Journal of Anesthesia & Clinical Research

Sayed et al., J Anesth Clin Res 2015, 6:5
DOI: 10.4172/2155-6148.1000530

Research Article Open Access

SEDLine Monitored Sedation and Recovery for Postoperative Ventilated Recipients of Living Donor Liver Transplantation: A Randomized Controlled Trial

Sayed E*, Refaat EK and Yassen K

Anaesthesia Departments of Liver Institute, Menoufiya University, Egypt

***Corresponding author: Sayed E,** Anaesthesia Departments of Liver Institute, Menoufiya University, Egypt, Tel: 01282271464; E-mail: emansayed825@gmail.com

Received date: April 22, 2015, **Accepted date:** May 29, 2015, **Published date:** May 30, 2015

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Abstract

Background: Monitoring of adequacy of sedation and careful drug selection can minimize the risks of over sedation and side effects. We evaluate the safety and efficiency of patient state index (PSI) versus Ramsay sedation scale (RSS) on postoperative sedation for living donor liver transplantation (LDLT) recipients.

Methods: Sixty postoperative mechanically ventilated LDLT recipients sedated with desflurane were randomly allocated to either R group (Ramsay group n=30), where sedation assessed using clinical assessment with the RSS, or S group (SEDline group n=30) where sedation assessed with PSI to target sedation depth (50-75). Memorization of five words, Trieger's dot (TT), digit symbol substitution tests (DSST) were recorded. Transesophageal Doppler (TED) parameters were recorded. Duration of mechanical ventilation, postoperative side effects and cost, were recorded.

Results: Mean values of time from cessation of desflurane to eye opening (min), hand squeezing (min), verbal command (min) and to extubation were statistically significant, shorter in S group than R group ($p<0.001$). Five words recall, TT and DSST were better in S group. Patients required norepinephrine were lower in S group than R group (10 (33.3%) vs. 23 (76.7%) P=0.001). Duration of ventilation was shorter in S group than R group (6.83 ± 2.00 vs. 8.26 ± 1.68 hour, P=0.004). Systemic vascular resistance (SVR) and mean blood pressure (MBP) were better preserved in S compared to R group at all measuring points (SVR, MBP after 2hrs sedation 915.73 ± 194.31 vs. 669.20 ± 119.82 dyn.sec.cm^{-5}, $P<0.001$ and 78.03 ± 6.242 vs. 65.13 ± 67.58 mmHg, $P<0.001$, respectively). Postoperative drowsiness, nausea and vomiting were lower in S compared to R group (P=0.000).

Conclusion: Sedation guided with PSI preserved better haemodynamics, enhanced recovery and rapid ventilation weaning at a lower cost compared to RSS monitoring. PSI-augmented sedation monitoring markedly reduced the total dose of sedative used to achieve the same level of clinical sedation without any measurable adverse effects.

Keywords: LDLT recipients; SEDline; Sedation; Recovery

Introduction

Intensive care management of recipients of liver transplantation mainly centers on rapid haemodynamic stabilization, correction of coagulopathy, early weaning from mechanical ventilation, proper fluid administration, kidney function preservation, graft rejection prevention, and infection prophylaxis [1]. A considerable number of liver transplant recipients will require mechanical ventilation during their immediate postoperative care for which they will receive one or more sedative medications. Providing adequate levels of sedation and avoiding the hazards of oversedation is a challenge for recipients with a newly transplanted liver and with immediate postoperative haemodynamic and metabolic changes as a consequence of the transplant procedure itself and the graft performance. Careful drug titration, frequent monitoring and evaluation of the depth of sedation and analgesia can help minimize unwanted sedative effects, reduce the duration of mechanical ventilation and improve related morbidity and mortality [2]. In an effort to control the level of sedation and anesthesia more accurately and potentially lower the number of adverse incidents, brain function monitors have been introduced, particularly in operating rooms [3]. The primary hurdle for brain function monitoring in a light to moderate sedation procedure has been electromyographical (EMG) interference from the frontalis muscle immediately beneath the array electrodes. This very high frequency and low voltage signal can cause an artificially high score on the patient state index (PSI). These monitors include filters to account for this signal. The filtering and algorithms of the SEDline appear effective in that type of setting to overcome this impediment [4]. This study aims to evaluate PSI monitoring and whether it provides additional value to traditional observational assessment in selecting an ideal level of patient sedation for postoperative mechanically ventilated ALDL recipients in the ICU setting using desflurane sedation.

Patient and Methods

Prospective hospital based double-blinded randomized controlled comparative study, written informed consent and Institutional Research and Ethics Committee approval from National Liver Institute, Menoufiya University, Egypt were obtained. The study was registered at the Cochrane research data base of South Africa

(PACTR201501001000118), (www.pactr.org). 60 patients underwent liver transplantation aged 18-60 years and model for end-stage liver disease (MELD) score 12-20 were enrolled. Patients with Severe haemodynamic instability at the end of the operation, need for re-operation, with neurologic conditions interfere with the ability to interact during the study and unwilling to participate in the study were excluded. Our patients were studied between January 2014 and February 2015. At the end of surgery, patients of the study were sedated with desflurane (Baxter, Germany) where the study observation period was started from arrival at the ICU to 2 h after tracheal extubation. The patients were randomly allocated using a simple random technique (closed envelopes) to either R group (Ramsay group n=30), where sedation was monitored using clinical assessment with the Ramsay scale [5] or S group (SEDline group n=30) where sedation was assessed with patients state index (PSI) monitoring by connecting SEDline electrodes to the patients (Masimo, Irvine, CA). Assessment of the sedation status according to either the Ramsay scale or the patient state index (PSI) was monitored at least hourly. All patients were ventilated with anesthesia ventilator (Cicero, kindly provided by Drager Medical, Germany).Ventilator offers synchronized intermittent mandatory ventilation, which seems ideal for intensive care patients. Fresh soda lime was used for each patient and PEEP was set to 5 cm H_2O. Desflurane was delivered by a modified TEC-6 vaporizer (Drager Medical). Fresh gas flow, regulated by oxygen and an air rotameters, was set to air/oxygen 6 liters/ min initially, reduced to 1 liter/min after 5 minutes. End-tidal desflurane and carbon dioxide concentrations were monitored by side-stream infrared spectroscopy. Ventilation was adjusted to maintain the $PaCO_2$ between 35 and 40 mm Hg and the PaO_2 between 100 and 150 mm Hg. Physicians in the ICU who were blinded to the study, had been titrated the dosage of desflurane to achieve target patient state index (PSI) 50-75 in S group or score of 4 in R group. Desflurane with end-tidal concentration of 3 vol% was used initially, and this was changed in steps of up to 0.5 vol%. If there was a need for additive analgesia, fentanyl was given and the requirements were recorded in both groups. The study was conducted over the course of a single physician shift (12 h). Physicians in the ICU had been using the Ramsay scale and PSI monitoring SedLine® brain function monitoring for the Root™ (Masimo, Irvine, CA, USA) prior to the onset of this study and were familiar with both tools. When patients were suitable for extubation desflurane was stopped, after this, patients was addressed by their name, asked to open their eyes and to squeeze the hand. The tracheal tubes were removed according to the clinical criteria. On the day before surgery, patients were asked to complete a Trieger's dot test (TT) (as a score of 40) and the digit symbol substitution test (DSST) (as a score of 10) to obtain baseline scores and the patient repeated these tests again 60 and 120 minutes after extubation. Operative data included dosage of used opioid e.g. fentanyl (μg), and blood transfusion requirements (units). Hemodynamic parameters; heart rate (HR), mean arterial blood pressure (MBP), systemic vascular resistance (SVR) and cardiac output (CAP) were monitored continuously from arrival at ICU to 2 h after tracheal extubation using transoesophageal doppler (TED), duration of sedation (hrs.), dosage of fentanyl ((μg), desflurane end tidal and consumption (ml), percentage of patients required norepinephrine support and time from cessation of sedation to extubation in minutes were recorded. Each patient's recovery profile was assessed using several parameters including times to early emergence (defined as verbal command responses (eye opening, hand squeezing), tracheal extubation, and orientation (defined as providing correct date of birth). Prevalence of postoperative nausea, vomiting, and agitation (all in %) were recorded. The mean costs of the medications per patient at the end of sedation were calculated. Any other side effects and laboratory data were recorded.

Sample size and power of the study

In the present study α was set to 0.05 (priori), and maximum β accepted=10% with a minimum power of the study of 90%. Thirty patients per group were calculated to be sufficient to detect a difference in the primary outcome of this randomized controlled trial. (Desflurane consumption (ml) between experimental group (SEDLine group) (54.4 ± 9.05 ml) and Ramsay group (73.8 ± 5.76 ml) (Internal pilot study, n=10 per group) [6], with a minimum effect size of (6 ml), one-tailed analysis will be adopted. Calculation of sample size was done using (IBM SPSS Sample power) software and was also confirmed using Lenth Java Applets for Power and Sample Size [7]. Correction of p value for multiple testing was set p to 0.01 to detect significance (Bonforroni correction of multiple comparisons). So, in the present study an alpha level was set to 1% with a significance level of 99%, and a beta error accepted up to 10% with a power of study of 90%.

Statistical procedure

Data was collected and entered to the computer using SPSS (Statistical Package for Social Science) program for statistical analysis. Data was entered as numerical or categorical, as appropriate. Two types of statistics were done: Descriptive statistics: Quantitative data was shown as mean, SD, and range. Qualitative data was expressed as frequency and percent at 95% confidence interval (95% CI). Analytical statistics: Chi- square test was used to measure association between qualitative variables. Student t-test and Mann Whitney test were done to compare means and SD of 2 sets of quantitative normally and not normally distributed data respectively (probability) value was considered to be of statistical significance if it is less than 0.05.

Results

Sixty patients were enrolled in this study, thirty patients in each group. Patient characteristics in SEDline (S group) versus Ramsay score (R group) were comparable regarding mean age, weight and body mass index. Male/ female ratio was 25/5 in S group and 23/7 in R group (Table 1). Mean model of end stage liver disease (MELD) values were (15.20 ± 1.90) in S group vs. (15.36 ± 1.35) in R group and there were no statistically significant differences between both groups, P value<0.01 as presented in Table 1. Intraoperatively, there was no statistically significant difference between S group and R groups regarding, mean duration of operation was (13.85 ± 1.86 vs. 13.78 ± 2.29 hrs. P value<0.01) respectively, mean amount of blood loss was (1816.66 ± 1075.45 vs. 1883.33 ± 801.32 ml P value<0.01) respectively, mean total consumption of Fentanyl was (1363.33 ± 403.84 vs. 1290.00 ± 325.20 μg P value<0.01) respectively, and mean packed RBCS transfusion requirements was (6.43 ± 4.93 vs. 5.93 ± 4.19 units P=0.01) respectively (Table 1). Data collected at intensive care unit showed that; there were no statistically significant differences between both groups in HR, (P value>0.05). Meanwhile, the mean arterial blood pressure (MBP) was significantly lower in R group than S group all over the time of sedation period (P value<0.001). However, all the MBP values were within the clinically acceptable range (Table 2). The mean systemic vascular resistance (SVR) values were significantly lower in R group than S group p<0.001 and this was associated with no

statistically significant difference between both groups as regards the cardiac output all over the time of study periods (Table 3). Mean values of time from cessation of desflurane to eye opening (min), hand squeezing (min), verbal command (min) and to extubation were statistically significant prolonged in R group than S group p<0.001 (Table 4). Regarding psychometric tests, mean values of TT as a score of 40 and DST as a score of 10 were comparable between both groups at T0, and T120, P value<0.05 but were statistically significant higher in S group compared to R group at T60, P value>0.001 (Table 5). End-tidal desflurane concentrations and total desflurane consumption were significantly lower in the S group than in the R group (53.13 ± 10.30 vs. 81.21 ± 9.40 and 1.93 ± 0.49 vs. 3.11 ± 0.22 p>0.001) respectively. The mean duration of mechanical ventilation was statistically significant lower in S group than in R group (6.83 ± 2.00 vs. 8.26 ± 1.68 hrs. p>0.001) respectively. There was statistically significant reduction in the total numbers of patients required noradrenaline support (n=10) in S group compared with (n=23) in R group p>0.001 (Table 5). The number of patients who presented with drowsiness were significantly lower in S group (n=0) (0.0%) than R group (n=5) (16.7%), P value>0.001 associated with lower number of patients who complained of nausea and vomiting (n=0) (0.0%) vs. (n=6) (20%) in S than R group respectively, P value>0.001. Regarding cost, mean cost /hr. (£) was significantly lower in S group than in R group (102.40 ± 17.67 vs. 148.55 ± 13.68 P>0.001) respectively (Table 6).

Variable	Group S (n=30)	Group R (n=30)	*P* value
Age	45.70 ± 6.94	44.60 ± 8.18	0.57 NS
Sex	25/5	23/7	0.75 NS
BMI (kg/m^2)	27.89 ± 2.73	27.63 ± 1.92	0.67 NS
MELD score	15.20 ± 1.90	15.36 ± 1.35	0.71 NS
CIT (min)	36.3 ± 8.8	35.3 ± 7.4	0.64 NS
WIT (min)	55.2 ± 9.1	54.4 ± 8.6	0.73 NS
GBWR	1 ± 0.2	1 ± 0.3	1 NS
Blood loss (ml)	1816.66 ± 1075.45	1883.33 ± 801.32	0.79 NS
RBCS(units) requirements	6.43 ± 4.93	5.93 ± 4.19	0.674 NS
Fentanyl (µg) requirements	1363.33 ± 403.84	1290.00 ± 325.20	0.44 NS
Duration of surgery (hrs.)	13.35 ± 1.86	13.78 ± 2.29	0.43 NS

Data were presented as mean ± SD, tested by student t-test, or as % tested by X^2 Chi square test, *P*-value<0.05 statistically significant. S group: SED line group; R group: Ramsay group; BMI: Body Mass Index; MELD: Model for End Stage Liver Disease; CIT: Cold Ischemia Time; WIT: Warm Ischemia Time; BBWR: Graft Body Weight Ratio; S.D.: Standard Deviation, NS: Not Significant.

Table 1: Patients characteristics.

Data	Group S (n=30)	Group R(n=30)	P value
HR (beat/min)			
T0	91.17 ± 14.012	90.63 ± 14.840	0.88 NS
T1	92.40 ± 10.394	95.33 ± 17.344	0.43 NS
T2	88.13 ± 8.69	91.53 ± 15.670	0.30 NS
T3	90.03 ± 9.489	88.63 ± 14.825	0.66 NS
T4	91.23 ± 7.232	86.70 ± 13.985	0.08 NS
MAP (mmHg)			
T0	64.86 ± 7.015	64.76 ± 7.055	0.95 NS
T1	77.36 ± 4.85	64.43 ± 7.39	<0.001*
T2	78.03 ± 6.242	65.13 ± 6.7.58	<0.001*
T3	93.20 ± 8.66	69.60 ± 6.54	<0.001*
T4	83.46 ± 8.015	84.46 ± 5.29	0.57 NS

Data were presented as mean ± SD, tested by student t-test, *P*-value<0.05 statistically significant. T0: Before start sedation; T1, T2: 60 min, 120 min after Sedation, T3: Before extubation; T4: After extubation; S.D.: Standard Deviation: *: Significant; NS: Not Significant; S: SED line group; R: Ramsay group.

Table 2: Heart rate (HR) (beats/min) and mean arterial blood pressure MAP (mmHg) differences between studied groups.

Data	Group S (n=30)	Group R (n=30)	P value
SVR (dyn.sec.cm^{-5})			
T0	627.20 ± 115.323	642.66 ± 132.97	0.72 NS
T1	918.93 ± 149.53	627.66 ± 114.58	<0.001*
T2	915.73 ± 194.31	669.20 ± 119.82	<0.001*
T3	1158.66 ± 198.88	781.26 ± 112.20	<0.001*
COP (Liters/min)			
T0	6.73 ± 0.76	6.68 ± 1.24	0.85 NS
T1	6.70 ± 0.76	6.65 ± 1.24	0.85 NS
T2	6.82 ± 0.80	6.85 ± 1.18	0.90 NS
T3	6.78 ± 1.12	6.94 ± 0.97	0.55 NS
Data were presented as mean ± SD, tested by student t-test, *P*-value<0.05 statistically significant. T0: SVR, COP before start sedation; T1, T2: SVR, COP 60 min, 120 min after Sedation; T3: SVR, COP before extubation; S.D.: Standard Deviation; *: Significant; NS: Not Significant; S group: SED line group; R group: Ramsay group			

Table 3: Systemic vascular resistance (SVR) (dyn.sec.cm^{-5}) and Cardiac output (COP) (Liters/min) differences between studied groups.

Data	Group S (n=30)	Group R (n=30)	*P* value
To eye opening (min)	4.07 ± 1.13	15.16 ± 4.47	0.000*
To hand squeezing (min)	4.98 ± 1.64	17.56 ± 4.90	0.000*
Till verbal command (min)	5.45 ± 1.66	24.60 ± 7.33	0.000*
To extubation (min)	10.93 ± 3.03	38.03 ± 18.21	0.000*
Data were presented as mean ± SD, tested by student t-test, P-value<0.05 statistically significant. S.D.: Standard Deviation: *: Significant; S group: SED line group; R group: Ramsay group			

Table 4: Time from cessation of desflurane to different parameters in the two study groups.

Test	Group S(n=30)	Group R(n=30)	*P* value
Trieger's dot			
T0	39.53 ± 0.51	39.52 ± 0.51	0.90 NS
T60	38.90 ± 0.71	36.10 ± 2.38	<0.001*
T120	39.07 ± 0.92	38.24 ± 1.99	0.01 NS
Digit symbol substitution			
T0	9.53 ± 0.63	9.52 ± 0.57	0.92 NS
T60	8.67 ± 0.71	7.57 ± 1.22	<0.001*
T120	8.43 ± 0.91	8.80 ± 0.80	0.117 NS
Data were presented as mean ± SD, tested by student t-test, *P*-value<0.05 statistically significant. T0: Baseline test done at the night of operation; T60: After 60 minute of extubation; T120: After 120 minute of extubation; S.D: Standard Deviation; *: Significant; NS: Not Significant; S group: SED line group; R group: Ramsay group			

Table 5: Trieger's dot test (TT) (as a score of 40) and digit symbol substitution test (DSST) (as a score of 10) in the two study groups.

Discussion

In our study, we decided to use the PSI, firstly to define objectively the target depth of sedation and secondly to measure the velocity of emergence. Reliable PSI monitoring (PSI 50-75) was available during most of sedation time in S group as the study was carried out at ICU where there was no procedure that might stimulate the patient and cause contraction of the frontalis muscle adjacent to EEG leads. Few studies are available regarding the use of PSI in the ICU setting. Schneider et al. [8], in a study of surgical intensive care patients receiving Propofol and Sufentanil, found the PSI to be highly predictive of the depth of sedation in mechanically ventilated patients. The PSI values showed significant differences between different levels of sedation as measured by the Ramsay sedation score (RSS). A prospective blinded study of mixed ICU patients by Ramsay et al. [9] also found a strong correlation between the PSI and the RSS. Similarly, another study by Sessler et al. [10] investigating the relationship between PSI and the sedation/agitation level measured by Richmond

agitation- sedation scale score found significant associations between PSI and Richmond Agitation-Sedation Scale to support the validity of the PSI as a tool to monitor the level of sedation in the ICU. Chen et al. [4] simultaneously evaluated the BIS and PSI in patients receiving general anesthesia and found a good correlation between the BIS and the PSI during general anesthesia. They concluded that the PSI was a suitable alternative to the BIS for assessing level of consciousness during general anesthesia Ramsay scale [5]. First published in 1974, the Ramsay sedation score has been used in many randomized controlled trials and is widely considered a reliable tool for assessment of sedation in critically ill patients with a satisfactory inter-rater variability [11]. In contrast to clinical assessment with the Ramsay scale, PSI constantly measures the level of sedation without applying arousal stimuli. This may allow the maintenance of a more constant level of sedation with continuous rather than intermittent monitoring. Desflurane was the primary sedative in the study used for the intensive care sedation of mechanically ventilated liver recipienst. With desflurane the mean arterial blood pressure and systemic vascular resistance are better preserved [12]. Normalizing systemic vascular resistance in cirrhotic patients with portal hypertension has several benefits. In these patients, expansion in central blood volume is not sustained and is rapidly redistributed to the hepatosplanchnic circulation. The elevated systemic vascular resistance returns hepatosplanchnic blood to the central compartment, improving perfusion into major organs and maintaining systemic blood pressure [13]. Our study found that Sedline monitored sedation (S group) resulted in patients receiving as much lower sedative as those whose sedation was guided by observation only (R group), where Desflurane consumption and end tidal were significantly lower in S group compared to R group. Perfect sedation for recipients of liver transplantation requires that the patient is neither over- nor undersedated. The most common adverse events in sedation are oversedation, leading to hypoventilation and oxygen desaturation, or inadequate sedation, resulting in an uncomfortable patient [14]. This study provide support that continuous assessment of sedation by Sedline monitor was associated with a decrease in the incidence of oversedation as was seen in S group. Decreasing sedative use in S group appeared safe and was not complicated by any increase in undersedation events as any self-device removal event, or ventilatory asynchrony [15]. All measured emergence times in this study (defined as verbal command responses (eye opening, hand squeezing) tracheal extubation, and orientation (defined as providing correct date of birth) were more prolonged in R group than in S group, this may be due to the relatively larger doses of sedative used in R group and secondly to the more precise control over sedation level in S group. In the ICU, rapid and reliably predictable emergence is itself a considerable advantage. It allows precise timing of extubation. Rapid emergence shortens the time during which the patient needs very close attention, thereby saving the time of staff. Apart from the quicker emergence, we found better cognitive function in S group. Patients in S group correctly stated their birth date earlier and were able to recall significantly more words at this time than patients in R group with a better (TT) test and (DSST) test. The patient who is maintained in a state of conscious sedation receives minimal sedative infusion and will quickly awaken when the sedation is removed [16]. The mean duration of mechanical ventilation was significantly lower in S group compared with R group. This can be explained by the reduced sedative dose used in S group. Kollef et al. [17] Concluded in their study that the strategies targeted at reducing the use of continuous IV sedation could shorten the duration of mechanical ventilation for some patients. Shortening the duration of ventilatory support has an important impact on patient outcome due to patient discomfort and the inherent risks associated with endotracheal intubation and ventilatory support [17]. The use of transoesophageal Doppler (TED) was able to demonstrate significant hemodynamic differences between both groups during the study period where MBP and SVR were significantly lower in R group compared to S group, meanwhile the need for noradrenaline support was significantly lower in S group and this again could be attributed to the minimal amount of sedative used to maintain an adequate level of sedation in S group. Shortened duration of sedation in S group was associated with lower incidence of postoperative drowsiness, nausea and vomiting. There is evidence in literature that increased sedation is associated with higher risk of postoperative complications [18]. Cost has become a matter of increasing concern, in our current study we reported higher costs in R group compared to S group and this could be due to the less hospital stay and sedative used [19]. This study provide support that the-sedline (PSI)-augmented sedation has an advantageous effects on recovery, ventilation, hemodynamics, hospital stay, inhalational requirements, cost and postoperative complications when compared with Ramsay monitored sedation. PSI-augmented sedation monitoring markedly reduced the total dose of sedative used to achieve the same level of clinical sedation without any measurable adverse effects.

Data	Group S (n=30)	Group R (n=30)	*P* value
Duration of MV (hrs.)	6.83 ± 2.00	8.26 ± 1.68	0.004*
Desflurane (ml) consumption	53.13 ± 10.30	81.21 ± 9.40	<0.001*
ET-Des (%)	1.93 ± 0.49	3.11 ± 0.22	<0.001*
Fentanyl (µg) consumption	129.00 ± 11.01	133.33 ± 12.33	0.156 NS
% of patients need Norepinephrine	10 (33.3%)	23 (76.7%)	<0.001*
Cost/hr. (£)	102.40±17.67	148.55 ±13.68	<0.001*
Data were presented as mean ± SD or %, tested by student t-test, Chi square test P-value<0.05 statistically significant, S.D.: Standard Deviation; *: Significant; S group: SED line group; R group: Ramsay group			

Table 6: Sedation data and Catecholamine (norepinephrine) support need differences between studied groups.

In brief Desflurane has many beneficial effects regarding postoperative sedation of recipients of liver transplantation, these effects included. Rapid emergence even after prolonged administration due to its pharmacokinetic properties, this will allow precise timing for extubation and decrease the period of mechanical ventilation [20,21]. Better cognitive functions after sedation with Desflurane [22,23].

Maintenance of systemic vascular resistance (SVR) which is very important in cirrhotic patients with portal hypertension, as the elevated SVR returns hepatosplanchnic blood to the central compartment, thus improving major organs perfusion and maintain ABP [24]. A frequently discussed adverse reaction to desflurane is sympathetic hyperactivity [24]. Interestingly, in our study there wasn't any episode of tachycardia or hypertension attributable to an increase in desflurane concentration probably because we never used more than 4 vol% Desflurane and guided with anesthesia depth monitors. The inclusion of baseline data is integral to the concept of recovery used in the post-operative recovery scale (PRS). It provides individual patient change data it is, however, a clear limitation of the ease with which the scale could be used in a busy clinical environment. The logistics required to perform the PRS in this way could interfere with the workflow of a busy anesthesiologist. The balance between brevity and richness of data is a delicate balance and to exclude baseline data would negate the ability for the scale to account for individual changes and the variety of performance of individuals. It is likely, therefore, that for many anesthesiologists, someone will have to be allocated to perform these assessments.

Conclusion

Sedation guided with PSI preserved better haemodynamics, enhanced recovery and rapid ventilation weaning at a lower cost compared to RSS monitoring. PSI-augmented sedation monitoring markedly reduced the total dose of sedative used to achieve the same level of clinical sedation without any measurable adverse effects.

Acknowledgement

The authors thank Massimo for the donation of equipment SEDLine for research purpose.

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