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Comparative Study Between Desflurane and Sevoflurane Regarding Haemodynamics and Recovery Profiles in Obese Patients Undergoing Laparoscopic Sleeve Gastrectomy

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ABSTRACT

Background: Enhanced recovery after bariatric surgeries and resumption of complicated physiological functions are properties of ideal anaesthetic. The goal of the current study was to compare the effects of desflurane and sevoflurane on intra-operative haemodynamics and recovery profiles in obese individuals undergoing laparoscopic sleeve gastrectomy.

Settings and Design: Prospective randomized controlled trial.

Methods: After Local Ethical Committee approval, 50 obese patients, between ages 20 and 40, undergoing elective LSG were randomly assigned to receive desflurane (group D) or sevoflurane (group S). Entropy value was maintained between 40 and 60. Haemodynamic parameters including cardiac index (CI) were recorded. Minimum alveolar concentration that maintained target entropy (MAC_{EN}) values were calculated immediately after intubation and every 30 minutes until the end of procedure. After weaning from anaesthesia, time to fully awake entropy values and immediate recovery parameters were recorded. In post anaesthesia care unit (PACU), intermediate recovery was assessed using Modified Aldrete's Score (MAS) and Digit Symbol Substitution Test (DSST).The duration of PACU stay was documented.

Results: Intra-operative haemodynamic parameters were comparable between two groups. The mean MAC_{EN} values for D group were significantly higher than S group immediately after intubation; however, they were significantly less than S group during the whole intra-operative period. Post-operatively, time to reach fully awake entropy values and immediate recovery parameters were shorter in group D than in group S. Desflurane anaesthetized patients had higher MAS than sevoflurane patients upon arrival at PACU and after 5 minutes. DSST restored to baseline values more quickly after desflurane anaesthesia. In comparison to group S, group D's PACU stay was shorter.

Conclusions: Desflurane and sevoflurane both had similar haemodynamic parameters; however, the recovery profiles were significantly quicker after desflurane anaesthesia enabling fast-tracking and patients to be early discharged.

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Morbidly obese; laparoscopic sleeve gastrectomy; sevoflurane; desflurane; haemodynamics; recovery profiles

1. Introduction

Obesity is a rapidly growing health issue that has a deleterious impact on both length and quality of life worldwide [1]. LSG is a surgical procedure that is often used in metabolic surgeries. It is associated with pneumoperitoneum which may lead to intra-operative cardiovascular instability, increases airway pressure and lowers respiratory compliance [2].

Obese patients are susceptible to hypoxia, sleep apnea and airway problems during the initial stages of recovery after surgery. Faster emergence, extubation with a secured airway and preservation of respiratory function may be assumed to improve recovery and patient satisfaction. Moreover, costs could be reduced through less time spent in operating room and rapid turnover [3].

The optimum general anaesthetic for bariatric surgeries should offer rapid recovery and intra-operative haemodynamic stability. Desflurane and sevoflurane both have lower blood/gas partition coefficients (0.45 and 0.65 respectively), that also provide better anaesthesia management and quicker return to daily performance after surgery [4].

The objective of the current study was to compare obese patients who underwent LSG utilizing desflurane versus sevoflurane for maintenance of anaesthesia in terms of intra-operative haemodynamic parameters and post-operative impact concerning: immediate recovery (the time to reach fully awake entropy values, the time to eye opening, extubation of trachea, following simple commands and orientation to person and place); intermediate recovery using MAS and DSST.

2. Patients and Methods

After Local Ethical Committee of the Faculty of Medicine approval (IRB-NO: 00012098-FWA-NO:

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00018699), informed written permissions were taken from all patients. The present study was carried out in Alexandria Main University Hospital, on 50 obese patients, body mass index (BMI) ≥35 kg/m^2, of either sex, belonging to ASA II and III, and aged between 20 and 40 years who underwent elective LSG.

Patients were randomly assigned by simple randomization method into two equal groups (25 each) and administered either desflurane (group D) or sevoflurane (group S) for maintenance of anaesthesia using numbered opaque envelopes. The results of the two groups were compared.

Patients with history of allergic reaction to anaesthetic drugs, including volatile anaesthetics, known drug addiction within ninety days of surgery, significant cardiac, hepatic, renal, neurological, severe pulmonary disease and/or history of use of any investigational medications within 30 days before operation were excluded from the study.

Criteria for early disposal from the study were: any surgical complications such as haemorrhage or staple line leakage that may prevent assessment of the study variables or any anaesthetic complications such as hypercapnia, hypovolemia or hypothermia that may necessitate post-operative long tracheal intubation.

3. Anaesthesia technique

The pre-anaesthetic evaluation comprised a detailed review of the patient's medical and surgical history, as well as systemic examination related to obesity especially an airway examination to determine the probability of a difficult intubation were done. Pre-operative investigations were included.

The Visual Analogue Scale (VAS) and DSST were explained to the patients and initial values were retrieved. Prior to surgery, all patients were instructed to fast for 6 h for solid meals and 2 h for clear liquids. Enoxaparin 40 mg was administered subcutaneously 12 h before surgery.

In OR, all patients were attached to a multichannel monitoring (GE, Datex-Ohmeda, S/5 Instrumentation Corp., Helsinki, Finland), as non-invasive blood pressure (NIBP), pulse oximetry (SpO_2), ECG and neuromuscular monitoring. A spectral entropy was used to monitor the depth of anaesthesia. A gas analyzer (GE Avance CS2) was applied to measure end-tidal desflurane or sevoflurane (%) as well as end-tidal carbon dioxide ($ETCO_2$) in mm Hg. Electrical cardiometry (ICON, Osypka Medical, Berlin, Germany) was used for non-invasive cardiac output and cardiac index monitoring.

All patients had access to difficult airway equipment trolley during induction of anaesthesia. To facilitate mask ventilation and tracheal intubation, every patient was placed on a ramp built of blocks which was kept beneath their shoulders and heads keeping their external auditory meatus and sternal notch in the same horizontal plane. Preoxygenation was done for all patients for three minutes before induction of anaesthesia. It was carried out in both groups by (0.02 mg/kg) of intravenous (IV) midazolam, IV fentanyl (1 μg/kg) lean body weight (LBW), IV propofol (2 mg/kg) LBW, and rocuronium (1.2 mg/kg) ideal body weight (IBW).

Elastic stockings were applied to all patients to help in prevention of deep vein thrombosis. Following a crystalloid loading of Ringer's lactate solution 10 mL/kg, all patients were seated in a semi-recumbent position, and their arms rested on a support in a horizontal posture. A special seat provided excellent support for their buttocks, and their legs were placed in padded supports.

According to the group allocation, oxygen was combined with either sevoflurane or desflurane to maintain anaesthesia in the two groups. The initial concentration of sevoflurane and desflurane were 2% and 6%, respectively. The delivered concentration of the inhalational anaesthetic was adjusted to keep entropy values between 40 and 60.

Tidal volume and respiratory rate were adjusted during lung ventilation to maintain $ETCO_2$ between 30 and 40 mm Hg. At the beginning of surgery, the surgeon injected local anaesthetic (40 mL of 0.25% bupivacaine), 7–10 mL at each surgical port site. To minimize occurrence of post-operative nausea and vomiting (PONV), ondansetron 8 mg and dexamethasone 8 mg were given IV. Also, 1 gm paracetamol was administered IV for all patients.

After last skin stitch, anaesthesia was discontinued, atropine 0.02 mg/kg and neostigmine 0.05 mg/kg were given intravenously to counteract any remaining neuromuscular block. The patient was extubated when fulfilled the following criteria: spontaneous breathing 8 mL/kg as a minimum; ability to maintain 5-s head lift; a sufficient negative inspiratory force (≥40 cmH_2O), SpO_2 > 94%; stable blood pressure and heart rate; sustained hand grip, train of four (TOF) >90% and returned of baseline value of state entropy (91) and response entropy (100).

4. Measurement parameters

Demographic data as regards (age, gender, weight, height, BMI) were documented. Intra-operative haemodynamic parameters concerning HR, MAP and CI were recorded before and after induction of anaesthesia, 3 min after intubation, at maximal abdominal inflation with gas, 3 min after patient was seated in the reverse Trendelenburg position, every 30 min till the end of operation and 3 min after extubation.

Operative data regarding (duration of anaesthesia and duration of surgery) were noted. MAC of

entropy (MAC_{EN}) was applied to express values of end-tidal concentrations of anaesthetic drugs that maintained target entropy. The published MAC value for the age group of 20 to 40-year-old with 100% oxygen to maintain target entropy from 40 to 60, for desflurane equal 6.5% and sevoflurane equal 2.3%, was utilized to calculate the MAC_{EN} values [5,6]. These values were noted immediately after intubation and every 30 min till the end of the procedure. The time to reach fully awake entropy values regarding two inhalational agents were measured. Following the cessation of the volatile anaesthetics, the patient's immediate recovery was evaluated by the time to eye opening, extubation of trachea, following simple commands and orientation to person and place.

In post-anaesthesia care unit (PACU), intermediate recovery was evaluated using modified Aldrete's score upon admission to PACU, after 5 min and after 10 min. In addition, the time to complete DSST successfully was recorded. When patients fulfilled the criteria for discharge (modified Aldrete's score must be ≥8 and/or return to the pre-operative level, oxygen therapy was discontinued for a minimum of 5–10 min before discharge patients and oxygen saturation must be maintained ≥92% and/or returned to the pre-operative level, temperature must be within normal range, pain score must decrease from the level indicated upon admission to PACU or adequate control at rest), the duration of stay at PACU was recorded.

Post-operative complications such as intra-operative awareness, PONV and post-operative pain were evaluated on arrival at PACU, after 5 min and again after 10 min.

5. Statistical analysis

The statistical test used for age, weight, height and BMI was unpaired student's t-test, while the chi-square test was utilized to compare qualitative data including patient's sex. The haemodynamic variables, immediate and intermediate recovery parameters were analyzed using student's t-test. The time to reach fully awake entropy was compared using Mann–Whitney U-test. All information were loaded to the computer and evaluated using IBM SPSS software package edition 20. Number and percentage were applied to describe qualitative data (Armonk, NY: IBM Corp). The study variables were expressed in mean ± SD. $P \leq 0.05$ showed significance for each variable.

6. Results

The study enrolled 70 patients after screening them for eligibility. Eleven patients were early excluded as nine patients failed to meet the inclusion criteria and two patients declined to participate, also, nine patients were withdrawn from the study (five patients in group D and four patients in group S). A total of 50 participants (25 desflurane and 25 sevoflurane) persisted until the study's conclusion (Figure 1).

Demographic profiles and operative data were comparable between the two groups (Table 1).

During anaesthesia, intra-operative haemodynamic variables did not reveal any statistically significant changes (Figure 2).

Mean values of MAC_{EN} for D group patients were significantly higher than S group patients immediately after intubation ($P < 0.001$); however, they were significantly less than group S during the whole intra-operative period (P 0.008–0.001) (Figure 3).

After cessation of volatile anaesthesia, the time to reach fully awake entropy was shorter in group D than in group S with mean values (1.8 ± 0.63 min, 3.64 ± 0.86 min, respectively). Moreover, the immediate recovery parameters were significantly shorter in D group than S group ($P < 0.001$) (Table 2).

D group patients had higher modified Aldrete's scores than S group patients upon arrival at the PACU and after 5 min, however later on patients in the two groups were comparable (Table 2). Desflurane anaesthetized patients required substantially less time than sevoflurane patients to successfully complete the DSST when they arrived at PACU, with a mean value of (23.88 ± 3.99 min, 33.94 ± 3.28 min respectively) (Table 2).

There was a statistically significant disparity between the two groups as regards to the duration of PACU stay. It was significantly shorter in group D ($p < 0.001$, Table 2). No significant discrepancies were observed between the 2 groups regarding intra or post-operative complications.

7. Discussion

Anaesthesiologists faces numerous special obstacles while providing anaesthesia to obese patients undergoing bariatric surgery. The most dreaded consequence associated with obesity due to anatomical changes is airway collapse. Therefore, prompt and smooth recovery from anaesthesia is the crucial factor in preventing airway and pulmonary complications in the obese undergoing bariatric surgery [7]. The current study demonstrated faster recovery profiles after desflurane anaesthesia when compared to sevoflurane anaesthesia in obese patients who underwent LSG, thus, enabling fast-tracking and early discharge of these patients.

In the present study, both desflurane and sevoflurane produced analogous haemodynamic variables throughout the maintenance phase of anaesthesia. Our results agreed with studies conducted by Kaur

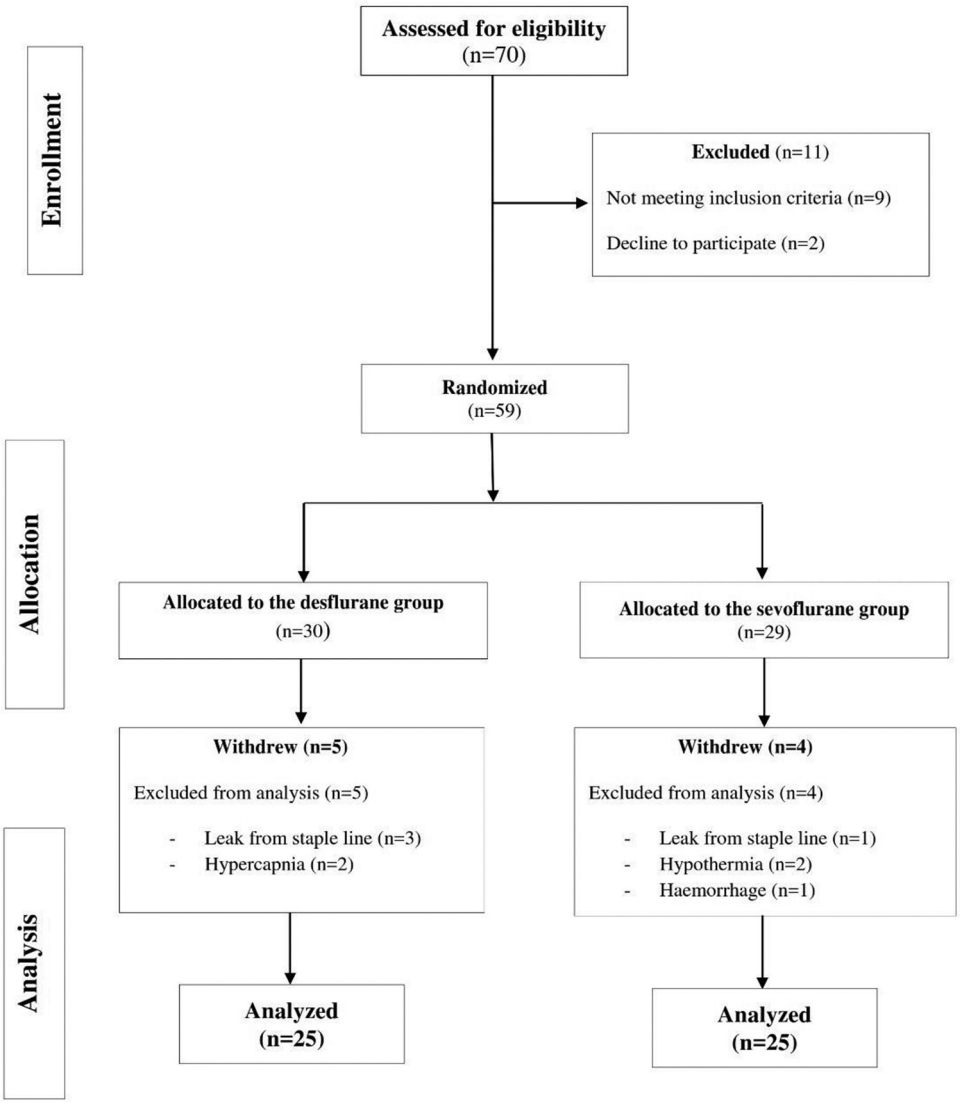

Figure 1. CONSORT flow diagram. Enrolment, randomization and allocation of the study subjects.

Table 1. Demographic and operative data.

Parameters	Group D (n = 25)	Group S (n = 25)	P value
Age (years)	31.60 ± 5.60	30.36 ± 6.14	= 0.459
Gender (M/F)	10/15	9/16	= 0.771
Weight (kg)	127.8 ± 27.90	124.4 ± 18.6	= 0.615
Height (cm)	166.3 ± 7.78	163.9 ± 7.59	= 0.267
BMI (kg/m^2)	46.02 ± 8.07	46.29 ± 6.16	= 0.892
Duration of anaesthesia (minutes)	116.2 ± 26.17	115.8 ± 23.53	= 0.959
Duration of surgery (minutes)	104.3 ± 23.87	103.5 ± 22.46	= 0.903

Values are expressed as mean standard deviation (**SD**) – t: **Student t-test** – χ^2: **Chi square test. p**: p value for comparing between the two studied groups. *: Statistically significant at p ≤ 0.05.
Abbreviation: BMI, body mass index.

et al. [4], Umbrain et al. [8], and Ozdogan et al. [9] . In opposition to our conclusions, Chudasama et al. [10] demonstrated that desflurane had superior haemodynamic stability than sevoflurane in terms of HR, BP and $ETCO_2$. This was explained by the fact that desflurane, similar to isoflurane, could maintain haemodynamic stability at concentrations sufficient to produce anaesthesia for surgery. Desflurane also had better control of hypertensive episodes than sevoflurane.

MAC_{EN} values with sevoflurane were tending to be higher than desflurane with time intra-operatively. This could be attributed to the fact that sevoflurane has higher blood/gas and tissue/blood partition coefficients than desflurane, which could increase total body uptake and cause delayed elimination, especially in patients with higher BMI [11]. Moreover, the greater analgesic properties of desflurane than sevoflurane [12].

This was comparable to a study conducted by Wang et al. [11] who stated in their research that employing end-tidal sevoflurane guided anaesthesia and maintaining sevoflurane concentration at 0.7–1.3 MAC

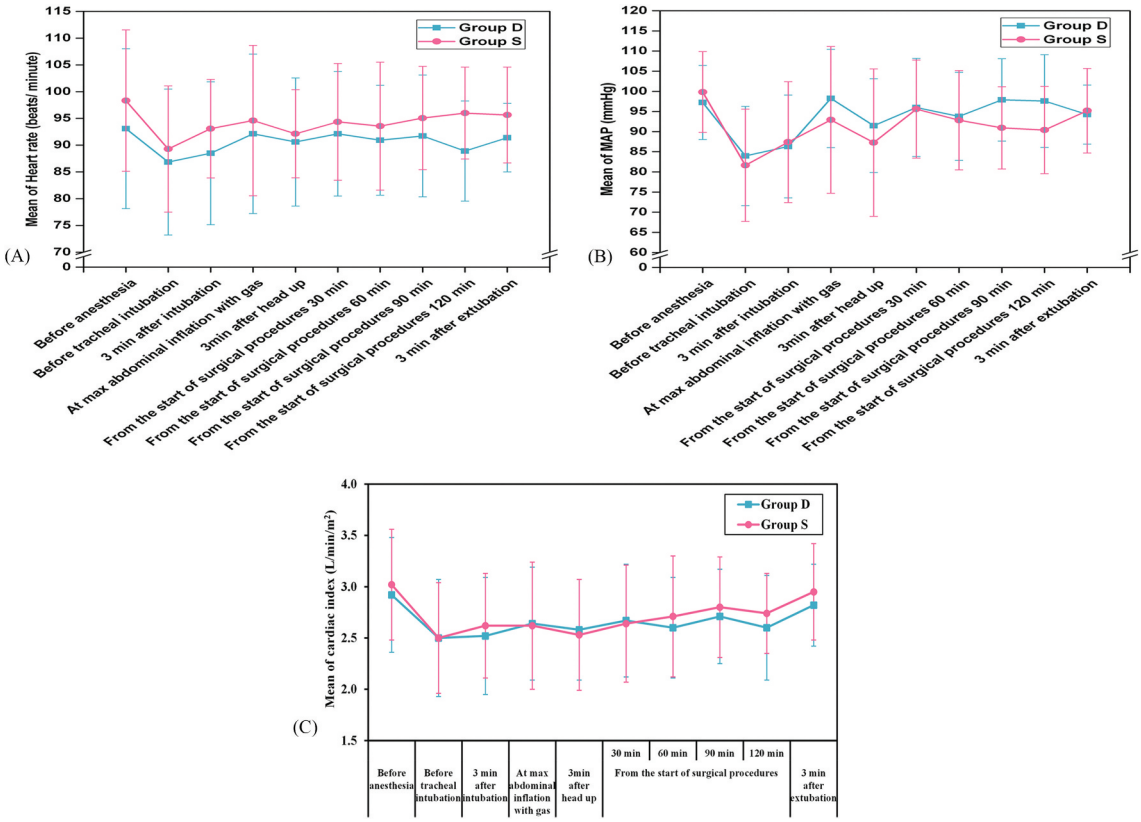

Figure 2. Comparison between the two studied groups according to haemodynamic parameters (a) heart rate, (b) mean arterial pressure and (c) cardiac index. Results are presented as mean ± SD.

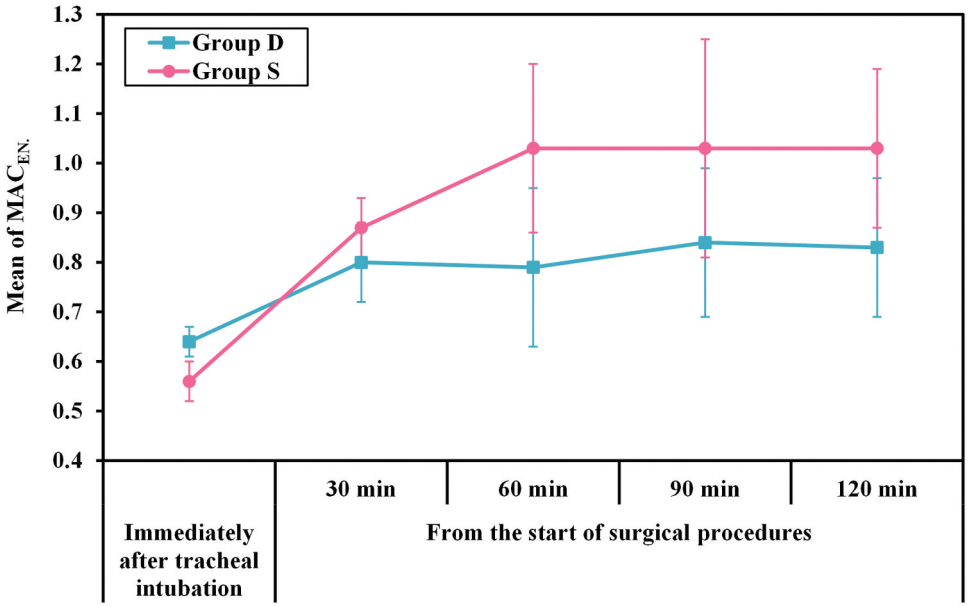

Figure 3. Comparison between the two studied groups according to $MAC_{EN.}$

may reduce occurrence of intra-operative awareness during endoscopic surgery.

Results of the current study demonstrated faster immediate recovery with desflurane compared to sevoflurane. Desflurane's blood/gas partition coefficient is 30% lower than sevoflurane's, while its oil/gas partition coefficient is 64% lower, both of which contribute to a faster wash-in and wash-out of desflurane than sevoflurane [13]. Additionally, it is believed that slower recovery following sevoflurane anaesthesia is caused by the prolonged effects of residual sevoflurane (hexafluoroisopropanol) and the fact that sevoflurane breaks down to compound A, which irreversibly binds to body proteins [14]. These observations were similar to studies conducted by La colla et al. [13] and Jindal et al. [15]. In a meta-analysis of non-obese

Table 2. Comparison between the two studied groups according to immediate, intermediate recovery, length of PACU stay.

Parameters	Group D	Group S	P value
Time to reach fully awake entropy (minutes)	1.80 ± 0.63	3.64 ± 0.86	<0.001
Time to eye opening (minutes)	4.83 ± 1.59	8.18 ± 2.11	<0.001
Time to extubation of trachea (minutes)	5.59 ± 1.71	8.89 ± 2.05	<0.001
Following simple commands (minutes)	6.21 ± 1.70	9.72 ± 2.05	<0.001
Orientation to person and place (minutes)	7.11 ± 1.63	10.96 ± 2.06	<0.001
Modified Aldrete Score (MAS):			
Upon arrival at PACU.	8.52 ± 0.59	7.96 ± 0.84	= 0.009
After 5 minutes.	9.12 ± 0.67	8.64 ± 0.86	= 0.032
After 10 minutes.	9.60 ± 0.50	9.32 ± 0.75	= 0.127
DSST (minutes)	23.88 ± 3.99	33.94 ± 3.28	<0.001
Length of PACU stay (minutes)	29.50 ± 3.45	37.65 ± 3.30	<0.001

SD: Standard deviation t: Student t-test U: Mann Whitney test p: p value for comparing between the two studied groups DSST: Digit Symbol Substitution Test. *: Statistically significant at p ≤ 0.05. PACU: Post Anaesthesia Care Unit.

patients, Macario et al. [16] found a similar pattern, noting that the expected advantages of desflurane administration were significantly more prominent in obese patients.

The results of present study were fully supported by Mahmoud et al. [17] who reported that desflurane group recovered much faster than sevoflurane group, therefore they get ready for discharge home and resume normal activity by the next day sooner. Moreover, White et al. [18] and Mckay et al. [19] explained the fact that patients who given desflurane were able to respond to command and swallow without drooling of saliva earlier than sevoflurane. This was probably attributable to the earlier return of protective airway reflexes in desflurane group. Unlikely, Sezen and Bombaci [20]. did not find any discrepancies between post-operative recovery variables and complications in either group.

Intermediate recovery was assessed using MAS and DSST. Desflurane group had higher modified Aldrete's scores than sevoflurane group upon arrival at the PACU and after 5 minutes, but after 10 minutes, there was no statistically reliable difference between the two groups. This was attributed to the fact that patients who utilized desflurane had higher oxygen saturation on room air than those who used sevoflurane. Additionally, due to its decreased solubility in blood and tissue, desflurane might promote a quicker recovery of protective reflexes. While sevoflurane is suggested to have a more profoundly depressing effect on these patients' respiratory systems [19,20].

These findings were consistent with study done by Strum et al. [21] who observed that desflurane anaesthetized patients upon admission to PACU had a greater oxygen saturation on room air (97.0% ± 2.4%) than patients who used sevoflurane (94.8% ± 4.4%). Similar results were demonstrated by Gangakhedkar and Monteiro [22]. who found that desflurane group attained a modified Aldrete's score of 9 substantially earlier than the sevoflurane group upon extubation.

These differences between two studied groups were also reported in a recent meta-analysis by Liu et al. [23]. Likely, Valasareddy et al. [24] reported that a median of the modified Aldrete's score 10 being attained after 5 minutes in the desflurane group and after 15 minutes in the sevoflurane group, their conclusions could explain the results of our study. Unlikely, De Baerdemaeker et al. [25] found in their study that no evident difference in recovery characteristics in PACU regarding morbidly obese patients anaesthetized with desflurane or sevoflurane in combination with a remifentanil scheduled for laparoscopic gastric banding.

Post-operative cognitive dysfunction (POCD) is the most popular form of cognitive impairment, this is mainly due to the cumulative effects of anaesthetic drugs. A quick recovery after general anaesthesia might lower the prevalence of POCD [26]. Desflurane anaesthetized patients required substantially less time than sevoflurane patients to complete the DSST successfully when they arrived at PACU. The same results were also confirmed in a study conducted by Ergönenç et al. [14] and Magni et al. [27].

Furthermore, Bilotta et al. [28] showed faster cognitive recovery following desflurane than sevoflurane in 65 patients who underwent craniotomy, as evaluated by Short Orientation-Memory-Concentration Test (SOMCT). Similarly, Dupont et al. [6] confirmed that recovery of cognitive functions was more rapid after desflurane than sevoflurane or isoflurane in pulmonary surgery.

On the other hand, Chen et al. [29] stated that both volatile anaesthetics had comparable post-operative effects on cognitive function on elderly patients undergoing total hip replacement procedures under general anaesthesia. However, studied patients were more than 65 years who had different pharmacokinetic profiles and different procedure related risk factors to the development of POCD. Contradictory results from studies carried out by Kuzminskaitė et al. [26], Deepak et al. [30], and Rörtgen et al. [31] revealed that the desflurane group performed much better on memory tests,

but there was no significant advantage in the individuals' overall cognitive scores.

Intra-operative awareness is a rare but serious intra-operative complication that can prompt patients into a panic situation even if they do not feel any pain at that time [32]. The use of entropy as an indicator for depth of anaesthesia in the present study resulted in no apparent difference between the two groups' awareness levels. Similar outcomes were described by Wu et al. [33] who revealed that employing M-Entropy guidance helped to reduce incidence of awareness, emerging agitation, decrease anaesthetic agent consumption, and facilitate the post-operative recovery from anaesthesia.

Regarding the length of the PACU stay, there was a substantially significant variance between the two groups. Desflurane patients met the criteria for discharge earlier than sevoflurane patients, hence they spent less time in the PACU. The present results coincided with the study done by La colla et al. [13], but did not agree with those observed by Werner et al. [34] who confirmed that patients received desflurane had a quicker emergence and fulfilled the discharge criteria from the recovery room sooner, however, the overall length of stay in PACU remained the same. The present study had several limitations. Patients were young adults hence the results can't be generalized. No blindness was possible which may lead to bias in the current results. Lastly, Patients had not been followed up for a longer period post-operatively to detect possible long-term consequences of the different anaesthetic techniques.

8. Conclusions

Desflurane and sevoflurane both had comparable haemodynamic profile; however, immediate and intermediate recovery were significantly quicker after desflurane anaesthesia, therefore enabling fast-tracking and patients to be early discharged.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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