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Original Article

Narcotrend and bispectral index for monitoring intraoperative anesthetic depth in patients with severe burns

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Abstract: Patients with severe burns has a high risk of cardiovascular accidents in surgery and their surgery requires an accurate monitoring of anesthesia depth. The values of Narcotrend and bispectral index (BIS) for intraoperative monitoring of anestheis depth in severely burned patients have not been fully evaluated. Aiming to study their values, 108 cases of severely burned patients who needed early surgery (escharotomy + dermatoplasty, <7 days) were randomly divided into group A, B, and C, in which the intraoperative anesthesia depth was controlled by the Narcotrend level (D2 to E0), BIS level (40 to 65), and systolic blood pressure (90 to 140 mmHg), respectively. Main observation indexes included intraoperative maximum differential mean arterial pressure (Max-Min MAP), maximum differential heart rate (Max-Min HR), narcotic drug dosage, and postoperative recovery quality. Compared with group C, intraoperative Max-Min MAPs in group A and B were significantly decreased (P<0.0001); intraoperative Max-Min HRs were obviously declined (P<0.0001); Propofol and remifentanil dosages were markedly reduced; and postoperative spontaneous breathing recovery time was significantly shortened (P<0.0001). Moreover, the directional force recovery time in group B was significantly shorter than that in group C (P<0.05), whereas the extubation time in group A was much shorter than that in group C (P<0.05). No significant differences in all tested indexes were observed between group A and B. In summary, Narcotrend- and BIS-controlled anesthesia depth are important for the surgery in severely burned patient by maintaining stable hemodynamics, decreasing anesthetic drugs dosage, and improving postoperative recovery quality.

Keywords: Anesthesia depth monitor, bispectral index, burn, anesthesia, surgery

Introduction

Ideal anesthesia depth is crucial to maintain a successful on-going operation and improve the quality of postoperative rehabilitation [1, 2]. Awareness can occur when the anesthesia is too light [3, 4], causing severe trauma sequelae and mental health problems [5, 6]. Too deep anesthesia will increase the risk of cardiovascular accidents [7-9]. The Narcotrend device is a computer-based electroencephalogram (EEG) monitor designed to measure the depth of anesthesia by a research group at the Hannover Medical University in German [10]. The Narcotrend can continuously collect and analyze EEG by attaching electrodes to any position of the head and display the Narcotrend grading on a color touch screen. Bispectral index (BIS) is one of several technologies used to monitor depth of anesthesia. BIS monitors distinguish EEG signals representing different anesthesia depth through ordinary electrodes attached to specific position of the head and translate to simple quantitative indicators: 1, <40 represents burst suppression; 2, 40~65 for narcosis; 3, 65~85 for sedation; and 4, 85~100 for normal status. The value of Narcotrend and BIS in monitoring anesthesia depth has been controversy. While some studies have suggested that both Narcotrend and BIS can monitor and regulate anesthesia depth during surgery in non-burn patients [11], others have indicated that intraoperative awareness may occur in BIS recommended range [12]. Rundshagen *et al.* have reported no Narcotrend-associated advantages in maintaining the hemodynamic sta-

Table 1. Comparison of primary clinical data of the patients in Narcotrend, BIS, and control groups

	Group A (Narcotrend)	Group B (BIS)	Group C (control)	*P* value
Male	20 (55.56%)	21 (58.33%)	19 (52.78%)	0.894
Female	16 (44.44%)	15 (41.67%)	17 (47.22%)	0.894
Age (y)	45.08 ± 14.81	47.17 ± 14.79	46.92 ± 13.81	0.801
APACHE II score	2.61 ± 1.27	2.25 ± 0.87	2.03 ± 1.06	0.073
Smoking history	9 (25%)	10 (27.78%)	7 (19.44%)	0.701
Alcoholism history	5 (13.89%)	6 (16.67%)	4 (11.11%)	0.793
BMI	24.43 ± 2.43	24.54 ± 2.34	24.56 ± 2.61	0.971
Complications				
Hyperlipidemia	6 (16.67%)	3 (8.33%)	2 (5.56%)	0.268
Other complications	3 (8.33%)	1 (2.78%)	2 (5.56%)	0.589
Burn area (%)	34.44 ± 8.44	33.71 ± 9.51	35.51 ± 9.99	0.714

bility, reducing anesthetic drugs dosage, and improving postoperative recovery compared with traditional anesthesia depth monitoring by hemodynamics [13].

Severely burned patients often suffer from hemodynamic instability due to large amounts of fluid loss in early stage. After early anti-shock treatment, some patients require "escharotomy + dermatoplasty" in early stage. The surgery is a secondary attack to the patients, which may cause intraoperative cardiovascular accidents. Therefore, it is crucial to accurately monitor the anesthesia depth in patients with severe burns. This study aimed to evaluate the application value of Narcotrend and BIS in accurate monitoring of anesthesia depth in surgery of severely burned patients.

Material and methods

Study subjects

This study included a total of 108 cases of severely burned patients who was going to undergo "escharotomy + dermatoplasty" under general anesthesia in the First Affiliated Hospital of Xinxiang Medical University between August 2013 and August 2015. Inclusion criteria were as follows: (1) severe burns (total area of 31%~50%, III degree burn area of 11%~20%, or total area <31% but combined with shock, compound injury, associated injury, and/or severe inhalation injury); (2) "escharotomy + dermatoplasty" under general anesthesia during early stage (within 7 days after burn); (3) 18-65 years of age; (4) 20<BMI<30; and (5) no history of primary hypertension. Exclusion criteria were as follows: (1) preoperative heart, lung, liver, kidney and other viscera insufficiency; (2) elective surgery; (3) other serious complications, such as myocardial infarction, cerebral infarction, etc. All selected cases conformed to the inclusion criteria, and were randomly divided intro group A, B and C, in which the intraoperative anesthesia depth was controlled by the Narcotrend level, BIS level, and systolic blood pressure, respectively. This study has been approved by the Ethical Committee at the First Affiliated Hospital of Xinxiang Medical University. Informed consents have been signed by all patients and healthy volunteers.

Anesthesia method

Group A: Patients were given an intramuscular injection of atropine (0.5 mg) at 30 min before surgery. Routine hemodynamics, pulse oxygen saturation (SpO_2), and end-tidal CO_2 partial pressure were monitored. Anesthesia induction was performed by an intravenous injection of 0.03 mg/kg midazolam, 0.2-0.3 mg/kg etomidate, 0.2-0.3 μg/kg sufentanil, and 0.6-0.8 mg/kg rocuronium. Anesthesia was maintained by continuous pumping of 4 mg/kg/h propofol and 6 μg/kg/h remifentanil. Rocuronium (15 mg) was added every 40 min until 30 min before the end of the surgery. Propofol and remifentanil dosage was regulated based on the Narcotrend level to control the anesthesia depth. The Narcotrend level was maintained between D2 to E0. At 10 min before the end of the surgery, propofol pump rate was modulated to reduce the anesthesia depth to level C. Propolf and remifentanil were terminated after the end of the surgery.

Group B: The anesthesia was performed as described in group A except that the intraoperative anesthesia depth was adjusted to achieve a BIS of 40~65, and propofol pump rate was

Table 2. MAP comparison among Narcotrend, BIS, and control groups (mmHg)

	Group A (Narcotrend)	Group B (BIS)	Group C (control)	*P* value
Before anesthesia induction	87.11 ± 10.88	85.11 ± 11.45	85.09 ± 11.86	0.690
After anesthesia induction	70.12 ± 11.78	70.01 ± 12.38	67.45 ± 8.88	0.516
Trachea intubation	70.42 ± 12.38	71.95 ± 11.63	67.78 ± 11.63	0.326
Surgery start[c]	78.60 ± 11.01	82.14 ± 13.18	73.93 ± 18.55	0.062
2 min after surgery start[b,c]	79.46 ± 12.88	78.23 ± 11.63	67.82 ± 16.66	0.001
15 min after surgery start[b,c]	79.79 ± 10.92	81.06 ± 10.76	65.47 ± 18.08	<0.0001
30 min after surgery start	76.18 ± 10.71	77.99 ± 11.33	72.72 ± 19.98	0.304
End of surgery[b,c]	83.45 ± 10.76	78.47 ± 10.26	67.54 ± 16.51	<0.0001
Extubation[b,c]	80.45 ± 11.38	80.41 ± 12.96	70.20 ± 18.26	0.003
Intraoperative Max-Min MAP[b,c]	34.56 ± 9.03	35.83 ± 9.92	58.00 ± 11.41	<0.0001

[b]$P<0.05$, group A compared with group B; [c]$P<0.05$, group B compared with group C.

decreased for a BIS of 65~85 at 10 min before the end of the surgery. Group C: The anesthesia was performed as described in group A except that the intraoperative anesthesia depth was modulated by controlling the systolic pressure at 90-140 mmHg. The anesthesia depth was gradually reduced at 20 min before the end of surgery.

Data collection

Primary clinical data were collected including sex, age, smoking history, alcoholism history, APACHE II score, burn severity score, BMI, and complications, etc. Main observation indexes were recorded including intraoperative maximum differential mean arterial pressure (defined as intraoperative highest MAP-lowest MAP, Max-Min MAP), and maximum differential heart rate (intraoperative maximum HR-lowest HR, Max-Min HR), propofol dosage, remifentanil dosage, spontaneous breathing recovery time, directional force recovery time, and awake extubation time (from the end of the surgery to extubation time). Secondary observation indexes included intraoperative awareness, MAP and HR before and after anesthesia induction, at trachea intubation, operation start, 2, 15, and 30 min after operation start, as well as at the end of the surgery, and extubation.

Statistical analysis

All data were analyzed by SPSS17.0 software (SPSS Inc. Chicago, IL, USA). Normally distributed measurement data were presented as mean ± standard deviation and compared by t test or ANOVA. Ranked data were presented as percentage and compared by chi-square test. Bilateral $P<0.05$ was considered statistically significant.

Results

Primary clinical data

No significant differences in gender, age, APACHE II score, smoking history, alcoholism history, BMI, hyperlipidemia, other complications (1 case of gallstones, 2 case of hyperplasia of prostate, 1 case of rheumatoid arthritis, and 2 cases of diabetes), and total burn area were observed among the three groups (**Table 1**, $P>0.05$).

Comparison of MAP at different periods

No obvious differences in MAP was observed before and after anesthesia induction, at trachea intubation, and 30 min after surgery start (**Table 2**, $P>0.05$). Pairwise comparison revealed that the MAP in group B was significantly higher than that in group C at the beginning of the surgery (82.14 ± 13.18 vs. 73.93 ± 18.55 mmHg, $P<0.05$). Compared with group C, the MAPs in groups A and B were markedly higher at 2 and 15 min after surgery start, the end of surgery, and extubation (**Table 2**, $P<0.05$). The Max-Min Maps in both groups were obviously decreased (**Table 2**, 34.56 ± 9.03 and 35.83 ± 9.92 vs. 58.00 ± 11.41 mmHg, $P<0.0001$). No significant difference in MAP between group A and B was observed at any time point ($P>0.05$).

Comparison of HR at different periods

Compared with group C, mean HRs in groups A and B were obviously lower at 15 min after sur-

Table 3. Comparison of HR in Narcotrend, BIS, and control groups (beats/min)

	Narcotrend	BIS	Control	*P* value
Before anesthesia induction	103.33 ± 29.70	102.55 ± 27.17	113.56 ± 28.38	0.192
After anesthesia induction	106.22 ± 27.75	101.75 ± 24.42	108.37 ± 33.72	0.614
Trachea intubation	118.48 ± 27.62	108.31 ± 26.69	111.10 ± 31.70	0.304
Surgery start[c]	100.63 ± 24.92	108.20 ± 28.01	110.70 ± 35.53	0.332
2 min after surgery start	101.74 ± 25.53	102.44 ± 26.34	101.39 ± 31.60	0.987
15 min after surgery start[b,c]	102.56 ± 25.35	100.40 ± 23.29	116.15 ± 31.13	0.029
30 min after surgery start	108.89 ± 27.17	110.10 ± 25.43	100.12 ± 42.00	0.268
End of surgery	102.30 ± 25.20	110.47 ± 28.02	98.43 ± 30.27	0.180
Extubation	110.72 ± 28.08	102.16 ± 25.54	114.01 ± 26.08	0.154
Intraoperative Max-Min MAP[b,c]	43.59 ± 11.11	41.32 ± 11.77	64.59 ± 16.22	<0.0001

[b]P<0.05, group A compared with group B; [c]P<0.05, group B compared with group C.

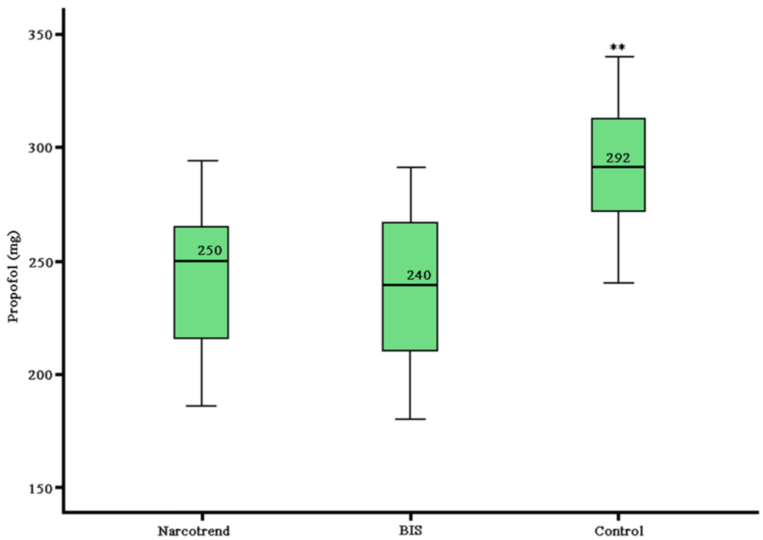

Figure 1. Comparison of propofol dosage in Narcotrend, BIS, and control groups. **P<0.0001, compared with Narcotrend or BIS group.

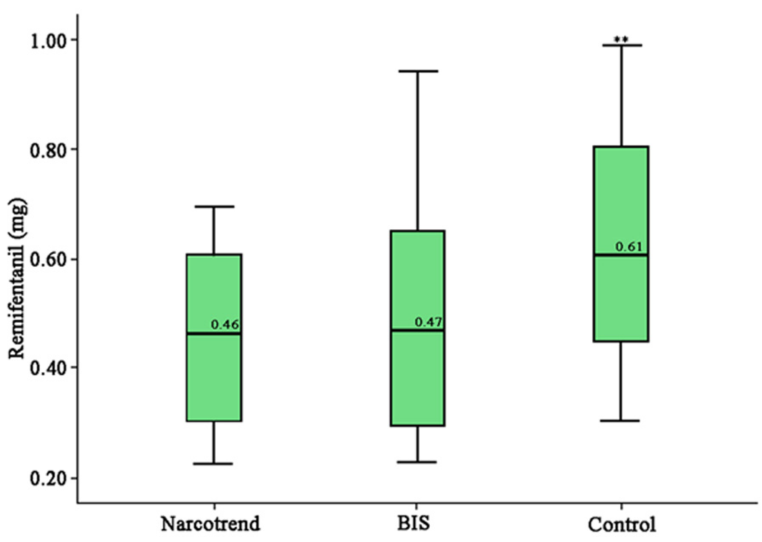

Figure 2. Comparison of remifentanil dosage in Narcotrend, BIS, and control groups. **P<0.0001, compared with Narcotrend or BIS group.

gery start (**Table 3**, 102.56 ± 25.35 and 100.40 ± 23.29 *vs.* 116.15 ± 31.13 beats/min, P=0.029). Intraoperative Max-Min HRs in groups A and B were also significantly lower (**Table 3**, 43.59 ± 11.11 and 41.32 ± 11.77 *vs.* 64.59 ± 16.22 beats/min, P<0.0001). No significant difference in HR was detected among the three groups at the remaining time points (**Table 3**, P>0.05).

Comparison of propofol and remifentanil dosage

Intraoperative propofol and remifentanil dosage in groups A and B were obviously lower compared with group C (P<0.0001, **Figures 1** and **2**), whereas there was no significant difference between groups A and B (P>0.05).

Comparison of postanesthesia recovery quality

The spontaneous breathing recovery time in groups A and B were markedly shorter than that in group C (**Table 4**, 7.58

Table 4. Comparison of recovery quality in Narcotrend, BIS, and control groups (min)

	Group A	Group B	Group C	*P* value
Spontaneous breathing recovery time[b,c]	7.58 ± 1.31	7.75 ± 1.59	9.94 ± 3.14	<0.0001
Directional force recovery time[c]	15.82 ± 2.66	14.95 ± 3.21	16.82 ± 3.32	0.040
Extubation time[b]	16.18 ± 2.41	17.01 ± 2.93	17.58 ± 3.05	0.110
Intraoperative awareness	0 (0%)	0 (0%)	0 (0%)	

[b]P<0.05, group A compared with group B; [c]P<0.05, group B compared with group C.

± 1.31 and 7.75 ± 1.59 *vs.* 9.94 ± 3.14 min, P<0.0001). While the directional force recovery time in group B was obviously shorter than that in group C (**Table 4**, 14.95 ± 3.21 *vs.* 16.82 ± 3.32 min, P<0.05), the extubation time in group A was significantly shorter than that in group C (16.18 ± 2.41 vs. 17.58 ± 3.05 min, P<0.05). No significant differences in all tested indexes were observed between groups A and B. Intraoperative awareness occurred in none of the cases in our study.

Discussion

The intraoperative anesthesia in severely burned patients has received wide attention due to the loss of a large amount of body fluid and even shock [14]. After recovery, they often require immediate "escharotomy + dermatoplasty", which is a second strike to homeostasis. Moreover, debridement and escharotomy may cause a lot of blood loss, while the unrepaired skin barrier may also lead to a substantial increase of water evaporation. All these factors can increase the risks of intraoperative cardiovascular accidents in burned patients. Anesthesia depth is one of the important factors affecting the hemodynamics stability of patients [15]. Therefore, accurate control of anesthesia depth is crucial for a successful operation in patients with severe burns. In the past, Anesthesiologists usually controlled the anesthesia depth by adjusting the propofol and remifentanil dosage based on hemodynamics. However, the inaccurately controlled anesthesia depth by this method may be associated with severe conditions. Too light anesthesia may lead to awareness [16, 17], causing severe trauma sequela and mental health problems, whereas too deep anesthesia may generate hemodynamic changes and increase the risk of cardiovascular accidents [9].

Recently, the technologies of Narcotrend and BIS have been developed by experts to address the issue of anesthesia depth monitoring [18]. Studies have shown that Narcotrend and BIS can accurately monitor the anesthesia depth in non-burn patients by maintaining intraoperative hemodynamic stability, reducing anesthesia dosage, and shortening postoperative awake time [11]. Schultz *et al.* have suggested that Narcotrend and BIS are especially useful for general surgery and plastic surgery anesthesia by quantitatively assessing the anesthesia depth [19]. For example, according to the Narcotrend scale, the anesthesia depth is divided into six stages and 15 grades: level A, B0-2, C0-2, D0-2, E0-2, and F0-1, where stage A means waking status, B for light sedation, C for normal sedation, D for normal anesthesia status, E for deep anesthesia status, and F (level 0, 1) for excessive anesthesia (burst suppression) and gradual disappearance of brain electrical activity. Anesthesiologist can accurately know the stage of patients and adjust the anesthesia drugs based on the Narcotrend levels of anesthesia depth, which prevents the occurrence of too deep or light anesthesia.

In this study, severely burned patients were randomly divided into Narcotrend, BIS, and control group. The anesthesia drugs dosage, postoperative directional force recovery time, spontaneous breathing recovery time, extubation time, MAP, HR, intraoperative Max-Min MAP and HR were compared. It was found that the Narcotrend and BIS was superior in reducing the dosage of anesthetic drugs, improving postoperative recovery quality, and maintaining the hemodynamic stability compared with the control group. Nevertheless, the safety of the two monitoring systems in patients with severe burns remains to be further evaluated despite the findings in our study. For instance, two studies have previously reported that intraoperative awareness occurred in the recommended range of BIS [12, 20]. No incidence of intraoperative awareness was observed in any of the cases in our study probably due to the limited size and low incidence of intraoperative awareness. The impact of Narcotrend and BIS monitoring systems on the incidence of intraoperative awareness shall be further investigated in large-scale clinical studies.

In summary, Narcotrend- and BIS-controlled anesthesia depth are important for the surgery in severely burned patient by maintaining stable hemodynamics, decreasing anesthetic drugs dosage, and improving postoperative recovery quality.

Disclosure of conflict of interest

None.

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