcg/kg group experienced significant reductions in heart rate and systolic blood pressure from baseline to one-hour post-intubation. Conversely, postoperative blood glucose increased significantly in the 1 mcg/kg group. No differences were observed in analgesic and morphine consumption or perioperative complications.

Conclusion: A dose of 1 mcg/kg of fentanyl administered during the induction phase before intubation results in lower postoperative pain scores at 24 hours compared with 2 mcg/kg in patients with morbid obesity undergoing laparoscopic sleeve gastrectomy. Both fentanyl dosages effectively control intraoperative hemodynamic parameters.

Keywords: Fentanyl; Dose; Morbid obesity; Laparoscopic sleeve gastrectomy; VAS; Lean body mass

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Obesity has been an increasing problem that has direct impacts on the patients' physical and mental health, such as types of vascular-related conditions such as cardiovascular diseases, stroke, and hypertension, diabetes, respiratory diseases such as asthma and pulmonary embolism, and early degenerative musculoskeletal problems[1]. These obesity-related problems inevitably cause socio-economic and public health service burdens. According to a study by Pitayatienanan et al. in 2012, the health costs for obese patients and their associated diseases were 12,142 million baht, approximately 0.13% of the country's gross domestic product (GDP)[2]. Obesity and related conditions require a multidisciplinary approach and health professional integration. Recently, one of the effective measures is bariatric surgery[3]. The most recognized and effective surgical intervention is laparoscopic sleeve gastrectomy[4]. Udon Thani Hospital currently provides laparoscopic sleeve gastrectomy to treat morbidly obese patients, resulting in more anesthesia for the surgery in these patients. An unsolved concern

Correspondence to:

Prommahachai T.

Division of Anesthesiology, Udon Thani Hospital, 33 Pheu Niyom Road, Mak Khaeng Subdistrict, Mueang Udon Thani District, Udon Thani 41000, Thailand.

Phone: +66-81-2663420

Email: pthanya17@gmail.com

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is determining the appropriate anesthetic dosage for patients with these specific characteristics. Obese patients have different physiological and anatomical characteristics from non-obese patients. An increased proportion of fat to body weight causes substantial alterations in the pharmacodynamic and pharmacokinetic properties of anesthetic agents[5]. Obese patients have an increase in cardiac output and total blood volume, including changing in regional blood flow, which affects peak plasma concentration, drug excretion, and clearance of medications[5,6]. Due to these characteristics, the calculation of dosage of various drugs used in obese patients is complicated and different from dosage calculation in non-obese patients. Fentanyl is an opioid that remains an important component of anesthesia offering effective analgesia at low cost for various surgeries including laparoscopic bariatric surgery[7,8]. Unlike opioids such as morphine or meperidine, fentanyl causes minimal systemic histamine release, which provides an advantage for cardiovascular stability by avoiding histamine-related side effects. Its short half-life and duration of action are well-suited to the operative time of sleeve gastrectomy, reducing the risk of postoperative complications such as delayed extubation, respiratory depression, or re-intubation that may occur with longer-acting opioids. Fentanyl is primarily metabolized in the liver by the cytochrome P450 isoenzyme CYP3A4 into norfentanyl, an inactive and non-toxic metabolite. Consequently, fentanyl is considered a safe opioid option, as it does not produce active metabolites that could accumulate to toxic levels, a risk associated with opioids like morphine. However, because fentanyl is a highly lipophilic drug, the dosage used in obese patients, which is defined as a body mass index (BMI) greater than 40 or more than 35 with other conditions related to obesity such as diabetes and hypertension, is a crucial consideration. A previous study has reported that fentanyl dosage can be used from 1 to 3 micrograms per kilogram of body weight for induction prior to endotracheal tube insertion[9]. A study by Sawano et al. in 2013[10] suggested that the appropriate dose for induction prior to endotracheal intubation for normal weight individuals was 2 mcg/kg. However, an appropriate fentanyl dosage for morbidly obese patients is still inconclusive. The fentanyl dosage issue is a critical concern because given an inappropriate amount during surgery, it can cause postoperative adverse events such as nausea, vomiting, delayed return of peristalsis, cardiac suppression, delayed extubation, and opioid-induced respiratory failure[11]. To date, there has still been a lack of scientific evidence determining the appropriate dose of fentanyl for anesthesia in morbidly obese patients. The main purpose of this study was to evaluate the efficacy of postoperative pain relief in morbidly obese patients undergoing laparoscopic sleeve gastrectomy by comparing different doses of fentanyl. The secondary objective was to examine the effects of various dosages of fentanyl on hemodynamic status, physiological stress-induced blood sugar level, total postoperative morphine consumption, and potential complications associated with each fentanyl dosage.

Materials and Methods

The present study was a single center, randomized, parallel, controlled trial conducted at Udon Thani Hospital, Udon Thani Province, Thailand between November 1, 2024, and July 15, 2025. The study protocol was approved by the Udon Thani Hospital Ethic Committee (registration number UDH REC No. 156/2567) and registered in the Thai Clinical Trial Registry (TCTR20250811002). All methods were conducted according to the CONSORT 2010 Statement[12]. The inclusion criteria were male or female patients aged 18 years or older diagnosed with morbid obesity, or with a BMI of more than 40, or more than 35 with obesity-associated medical conditions such as diabetes, dyslipidemia, or hypertension, and classified as American Society of Anesthesiologists (ASA) class II or III, who underwent laparoscopic sleeve gastrectomy under general anesthesia. Laparoscopic sleeve gastrectomy was performed by two experienced surgeons using similar surgical techniques. All patients were examined by a psychiatrist before undergoing the surgery and evaluated in the Udon Thani Preanesthetic Assessment Clinic (UDPAC) 30 days prior to the surgical procedure. After hospitalization, the second preoperative evaluation was performed for potential difficulty in airway management. The participants had to be able to cooperate and communicate in Thai language with the study assessor postoperatively. Patients who were unable to give informed consent, illiterate, or not willing to participate were excluded from the study. Patients with a history of pain medication used, including NSAIDs or opioids, within the last seven days prior to surgery, as well as those with any history of opioid allergy or psychiatric conditions, were excluded from the study. Written informed consent was obtained from all participants. Patients were randomized in

a one-to-one ratio to receive either the 2 mcg/kg of lean body mass (LBM) of intravenous fentanyl during the induction phase before intubation, or 1 mcg/kg of LBM intravenous fentanyl as the comparison group. The allocation sequence was generated by using a web-based system[13] to achieve a sequence with block sizes of 4. The random number allocation sequences were secured and prepared in sealed envelopes by a research coordinator (AP) who was not involved in the surgery or the patient assessments. The envelope was opened by the research assistant (NT), who was not involved in outcome assessments, when the patient entered the operating room before anesthetic induction.

Intervention

All patients were pre-oxygenated with 6 L/minute of 100% oxygen for five minutes. Patients assigned to the 2 mcg/kg fentanyl group received an intravenous bolus of fentanyl 2 mcg/kg of LBM for induction before induction of anesthesia, while those assigned to the fentanyl 1 mcg/kg group received fentanyl 1 mcg/kg of LBM. The LBM formula for adults, calculated using the Hume formula[8,14], was as follows: For males, estimated LBM = 0.32810 W + 0.33929H – 29.5336. For females, estimated LBM = 0.29569 W 0.41813H – 43.2933.

In these formulas, W represented body weight in kilogram, and H represented body height in centimeters.

In the present study, fentanyl dosage was calculated based on LBM, as total body weight was not appropriate in morbidly obese patients due to the high proportion of adipose tissue. Using total body weight can lead to excessive dosing[15] and adverse effects such as upper airway obstruction, abnormal breathing patterns, central apnea, ataxic breathing, and hypoxemia. Although ideal body weight is often used because of its simplicity, studies have shown that it might result in underdosing in morbidly obese patients[16]. Consequently, studies have concluded that LBM provides a more accurate basis for fentanyl dosing in this population[15,16]. LBM, defined as the difference between the total body weight and body fat mass, varies by gender, with men having a higher proportion than women. Multiple formulas have been proposed to estimate LBM, with the Hume formula[14] being the most widely applied. In the present study, fentanyl doses were calculated by the primary investigator (TP), prepared accordingly, and administered by an anesthetic nurse, who also recorded perioperative vital signs and blood glucose levels.

Anesthetic protocol

All participants followed the standard anesthetic protocol. Balanced general anesthesia was provided by the principal investigator (TP) for all participants. Standard anesthetic induction was achieved using two to 3 mg/kg of LBM of propofol, and 2 mg/kg of ideal body weight cisatracurium was used for muscle relaxant according to the recommendation by the Ingrande et al. study[16]. Maintenance of anesthesia was conducted using oxygen, air, and sevoflurane. Laryngoscopy and endotracheal intubation were performed five minutes after cisatracurium administration.

Cisatracurium was used in the present study because its elimination is organ-independent, making it a preferred and reliable choice for patients with renal or hepatic dysfunction, as clearance remains consistent. In addition, cisatracurium does not cause significant changes in heart rate (HR) or blood pressure, thereby avoiding interference with the secondary outcome measurements. Owing to its predictable metabolic pathway, cisatracurium provided a consistent recovery profile and carried a low risk of postoperative residual paralysis compared with other neuromuscular blocking agents. All participants underwent elective gastrectomy and were kept NPO for 12 hours prior to surgery; therefore, the risk of aspiration during intubation was minimal.

The average operative time for sleeve gastrectomy is one to two hours. Since the duration of action of fentanyl is only 30 to 60 minutes, repeated doses were required to maintain analgesia and suppress the physiological response to surgical stimuli. To evaluate and control intraoperative fentanyl usage comparing between the two groups, fentanyl was given as 25 mcg intravenous bolus every 30 minutes for every participant after intubation until the operation finished. However, additional fentanyl doses were allowed for the patient if the patient's response to the previous dose of 25 mcg showed signs of inadequate analgesia. The decision of extra dose of fentanyl was made by the primary investigator (TP). Intravenous neostigmine 0.05 mg/kg of total body weight and atropine 0.02 mg/kg (LBM) were used for extubation. After the operation, the patients were monitored at the post anesthetic care unit (PACU) until they passed the Aldrete score[17] and then transferred to the patients' surgical ward. In PACU, if the patient required additional analgesia, the anesthetic nurse on duty in PACU administered fentanyl 25 mcg intravenous

bolus, repeating in the same dose every 30 minutes as needed based on the patient's request. The study stopped recruiting participants after obtaining the required precalculated minimum sample size and there was no interim analysis.

Data collection

Baseline information consisted of age, gender, BMI, underlying medical conditions, previous history of substance drug use, and total operative times. The primary outcome was the pain scores assessed by patients blinded to the study allocation, in the PACU, after they had regained full consciousness, and at 24 hours postoperatively in the ward. The patients were instructed to mark a cross on a visual analog scale (VAS) consisting of a 10-centimeter linear line on the paper, on a 0 to 10 scale. A score of 0 represented no pain during the procedure, whereas a score of 10 represented the worst pain ever experienced by the patient. To evaluate the physiological changes resulting from different dosages of fentanyl, the secondary outcomes were defined as intraoperative parameters including baseline HR, systolic blood pressure (SBP), and diastolic blood pressure (DBP) measured before the operation and one hour after the surgeon made the skin incision by anesthetic nurses who were not involved in the patient allocation and data analysis. Additionally, blood sugar level was measured by checking the patient's finger capillary blood glucose immediately after intubation as the baseline value and again in the PACU. Intraoperative fentanyl dosages for maintenance were collected in micrograms per minute, based on the total operative time for each participant. In PACU, additional fentanyl doses and complications such as nausea vomiting or signs of respiratory compromised were recorded. During the first 24 hours after the operation, additional pain-control medications were prescribed as the participants requested and according to surgeon preference. Total analgesic consumption was recorded by type such as morphine or parecoxib, and dosage.

Statistical analysis

For a priority sample size calculation, the mean change in pain score using VAS 0 to 100, at PACU in the patient with morbid obesity underwent bariatric surgery was estimated at 25.9 with a standard deviation of 16.2 on the basis of a previous study[8]. The effect size of 16 was used regarding the minimally clinically difference of the VAS for pain score defined by Charoenpol et al. in 2023[18]. Sixteen patients per group, or 32 patients in total, were required for the study to obtain 80% power and 5% alpha error. Twenty percent of data loss was determined and at least 20 patients per group, or 40 patients of the total sample size, were recruited in the present study. All outcomes were analyzed under an intention-to-treat approach. Categorical data were reported as counts and percentages and analyzed with the Pearson chi-square or Fisher exact probability test. Continuous data were presented as means ± standard deviations (SDs) or median and interquartile ranges (IQRs) depending on data distribution. Distribution of continuous variables were examined with the Shapiro-Wilk test. Normally distributed continuous data were analyzed with an unpaired Student's t-test to compare between two groups and a paired t-test to compare between baseline valuables and intraoperative valuables in each group. The Mann-Whitney U test for groups comparison and the Wilcoxon signed rank test for paired comparison of each individual would be used for non-parametric statistical tests if the requirement of normal distribution were not met. In the case of a combined distributed valuables comparison, which exhibits both non-normally distributed and normally distributed data, in addition to the Mann-Whitney U test, Bootstrap method for mean estimation based on 1,000 bootstrap samples would also be analyzed for the robustness of the results. Missing values would be managed by simple imputation with mean group substitution if they occurred. Multiple comparisons were analyzed by using the Holm-Bonferroni procedure of multiplicity correction to reduce inflation of error. Adjusted p-values were marked $p_{adjusted}$ based on 10 hypotheses. All analyses were conducted using IBM SPSS Statistics, version 26.0 (IBM Corp., Armonk, NY, USA).

Results

Between November 1, 2024, and July 15, 2025, the authors screened 295 patients for eligibility, 254 patients were excluded because they underwent other laparoscopic abdominal operations beside laparoscopic sleeve gastrectomy. One patient declined consent. Of the 40 remaining patients, they were randomly allocated to two groups, 20 were assigned to receive intravenous fentanyl 2 mcg/kg during the induction phase before intubation, and 20 were assigned to receive intravenous fentanyl 1 mcg/kg before intubation. There were no missing data or participant dropouts during the study period, all participants were analyzed according to their assigned

Table 1. Baseline characteristics

Characteristics	Fentanyl 2 mcg/kg (n=20)	Fentanyl 1 mcg/kg (n=20)	p-value
Age (year); median (IQR)	32 (27 to 39)	35 (26 to 44)	0.495[a]
Sex; n (%)			0.302[b]
Female	19 (95)	17 (85)	
Male	1 (5)	3 (15)	
Body mass index (kg/m^2); mean±SD	41.75±8.46	38.84±5.4	0.203[d]
Lean body mass (kg); mean±SD	55.4±8.8	53.9±7.1	0.556[d]
Underlying conditions; n (%)			
Hypertension	11 (55)	7 (35)	0.170[c]
Diabetes	4 (20)	9 (45)s	0.088[b]
Dyslipidemia	7 (35)	6 (30)	0.500[c]
Obstructive sleep apnea	10 (50)	3 (15)	0.020[b]
Thyroid disease	1 (5)	3 (15)	0.302[b]
Cerebrovascular disease	2 (10)	0 (0)	0.244[b]
Substance use; n (%)	0 (0)	9 (45)	0.001[b]
Operative time-minute; mean±SD	108.75±32.92	106.25±21.94	0.779[d]
Intraoperative fentanyl dosage used (mcg/minute); mean±SD	0.80±0.08	0.80±0.07	1.000[d]
Actual dose to fentanyl (mcg); mean±SD	170±28.8	247.7±33.6	0.000[d]

IQR=interquartile range; SD=standard deviation
Actual dose of fentanyl = induction fentanyl dose (1 or 2 mcg/LBM) + intraoperative fentanyl maintenance dose
(a) Result of Mann-Whitney U-test, (b) Result of Fisher's exact test, (c) Result of chi-square test, (d) Result of independent t-test

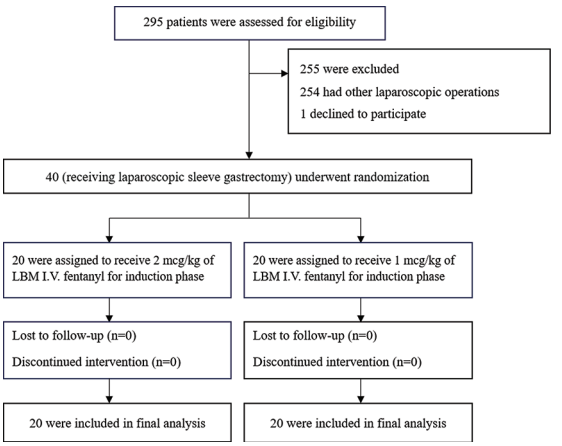

Figure 1. Consolidated Standards of Reporting Trials (CONSORT)[13] flow diagram showing the progress of study participants throughout the trial.

group. The final analysis included 20 patients in each group (Figure 1).

The mean age of all participants was 34.4 years (range 20 to 66, SD 9.8), and the mean BMI was 40.3 kg/m² (range 35 to 62.1, SD 7.1). The majority of the participants, or 36 patients (90%) were female and the main comorbidity was hypertension in 18 patients (45%), followed by diabetes, dyslipidemia, and obstructive sleep apnea (OSA), each affecting 13 patients (32.5%). Two participants had a previous history of cerebrovascular disease and four participants had hypothyroidism. Most baseline characteristics between the two groups showed no significant difference, as presented in Table 1. There were more OSA patients in the fentanyl 2 mcg/kg group with 10 patients than OSA patients in the fentanyl 1 mcg/kg group with three patients. Nine participants in the fentanyl 1 mcg/kg group had history of substance abuse, which all were cigarette smokers, whereas none in the fentanyl 2 mcg/kg group. Nevertheless, due to the small sample size, subgroup analyses for OSA and substance used were not performed.

According to primary outcome analysis, the result of Bootstrap for independent t-test, there was no statistically significant differences in pain VAS at PACU with mean difference of 13.11 S.E. 8.89, 95% CI –5.41 to 29.73, p=0.155. However, at 24 hours after the operation, VAS in the fentanyl 2 mcg/kg group was statistically significantly higher than VAS in the 1 mcg/kg group with mean difference of 17.82 S.E. 5.38, 95% CI 7.13 to 29.29, $p_{adjusted} < 0.0062$. Pain VAS in each group is presented in Table 2.

Regarding changing intraoperative parameters, a paired t-test identified no significant mean HR differences in the fentanyl 1 mcg/kg group with HR baseline to HR at 1 hour after intubation (3.9±16.8 bpm, 95% CI –3.97 to 11.77, p=0.313), which was

Table 2. Results of primary outcomes

Outcomes	Fentanyl 2 mcg/LBM (n=20)	Fentanyl 1 mcg/LBM (n=20)	p-value
Primary outcome: pain; median (IQR)			
VAS (0 to 100) at PACU	50 (21.5 to 71.5)	25 (2.1 to 59.4)	0.157[a]
VAS (0 to 100) at 24 hours	28 (19.87 to 50)	16.2 (0 to 26.6)	0.0059[a]*

IQR=interquartile range; VAS=visual analog scale; PACU=post anesthetic care unit; LBM=lean body mass
(a) Result of Mann-Whitney U test, * Statistically significant ($p_{adjusted}$ <0.0062)

Table 3. Results of secondary outcomes

Outcome	Fentanyl 2 mcg/kg (n=20)		p-value	Fentanyl 1 mcg/kg (n=20)		p-value
	Baseline	1 hour after intubation		Baseline	1 hour after intubation	
HR; mean±SD	89.8±14.8	78.4±11.1	0.003[a]*	91.4±16.0	87.5±13.9	0.313[a]
SBP; mean±SD	133±12.6	116.7±14.4	0.000[a]*	135±18.8	123±17.3	0.019[a]
DBP; mean±SD	75.2±10.4	71.3±9.1	0.139[a]	84.0±13.8	74.5±13.5	0.031[a]
	After intubation	At PACU		After intubation	At PACU	
BS; median (IQR)	114.5 (88 to 141)	134.5 (118 to 151)	0.009[b]	104 (90.5 to 117.5)	139 (112 to 166)	0.001[b]*

HR=heart rate; SBP=systolic blood pressure; DBP=diastolic blood pressure; BS=blood sugar; PACU=post anesthetic care unit; SD=standard deviation; IQR=interquartile range
(a) Results of paired t-test, (b) Results of Wilcoxon signed rank test, * Statistically significant after Holm threshold adjustment

contrary to the result of fentanyl 2 mcg/kg showing statistically significantly lower HR with mean differences of 11.6±14.9 bpm (95% CI 4.61 to 18.8, $p_{adjusted}$ <0.007). In both groups, SBP reduced from baseline at 1 hour after intubation with a mean difference of fentanyl 1 mcg/kg group at 11.5±20.0 mmHg (95% CI 2.12 to 20.9, p=0.019) versus mean difference of fentanyl 2 mcg/kg group at 16.3±14.2 mmHg (95% CI 9.588 to 22.91, $p_{adjusted}$ <0.005) but only the fentanyl 2 mcg/kg group indicates statistical significance after p-value adjustment by the Holm method. Nevertheless, DBP lowered at 1 hour after intubation in both compared groups with fentanyl 1 mcg/kg group: mean difference, DBP baseline-DBP at 1 hour, 9.5±18.5 mmHg (95% CI 0.8 to 18.2, p=0.031) versus fentanyl 2 mcg/kg group: mean difference of 3.9 mmHg (95% CI –1.5 to 9.3, p=0.139) without statistical significance after Holm-Bonferroni correction. A Wilcoxon signed-rank test revealed a statistically significantly increased blood sugar level post-operatively at PACU in fentanyl 1 mcg/kg groups with fentanyl 1 mcg/kg: z=–3.472 ($p_{adjusted}$ <0.0056) versus fentanyl 2 mcg/kg: z=–2.617 (p=0.009) with significant level of $p_{adjusted}$=0.0083) (Table 3).

In PACU, 10 patients in each group declined additional analgesia while the remaining patients requested comparable amounts of fentanyl, with a median of 50 mcg, IQR 25 to 75 in the fentanyl 1 mcg/kg group versus median 50 mcg IQR 19 to 81 in the fentanyl 2 mcg/kg group (p=0.796), using the Mann-Whitney U test.

In terms of the patient's request for additional opioid pain control at ward during the 24 hours post-operation, the number of patients who requested additional opioid medication postoperatively in both groups were the same at 13 patients (65%) in each group. The mean intravenous morphine consumption during the 24 hours postoperative period was 9.6±1.9 mg (95% CI 8.5 to 10.5) in the fentanyl 2 mcg/kg group, and 8.3±2.8 mg (95% CI 7 to 9.9) in the fentanyl 1 mcg/kg group with mean difference of 1.3, S.E. 0.92 (95% CI –0.74 to 3.1), with no statistically significant differences (p=0.180). Among the patients who declined additional morphine, seven patients (37%) in the fentanyl 2 mcg/kg group and ten patients (50%) in the fentanyl 1 mcg/kg group received two doses of intravenous parecoxib 40 mg every 12 hours. There were no significant differences between the groups (p=0.205) using the Fisher's exact test.

In the PACU, postoperative nausea and vomiting (PONV) occurred in three patients (15%) in the fentanyl 1 mcg/kg group and five patients (25%) in the fentanyl 2 mcg/kg group (p=0.347, Fisher's exact test). One patient in the fentanyl 2 mcg/kg group experienced chest tightness in the PACU, investigations were normal, and the patient fully recovered the following postoperative day. No other major complications, such as hemodynamic instability, respiratory depression, or re-intubation, were observed during the present study.

Discussion

The present study indicates that administering a minimal dosage of fentanyl of 1 mcg/kg of LBM as an intravenous bolus during the induction phase prior to intubation results in lower postoperative pain scores at 24 hours compared to the higher dose of 2 mcg/kg of LBM in patients with morbid obesity undergoing laparoscopic sleeve gastrectomy. Both fentanyl dosages effectively maintain intraoperative hemodynamic and physiological parameters, with comparable incidences of PONV during the perioperative period.

Fentanyl dosage in the induction phase before intubation has been debatable. In general anesthesia, 0.5 to 2 mcg/kg/dose intravenous for a single dose was considered an effective dosage[19]. Vaswani et al.[20] reported that intravenous fentanyl 0.5 mcg/kg administered as a loading dose over 10 minutes before induction for patients undergoing elective laparoscopic surgery demonstrated that the mean HR of 92.23±10.037 bpm at 60 minutes of the operation was slightly higher compared to HR in our study, but SBP of 126.27±15.328 millimeters of mercury (mmHg) and DBP of 77.43±11.181 mmHg, were similar to our results. Bakr et al.[21] in a 2024 study in morbidly obese patients undergoing sleeve gastrectomy with similar participant characteristics with age of 34.91±7.45 years old, operative time of 70.16±10.73 minutes, and BMI of 42.63±4.41 kg/m² compared to our study were given 1 mcg/kg fentanyl during induction. After intubation, continuous fentanyl infusion was maintained at a rate of 1 mcg/kg/hour. They reported a pain score by VAS at PACU of 4 out of 10 and at 12 hours of 2 out of 10, including a total dose of postoperative morphine consumption in 12 hours of 8.00±2.38 mg and a HR at 45 minutes of 90 bpm, which are consistent with the results of the fentanyl 1 mcg/kg group. A higher dose of fentanyl has been used by several studies. Teong et al.[9] in 2020 found significantly lower hemodynamic responses recorded every ten minutes after intubation in the group who were given 2 mcg/kg fentanyl two minutes before intubation and recommended the dosage to obtain the most stable hemodynamic status. Their results are similar to the present study results that hemodynamic status compared between fentanyl 2 mcg/kg and 1 mcg/kg demonstrated similar HR, SBP, and DBP. The present study results demonstrated statistically significant reductions in HR and SBP from baseline to one hour after skin incision in the fentanyl 2 mcg/kg group, indicating that a higher fentanyl dose can suppress hemodynamic responses during surgery[22]. Additionally, both groups showed an increase in blood glucose from baseline to the PACU. Perioperative changes in blood glucose may be influenced by factors, including surgical stress response, hypoxia, and underlying diabetes. A higher fentanyl dose may attenuate surgical stress and thereby limit hyperglycemia[23], which could explain why the increase in blood glucose in the 2 mcg/kg group was less pronounced than in the 1 mcg/kg group. However, these differences lacked clinical significance, as the effect size did not warrant changes in management or impact clinical outcomes.

Pain score results in the present study were different between two time-point measurements. At PACU, the pain scores were similar between the two compared groups which could be influenced by the effect of fentanyl use in the induction phase combined with intraoperative maintenance use of 25 mcg intravenous every 30 minutes. In contrast, the pain scores at postoperative 24 hour at ward showed significantly higher pain perception in the fentanyl 2 mcg/kg group. The authors hypothesize that a high dose of fentanyl may induce postoperative hyperalgesia. This phenomenon has been reported in studies[24,25]. Rupniewska-Ladyko et al.[25] reported that patients, who received large doses of fentanyl intraoperatively, of over 3 μg/kg body weight, had a significantly accelerated onset of acute postoperative pain compared with those receiving lower doses. The study by Mauermann et al.[26] reported that intraoperative fentanyl concentration of mcg per hour, in patients undergoing abdominal, obstetric, or ENT surgery did not correlate with peak pain scores in the PACU, however, it did correlate with peak pain scores within the first 24 hours. Additionally, the study showed that a 100 mcg/hour increase in intraoperative fentanyl was associated with an increase of one point on the numerical rating scale. These findings are consistent with the present study pain outcomes, in which pain scores in the PACU were comparable between groups, whereas the mean of actual fentanyl dose of 247.7 mcg per mean of operative time of 106.25 minutes in the 2 mcg/kg group exceeded 100 mcg/hour at 139.9 mcg/hour, resulting in higher pain scores at 24 hours postoperatively. Nevertheless, both fentanyl dosing groups in the present study effectively reduce postoperative pain. Although a statistically significant difference was observed, the effect size in pain scores was small and unlikely to change management.

PONV is the most frequent side effect following anesthesia with an average incidence of 20% to

30%[27]. The present study showed that the overall incidence of PONV in PACU was 20%, with 15% in the fentanyl 1 mcg/kg group versus 25% in the fentanyl 2 mcg/kg group. The higher dose of fentanyl tended to cause more PONV than the lower dose. This finding is consistent with the study of Mauermann et al. study[26], which reported that higher intraoperative fentanyl doses were associated with increased PONV, higher 24-hour pain scores, and a trend towards higher 24 hours morphine requirements.

The present study has strengths. The study design, a prospective single blinded, with the participants blinded, randomized controlled trial with no missing data, reduced potential bias. The pre-specified calculated sample size allowed for analysis and to be able to detect statistically significant findings in primary and secondary outcomes. There are drawbacks to the present study. A majority of participants in the study fell in a morbid obesity category and only four patients (10%) were super-morbid obesity, with a BMI of 50 or higher. Therefore, the results might not be able to apply to the other specific population. All the patients with substance used were also found in the fentanyl 1 mg/kg group, which could be a confounding factor for postoperative pain assessment and the amount of postoperative pain medications. However, the present study did not perform subgroup analysis due to the subgroup populations being too small. Additionally, few male patients, just 5% of the study population, were included in the study, which may place limitations on clinical application to male obesity patients.

Conclusion

An intravenous low dose of 1 mcg/kg fentanyl for the induction phase of anesthesia before intubation can provide effective and adequate postoperative pain control and the ability to maintain hemodynamic and physiological status in patients with morbid obesity undergoing laparoscopic gastrectomy.

What is already known about this topic?

Fentanyl has been widely used during the induction phase of anesthesia for bariatric surgery, which has been increasingly performed recently due to the growing morbid obesity population. However, an appropriate dosage of fentanyl for those patients is still debatable to obtain adequate postoperative pain control and to maintain intraoperative hemodynamics.

What does this study add?

The present study revealed that using a minimal dose of intravenous fentanyl of 1 mcg/kg of LBM before intubation during the induction phase of anesthesia in morbidly obese patients undergoing sleeve gastrectomy could reduce postoperative pain at 24 hours better than using a high dose of fentanyl of 2 mcg/kg of LBM did. Nonetheless, hemodynamic and physiological responses of both dosages were still comparable and effective. There was no difference in postoperative complications between the groups.

Authors' contributions

TP conceived, designed, and directed the study. NT was responsible for data collection. AP conducted the data analysis and interpretation. The manuscript was developed and written by TP.

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Conflicts of interest

The authors declare no conflict of interest.

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