

# Fast-track method in cardiac surgery: evaluation of risks and benefits of continuous administration technique

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## ABSTRACT

**Introduction:** Fast-track is a method proposed to decrease medical costs through the reduction of patients' length of stay in the hospital. This study was carried out to assess the risks and benefits of conducting the fast-track method in cardiac anaesthesia and to evaluate the role of continuous infusion of short-acting anaesthetics in a successful fast-track protocol.

**Methods:** 100 cases were divided into two groups. In the fast-track group, fentanyl and propofol infusions were started at induction time and atracurium one hour later. No bolus drug was administered during the operation. Fentanyl infusion was continued up to 12 hours after surgery. The conventional extubation group received fentanyl and pancuronium as bolus doses. The two groups were evaluated for time of alertness and extubation in the intensive care unit, total analgesic dosage administered during the 24 hours after operation, arterial blood gas and peripheral saturation of oxygen before and after extubation.

**Results:** Time period between intensive care unit admission and alertness was significantly different in the fast-track (1.3 hours) and control (3.3 hours) groups (p-value is less than 0.001) as well as total time of intubation in the intensive care unit (4.3 hours vs. 7 hours) (p-value is less than 0.001). No patient of the fast-track group experienced low pressure of arterial oxygen, low saturation of arterial oxygen, high pressure of arterial carbon dioxide or need for reintubation in the first 24 hours after surgery.

**Conclusion:** Continuous infusion of drugs in the fast-track method facilitates earlier extubation. It maintains continuous sedation and analgesia without increasing respiratory complications.

**Keywords:** coronary artery bypass, fast-track, general anaesthesia, intensive care unit, length of stay, postoperative complications

Singapore Med J 2008;49(6):470-475

## INTRODUCTION

At the beginning, management of cardiac operation included high dose opioid anaesthesia with postoperative overnight sedation. The intensive care unit (ICU) is an important component of the total cost of management after coronary artery bypass grafting (CABG) and discharge from ICU is impossible when the patient is intubated. Thus, early extubation evolved as the main part of the fast-track method in cardiac anaesthesia.

There are various definitions for early extubation.<sup>(1)</sup> The window of opportunity for early extubation has been defined by Higgins as between three and ten hours after ICU admission.<sup>(2)</sup> By three hours, the patient is usually rewarmed and past the nadir ventricular dysfunction, and after ten hours, the incidence of complications increases. But the widely accepted definition is extubating patient within eight hours after surgery.<sup>(3)</sup>

Fast-track (FT) is a term intended to describe a multidisciplinary clinical pathway or process/procedure for patient care that is broad in concept and not limited to expeditious tracheal extubation. The scope of FT is aimed at cost containment strategies through decreasing the length of stay in ICU and hospital without increasing complications.<sup>(4)</sup>

Approach of the first FT protocols was focused on low dose and/or short acting opioids. Now various methods of drug administration are proposed to accomplish FT goals.<sup>(5,6)</sup> There is no standard protocol for anaesthetics, usage in FT cardiac anaesthesia, and the best method of drug administration is a controversial issue which merits further investigation.<sup>(6)</sup> This study was conducted to compare the risks and benefits of a FT method compared to conventional anaesthesia in perioperative care of isolated CABG candidates. Besides, we evaluated the role of continuous administration of all intravenous drugs in decreasing intubation time.

## METHODS

100 consecutive patients undergoing elective isolated CABG participated in the study with informed consent. Patients of six surgeons and one anaesthesiologist were recruited for this study. Exclusion criteria included the following:

- Previous CABG or heart valve surgery.

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**Table I. Comparison of patients' characteristics in fast-track and conventional extubation groups.**

	FT group	CE group	p-value
No. of patients* (M/F)	50 (40/10)	50 (38/12)	NS
Age* years	56.1 (8.9)	58.5 (9.2)	NS
No. of grafts*	3.6 (0.97)	3.8 (0.9)	NS
Cross clamp* (minutes)	39 (11.6)	44 (11.5)	NS
Perfusion* (minutes)	65 (18.4)	73 (3.2)	NS
Waking up* (hours)	1.3 (1.1)	3.3 (2)	< 0.001
Extubation* (hours)	4.3 (2.7)	7 (3.2)	< 0.001
ICU discharge* (hours)	32.9 (16.7)	32.1 (16.7)	NS
Hospital discharge* (days)	7.3 (3.2)	7.6 (3.9)	NS
No. reintubation	0	1	NS
Nausea/vomiting (%)	6	25	0.03
No. of patients with low SpO <sub>2</sub> (< 95%) episodes	30	20	NS
No. shivering	2	0	NS
Total analgesic (mg)	0.97 (1.7)	1.9 (3.3)	NS
Total sedative (mg)	0	2.9 (5.2)	< 0.001

\* Data is expressed as mean ( $\pm$  standard deviation)

FT: fast track; CE: conventional extubation; ICU: intensive care unit; NS: not significant

- A left ventricular ejection fraction of less than 40%.
- Documented myocardial infarction within the previous six weeks.
- Overt congestive heart failure.
- Severe chronic obstructive pulmonary disease and/or history of steroid or bronchodilator consumption.
- Renal insufficiency (creatinine > 2 mg/dL).
- Severe liver disease (alanine aminotransferase and aspartate aminotransferase >75 IU/dL).
- A history of seizure or stroke.

Patients who had a cardiopulmonary bypass (CPB) time > 20 min were also excluded. Any patient who did not meet the criteria was substituted with the next consecutive one.

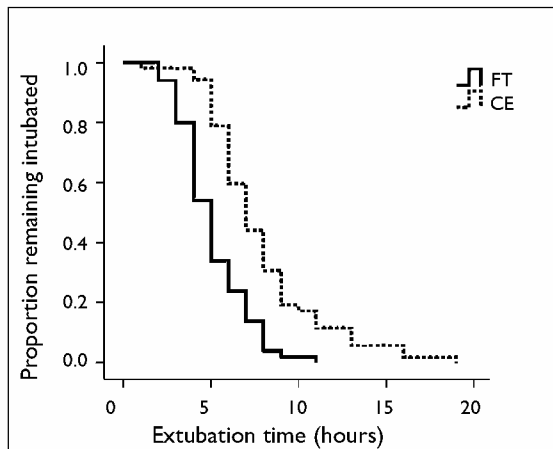
Patients of both FT and conventional extubation (CE) groups received 1–2 mg lorazepam (Chemidarou, Tehran, Iran) at 10 p.m. the night before their surgery. Preoperative sedation consisted of 0.1 mg/kg morphine sulphate (Darou Pakhsh, Tehran, Iran) and 0.5 mg/kg promethasin (Tehran Chemie, Tehran, Iran), both administered one hour before surgery. Anaesthesia was induced with 5–10  $\mu$ g/kg fentanyl (Fentanyl-Janssen®, Janssen-Cilag, Beerse, Belgium), with sodium thiopental (Thiopental®, Sandoz, Kundl, Austria) 250 mg IV.

The CE group received pancuronium bromide (Darou Pakhsh, Tehran, Iran) as a neuromuscular blocker with the following details: 80  $\mu$ g/kg for intubation and 40  $\mu$ g/kg every hour as maintenance. Analgesia was maintained with bolus doses of 20–30  $\mu$ g/kg fentanyl every hour, and administered subsequently as needed. Before CPB, these patients received no halothane (Nicholas Piramal India, Chennai, India), or < 0.5 minimal alveolar concentration

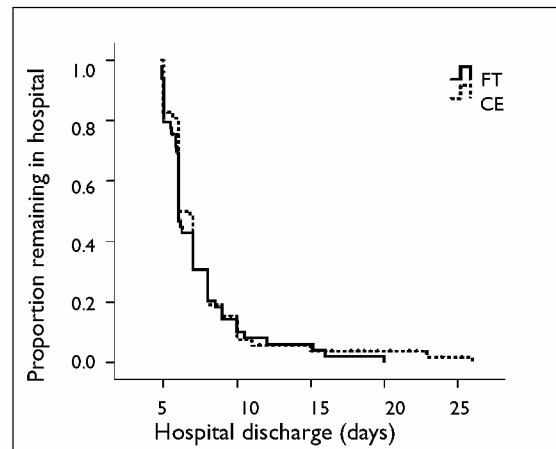
(MAC). Propofol (Propofol-Lipuro®, B Braun Melsengen, Melsengen, Germany) infusion was used for maintaining anaesthesia at 20–50  $\mu$ g/kg/min until the end of surgery. Conventional rewarming on CPB at the end of artificial perfusion was the only method of thermoregulation. Muscle relaxation was not reversed in the CE group.

In the FT group, muscle relaxation was facilitated by atracurium besylate (Tracrium®, GlaxoWellcome, Dubai, UAE). Anaesthesia maintenance before CPB was achieved with a propofol infusion at 50–150  $\mu$ g/kg/min with 0.5–1.5 MAC halothane. Halothane dosage was reduced to 0.5 MAC after CPB. Muscle relaxation was continued with atracurium infusion at 3–5  $\mu$ g/kg/min. The propofol infusion was continued during CPB with the same dose. Systolic blood pressure of 90–130  $\mu$ g/kg/min was maintained with nitroglycerine (Trinitrosan®, Merck, Darmstadt, Germany) infusion. Shivering was prevented with a patient warmer system (KanMed Operatherm®, Bromma, Sweden), warm injectable solutions and blanket. Supplemental analgesia was conducted with fentanyl infusion at 0.01  $\mu$ g/kg/min. Standardised surgical procedure consisted of median sternotomy, left internal mammary artery and saphenous vein grafts, minimum core temperature of 33°C during CPB, haematocrit concentration above 20% and a mean perfusion pressure of 50–60 mmHg. Active cooling was not performed and patients were actively rewarmed to a nasopharyngeal temperature of 38°C before weaning off CPB. Muscle relaxation was reversed with 70  $\mu$ g/kg neostigmine (Ipostigmine®, IPDIC, Rasht, Iran) and 35  $\mu$ g/kg atropine (Darou Pakhsh, Tehran, Iran) at the end of surgery.

Extubation protocol and ICU management were the



**Fig. 1** Kaplan-Meier survival curve for extubation time in FT and CE groups.  
FT: fast-track; CE: conventional extubation



**Fig. 2** Kaplan-Meier survival curve for length of hospital stay in FT and CE groups.  
FT: fast-track; CE: conventional extubation

same in both FT and CE groups, but in the FT group, the administration of fentanyl at 0.01 µg/kg lasted for 12 hours after surgery. ICU personnel had no prior experience with FT cardiac anaesthesia, so comprehensive instructions with detailed written information were provided for them.

Patients were ventilated artificially in the ICU to maintain PaCO<sub>2</sub> between 35 and 45 mmHg, and PaO<sub>2</sub> greater than 80 mmHg. Patients who met the following criteria after the ICU entrance were considered for early extubation: low-dose inotropic support if any, minimal drainage, core body temperature > 36°C, oxygen saturation of haemoglobin (SaO<sub>2</sub>) > 94% with an inspired oxygen concentration ≤ 50%, no evidence of new myocardial ischaemia and no uncontrollable agitation. Then, ventilator weaning protocol (Appendix I) was performed and patients who were warmed, oriented and awake, were extubated based on the extubation criteria (Appendix II) with the instructions from the anaesthesiologist. The patients received oxygen with a nasal canula or mask to maintain peripheral saturation of oxygen (SpO<sub>2</sub>) > 90%. Chest physiotherapy and/or mucolytic agents were used to clear sputum as needed. Any patient with irreversible respiratory failure according to the arterial blood gas analysis and anaesthesiologist diagnosis was a candidate for reintubation.

Morphine sulphate was the sole bolus analgesic, and midazolam (Dormicum®, Roche, Basel, Switzerland) was the sole sedative used during the first 24 hours post-operation, and the total number of doses were recorded. Morphine sulphate was administered based on patients' complaints of moderate to severe pain and/or with the anaesthesiologist's order. Midazolam was administered based on score one according to the Ramsay sedation scale (Appendix III).<sup>(7)</sup>

Wake-up time was the time (in hours) from exiting the ICU to waking up, at a Ramsay sedation scale score of

five or less (Appendix III). Extubation time was the time (in hours) from exiting the ICU to tracheal extubation. The discharge time from the ICU was the time (in hours) from entry to ICU to discharge from ICU, and the discharge time (in days) from the hospital was the time from the day of surgery until the day of discharge from the hospital. Respiratory parameters were measured at the first hour, sixth hour, 12th hour, and 24th hour after surgery, and were recorded as PaO<sub>2</sub> 1, PaO<sub>2</sub> 6, PaO<sub>2</sub> 12, PaO<sub>2</sub> 24 (arterial oxygen pressures), SaO<sub>2</sub> 1, SaO<sub>2</sub> 6, SaO<sub>2</sub> 12, SaO<sub>2</sub> 24 (arterial oxygen saturation) and PaCO<sub>2</sub> 1, PaCO<sub>2</sub> 6, PaCO<sub>2</sub> 12, PaCO<sub>2</sub> 24 (arterial carbon dioxide pressures). The incidence of reintubation, vomiting and shivering after ICU admission was also recorded.

Results are expressed as mean (standard deviation) or median (range), as appropriate. Analysis between groups was conducted with the unpaired *t*-test. Serial comparison was done using either one-way analysis of variance, or a two-way between-group analysis of variance, with repeated measurements over time. Non-parametric data was analysed with the  $\chi^2$  test and Mann-Whitney U test. Differences were considered significant if *p* < 0.05. Kaplan-Meier survival curves were calculated for time to extubation and length of ICU and hospital stay. The log rank test was used to compare the groups for these timed variables.

## RESULTS

Data from 100 patients (50 each in the FT and CE groups) was analysed. The demographical data were similar for both groups (Table I). There were no significant differences between groups in duration of surgery, CPB time, cross-clamp time and number of grafts placed.

The time period between ICU admission and alertness in the FT group was less than that in the CE group (1.3 hours vs. 3.3 hours); this was statistically significant (*p* < 0.001). Kaplan-Meier survival curves of the extubation

**Table II. Comparison of arterial blood gas parameters in FT and CE groups.**

Arterial blood gas parameters	FT group	CE group
P <sub>a</sub> O <sub>2</sub>		
(1st hour)	112.3 (31.7)	104.3 (28.3)
(6th hour)	107 (22.8)	100.7 (33.4)
(12th hour)	95.7 (20.9)	99.1 (28.2)
(24th hour)	97.7 (26.3)	91 (18.8)
S <sub>a</sub> O <sub>2</sub>		
(1st hour)	95.4 (8)	96.2 (2.45)
(6th hour)	95 (9)	95.1 (5.5)
(12th hour)	93.2 (14.1)	95.3 (6)
(24th hour)	93.5 (13)	95.3 (2.2)
P <sub>a</sub> CO <sub>2</sub>		
(1st hour)	36.3 (4.2)	37.6 (5)
(6th hour)	36.2 (4)	37.6 (4.4)
(12th hour)	38 (8.5)	37.3 (7.4)
(24th hour)	36.6 (3.7)	37.6 (3.5)

Numbers are shown as mean ( $\pm$  standard deviation)  
 FT: fast-track; CE: conventional extubation

times for both groups are shown in Fig. 1. The mean time to extubation in the FT group was 4.29 (2.7) hours. This was significantly less than the CE group ( $p < 0.001$ ), which had a mean time to extubation of 7.04 (3.2) hours. The mean length of stay in the ICU was 32.86 (16.7) hours for the FT group and 32.11 (16.7) hours for the CE group. The mean length of stay in the hospital for the FT and CE groups were 7.3 (3.2) days and 7.6 (3.9) days, respectively, and there was no significant difference between the groups. Kaplan-Meier survival curves for length of stay in the hospital are shown in Fig. 2. Data extracted from serial ABG values and pulse oximetry values in the first 24 hours after entering the ICU showed no differences between the groups (Table II). There was only one patient in the CE group requiring intubation. No patient in the FT group received sedative drugs (zero vs. two patients in the CE group). The incidence of nausea in the FT group was significantly lower compared to the CE group (6% vs. 25%,  $p = 0.013$ ). Although patients in the FT group received less bolus doses of analgesics, there was no significant difference between the two groups ( $0.98 \pm 1.7$  vs.  $1.93 \pm 3.3$ ,  $p = 0.08$ ).

## DISCUSSION

The principal aspects of the FT method in this study are continuous infusion of short-acting drugs and active warming. There are different anaesthesia techniques proposed to decrease postoperative intubation time. Common among them is a decrease in the total opioid dose administered to avoid postoperative respiratory depression.<sup>(6,8)</sup> Propofol is a suitable substitute for opioids and prevents late extubation in the ICU. Some researchers claimed that propofol infusion rather than benzodiazepines<sup>(9,11)</sup> and/or opioids,<sup>(9,12)</sup> results in a shorter extubation time. Our patients received propofol in both

groups, but we did not administer morphine sulphate and/or diazepam to the FT group, nor did we give any bolus dose of fentanyl or propofol to this group. The interesting result of this study is the mean extubation time, which was < eight hours in both FT and CE groups (Table I). Since the time limit for extubation is eight hours in most studies on the FT method,<sup>(3,13)</sup> most of our patients in the CE group also fulfilled the criteria. The short time of intubation in the CE group is attributable to propofol administration in both groups.

Moreover, Silbert et al claimed that propofol administration as a substitute for isoflurane resulted in a decreased incidence of shivering in patients<sup>(14)</sup> compared to a study by Cheng et al.<sup>(9)</sup> There are few studies in which inhalational anaesthetics had not been administered.<sup>(10,14)</sup> Our patients received halothane deliberately at the beginning of the surgery; we then reduced the dose to 0.5 MAC thereafter. Shivering occurred in two patients in the FT group, and not in the CE group; there was no significant difference between them. Utilisation of warming equipment and warm IV fluids postoperatively could be helpful in controlling shivering. It seems that shivering is not a remarkable postoperative complication, as shown by the low rate of shivering occurrence in this study. Perhaps maintaining a room temperature near normal during surgery and CPB has a key role in the prevention of shivering.

Tracheal reintubation is one of the most important indices of FT cardiac anaesthesia. The incidence of reintubation in the FT method ranges from 1% to 7%.<sup>(15)</sup> In this study, no patient required reintubation in the FT group. Cheng et al reintubated one patient (2%) in their FT group.<sup>(9)</sup> Wong studied 885 patients and reported reintubation with an incidence of 1.6%.<sup>(16)</sup> Reis et al reported reintubation in one patient in FT group and one patient in the CE group (1.3% vs. 0.5%).<sup>(17)</sup> In addition, there was no difference in arterial blood gas indices between the two groups in time intervals before and after tracheal extubation, which emphasises the safety of early extubation when considering respiratory parameters. This agrees with the results of the detailed study performed by Johnson et al.<sup>(18)</sup>

Postoperative sedation and/or analgesia are the cornerstones of performing FT cardiac anaesthesia. This goal is achieved by administering intravenous infusion of drugs such as midazolam,<sup>(10)</sup> propofol,<sup>(9,10)</sup> fentanyl<sup>(19)</sup> and morphine sulphate.<sup>(9)</sup> Others provided additional analgesia with epidural<sup>(19)</sup>/intrathecal<sup>(20)</sup> analgesia or bolus doses of sodium diclofenac.<sup>(21)</sup> Some authors reported patient-controlled analgesia via intravenous pumps.<sup>(17,20)</sup> In our current study, fentanyl infusion was continued through the postoperative period for 12 hours in the FT group. Though

there was no significant difference between the FT and CE groups regarding bolus analgesic use, patients in the FT group experienced a painless recovery with no need for midazolam bolus administration as a sedative. It is perhaps due to the synergistic effect of fentanyl with the sedation.

Although we infused atracurium as a neuromuscular blocker, and reversed its effect at the end of the surgery, there is controversy about the priority of short-acting neuromuscular blockers on long-acting drugs. Researchers, who have used pancuronium, did not report any postoperative problem, such as remaining muscle paralysis or respiratory compromise.<sup>(9,15,16)</sup> Butterworth et al compared short-acting and long-acting drugs and found no difference in postoperative parameters.<sup>(22)</sup> Murphy et al showed the impact of short-acting drugs on intubation time, but not on the length of stay in the ICU and hospital.<sup>(23)</sup> The role of neuromuscular blockade in FT is not as important as other drugs such as analgesics.

Although it seems obvious that FT treatments reduce the total costs of the treatment of CABG patients through different ways, ICU care is still an important component of post-CABG care, and earlier transfer to the surgical ward would decrease the cost of hospitalisation.<sup>(15)</sup> In this study, extubation time for the FT group was significantly shorter than that of the CE group, a result which is common among nearly all similar studies. However, the length of stay in the ICU and hospital in the two groups was similar in this study. This result confirms those of Silbert et al and Chong et al,<sup>(14,24)</sup> but differs from those of Cheng et al and Lazar et al.<sup>(25,26)</sup> The time intervals in our study were comparable to those of other studies and there was not much delay in the discharge times from the ICU and hospital.<sup>(10,17)</sup> Considering the short time of postoperative intubation in both groups, we could assume that the CE group was similar to the FT group in characteristics. This might explain why the length of stay in the ICU and hospital in the two groups, though comparable to other studies, was not different from each other, as stated by Hawkes et al.<sup>(3)</sup> Time intervals to wake up and extubation were different in the two groups due to differences in drug administration protocols. Thus, it seems that different anaesthetic types and dosages have short-term effects and may not be as effective as the other factors in decreasing length of stay in the ICU and hospital.<sup>(3,13,22,23)</sup>

We did not discharge any patient from the ICU overnight. Overnight discharge is discouraged in our routine protocol; in addition, it would increase the risk of postoperative delirium. We recorded the patients' actual discharge times rather than dischargeable times (time they were eligible to be discharged) in the current study. We did not have standard ICU discharge criteria; discharge

from the ICU and hospital was based on the patients' anaesthesiologist's or surgeon's order. It has been shown that without an ICU discharge criteria, it is difficult to judge whether or not patients are eligible for discharge. In fact, only a few studies have reported on ICU discharge criteria.<sup>(10,25,27-29)</sup> Although the criteria is necessary to accomplish FT goals in reducing the length of stay in the ICU and hospital, from a cost perspective, it is more important to calculate the patients' actual length of stay overall.

In this study, continuous perfusion of short-acting drugs, active warming, reversal of neuromuscular blockade and postoperative continuous analgesia were utilised as FT protocol and this resulted in decreased time intervals to waking up and extubation. The FT group had better postoperative analgesia and required less analgesics. Postoperative complications in the FT and CE groups were not significantly different. In conclusion, FT cardiac anaesthesia using continuous drug administration is a safe method which facilitates early extubation and better ICU care. Its effect on the length of stay in the ICU and hospital warrants the introduction of ICU and hospital discharge protocols as well.

#### ACKNOWLEDGEMENTS

The author thanks Dr Babak Haghghat and Dr Maryam Soleymanzadeh for their help in data collection, Dr Nader Fallah for statistical assistance, Dr Kazem Najafi for reviewing the manuscript, and the nursing staff of the operating room and the intensive care unit for their contribution.

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## Appendix I

### Process of postoperative ventilation, weaning and extubation

#### Ventilation

- SIMV + PSV (10 cmH<sub>2</sub>O) + CPAP (3–5 cmH<sub>2</sub>O)
- VT 10 ml/kg & fIMV 10 breaths/min
- Keep PaCO<sub>2</sub> < 40 mmHg & pH 7.35–7.45
- ABG 15 min after arrival and then every hour

#### Weaning criteria

- Haemodynamically stable (no inotrop or low dose, warm extremities)
- Neurologically stable (awake, no agitation, presence of gag and cough reflexes)
- Acceptable ABG

#### Weaning method

- PSV (10–15 cmH<sub>2</sub>O)
- fIMV 4–6
- ABG every 15 minutes
- Extubation immediately if criteria for extubation met (Appendix II) and anaesthesiologist confirmation obtained
- ABG 30 min after extubation

SIMV: synchronised intermittent mandatory ventilation; PSV: pressure support ventilation; CPAP: continuous positive airway pressure; fIMV: frequency of SIMV ventilation; ABG: arterial blood gas

## Appendix II

### Tracheal extubation criteria

#### Clinical

- Patient responsiveness to simple commands
- Enough respiratory force
- Oropharyngeal temperature > 36.5°C
- Haemodynamically stable
- Absence of uncontrolled arrhythmia
- Chest tube drainage < 100 ml/h

#### Blood gas analysis

- pH > 7.30
- PaO<sub>2</sub> > 80 mmHg, FIO<sub>2</sub> < 0.5
- PaCO<sub>2</sub> < 45 mmHg

## Appendix III

### Ramsay sedation scale<sup>(7)</sup>

- Score 1: Anxious or restless or both
- Score 2: Cooperative, oriented and tranquil
- Score 3: Responding to commands
- Score 4: Brisk response to stimulus
- Score 5: Sluggish response to stimulus
- Score 6: No response to stimulus