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 have 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 narco- sis; 3, 65~85 for sedation; and 4, 85~100 for normal status. The value of Narcotrend and BIS in monitoring anesthesia depth has been controversial. 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-
Narcotrend and BIS in burn surgery

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) pre-operative 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 into 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 (SpO₂), and end-tidal CO₂ 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. Propofol 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
Narcotrend and BIS in burn surgery

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

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

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)

<table>
<thead>
<tr>
<th></th>
<th>Narcotrend</th>
<th>BIS</th>
<th>Control</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before anesthesia induction</td>
<td>103.33 ± 29.70</td>
<td>102.55 ± 27.17</td>
<td>113.56 ± 28.38</td>
<td>0.192</td>
</tr>
<tr>
<td>After anesthesia induction</td>
<td>106.22 ± 27.75</td>
<td>101.75 ± 24.42</td>
<td>108.37 ± 33.72</td>
<td>0.614</td>
</tr>
<tr>
<td>Trachea intubation</td>
<td>118.48 ± 27.62</td>
<td>108.31 ± 26.69</td>
<td>111.10 ± 31.70</td>
<td>0.304</td>
</tr>
<tr>
<td>Surgery startc</td>
<td>100.63 ± 24.92</td>
<td>108.20 ± 28.01</td>
<td>110.70 ± 35.53</td>
<td>0.332</td>
</tr>
<tr>
<td>2 min after surgery start</td>
<td>101.74 ± 25.53</td>
<td>102.44 ± 26.34</td>
<td>101.39 ± 31.60</td>
<td>0.987</td>
</tr>
<tr>
<td>15 min after surgery startbc</td>
<td>102.56 ± 25.35</td>
<td>100.40 ± 23.29</td>
<td>116.15 ± 31.13</td>
<td>0.029</td>
</tr>
<tr>
<td>30 min after surgery start</td>
<td>102.89 ± 27.17</td>
<td>110.10 ± 25.43</td>
<td>100.12 ± 42.00</td>
<td>0.268</td>
</tr>
<tr>
<td>End of surgery</td>
<td>102.30 ± 25.20</td>
<td>110.47 ± 28.02</td>
<td>98.43 ± 30.27</td>
<td>0.180</td>
</tr>
<tr>
<td>Extubation</td>
<td>110.72 ± 28.08</td>
<td>102.16 ± 25.54</td>
<td>114.01 ± 26.08</td>
<td>0.154</td>
</tr>
<tr>
<td>Intraoperative Max-Min MAPbc</td>
<td>43.59 ± 11.11</td>
<td>41.32 ± 11.77</td>
<td>64.59 ± 16.22</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

P<0.05, group A compared with group B; 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.

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 was markedly shorter than that in group C (Table 4, 7.58
± 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 + dermato-
plasty”, which is a second strike to homeosta-
sis. Moreover, debridement and escharotomy
may cause a lot of blood loss, while the unre-
paired skin barrier may also lead to a substan-
tial increase of water evaporation. All these fac-
tors can increase the risks of intraoperative
cardiovascular accidents in burned patients.
Anesthesia depth is one of the important fac-
tors 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 anesthe-
sia 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 intraopera-
tive hemodynamic stability, reducing anesthe-
sia 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 anes-
thesia by quantitatively assessing the anesthe-
sia 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 sup-
pression) and gradual disappearance of brain
electrical activity. Anesthesiologist can accu-
ately know the stage of patients and adjust the
anesthesia drugs based on the Narcotrend lev-
els 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, extuba-
tion time, MAP, HR, intraoperative Max-Min
MAP and HR were compared. It was found that
the Narcotrend and BIS was superior in reduc-
ing 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 stud-
ies have previously reported that intraoperative
awareness occurred in the recommended
range of BIS [12, 20]. No incidence of intraop-
erative awareness was observed in any of the
cases in our study probably due to the limited

| 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 | 7.58 ± 1.31     | 7.75 ± 1.59     | 9.94 ± 3.14     | <0.00001       |
| Directional force recovery time  | 15.82 ± 2.66    | 14.95 ± 3.21    | 16.82 ± 3.32    | 0.040          |
| Extubation time                 | 16.18 ± 2.41    | 17.01 ± 2.93    | 17.58 ± 3.05    | 0.110          |
| Intraoperative awareness        | 0 (0%)          | 0 (0%)          | 0 (0%)          |                |

*P<0.05, group A compared with group B; *P<0.05, group B compared with group C.*
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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References

Narcotrend and BIS in burn surgery


