

# Comparison of Bispectral Index Monitoring With the Critical-Care Pain Observation Tool in the Pain Assessment of Intubated Adult Patients After Cardiac Surgery

Zahra Faritous,<sup>1</sup> Arvin Barzanji,<sup>1</sup> Rasoul Azarfarin,<sup>1</sup> Behshid Ghadrdoost,<sup>1</sup> Mohsen Ziyaeifard,<sup>1</sup> Nahid Aghdai,<sup>1</sup> and Mostafa Alavi<sup>1,\*</sup>

<sup>1</sup>Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, Iran

\*Corresponding author: Mostafa Alavi, Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, Iran. Tel: +98-2123922154, E-mail: mostafa.alavi@gmail.com

Received 2016 April 09; Revised 2016 May 04; Accepted 2016 May 21.

## Abstract

**Background:** Detecting pain is crucial in sedated and mechanically ventilated patients, as they are unable to communicate verbally. **Objectives:** This study aimed to compare Bispectral index (BIS) monitoring with the Critical-care pain observation tool (CPOT) and vital signs for pain assessment during painful procedures in intubated adult patients after cardiac surgery.

**Materials and Methods:** Seventy consecutive patients who underwent cardiac surgery (coronary artery bypass graft or valvular surgery) were enrolled in the study. Pain evaluations were performed early after the operation in the intubated and sedated patients by using BIS and CPOT, and also checking the vital signs. The pain assessments were done at three different times: 1) baseline (immediately before any painful procedure, including tracheal suctioning or changing the patient's position), 2) during any painful procedure, and 3) five minutes after the procedure (recovery time).

**Results:** The mean values for CPOT, BIS, and mean arterial pressure (MAP) scores were significantly different at different times; they were increased during suctioning or changing position, and decreased five minutes after these procedures (CPOT:  $3.98 \pm 1.65$  versus  $1.31 \pm 1.07$ , respectively ( $P \leq 0.0001$ ); BIS:  $84.94 \pm 10.52$  versus  $63.48 \pm 12.17$ , respectively ( $P \leq 0.0001$ ); MAP:  $92.88 \pm 15.37$  versus  $89.77 \pm 14.72$ , respectively ( $P = 0.003$ )). Change in heart rate (HR) was not significant over time ( $95.68 \pm 16.78$  versus  $93.61 \pm 16.56$ , respectively;  $P = 0.34$ ). CPOT scores were significantly positively correlated with BIS at baseline, during painful stimulation, and at recovery time, but were not correlated with HR or MAP, except at baseline. BIS scores were significantly correlated with MAP but not with HR.

**Conclusions:** It appears that BIS monitoring can be used for pain assessment along with the CPOT tool in intubated patients, and it is much more sensitive than monitoring of hemodynamic changes. BIS monitoring can be used more efficiently in intubated patients under deep sedation in the ICU.

**Keywords:** Bispectral Index Monitoring, Pain Assessment, Vital Signs, Intensive Care Unit, Cardiac Surgery

## 1. Background

Control of pain after open-heart surgery in patients in the intensive care unit (ICU) is a major concern of health-care providers. Pain is a subjective and personal experience that affects most body systems and can result in prolonged hospital stays (1-3). Many procedures performed by nurses in the ICU, such as patient repositioning, catheter and drain removal, endotracheal suctioning, and wound care, have been identified as painful for patients. However, verbal communication is altered in patients with endotracheal intubation or a reduced level of consciousness due to sedative or paralyzing drugs; therefore, pain assessment in such situations is crucial and difficult (4, 5).

For adequate pain assessment and proper treatment in intubated or unconscious patients, some valid observable behavioral scales and physiological indicators, such as the Critical-care pain observation tool (CPOT), are used (6). The CPOT is a feasible, easy-to-complete, and simple-to-understand tool that includes an evaluation of four different behaviors (facial expressions, body movements, muscle tension, and compliance with the ventilator for mechanically ventilated patients or vocalization for non-intubated patients) (7). However, in some situations, such as when the patient is receiving high doses of sedative drugs or neuromuscular blockers, the use of CPOT is less valuable due to inhibition of motor function (8).

Another criterion used to assess pain in ICU patients is vital signs. Although vital signs are easily accessible in the ICU, their validity for pain assessment is not strongly confirmed. Moreover, vital signs are not recommended indicators for pain assessment in nonverbal patients, based on the American society for pain management nursing (ASPMN) guidelines (9). Also, administration of various drugs, such as beta-blockers, calcium-channel blockers, and other drugs that affect blood pressure and heart rate (HR), can modulate the cardiovascular response to pain.

On the other hand, because there is a significant relationship between pain and the sensory system, the cortical arousal response is a known pain indicator. BIS monitoring is used for this purpose as a potential tool for the detection of pain (10, 11). BIS is a non-invasive technology with the main purpose of quantifying changes in the brain's electrophysiological state during sedation and anesthesia by measuring different indices, including the BIS value, electromyographic (EMG) activity, electroencephalographic (EEG) data, and the density spectral array (DSA) (6).

## 2. Objectives

The aim of this study was to evaluate BIS for pain assessment in sedated and mechanically ventilated adult ICU patients after cardiac surgery. The CPOT and vital signs, such as mean arterial pressure (MAP) and HR, were assessed during painful procedures, then compared with each other and with BIS.

## 3. Materials and Methods

Seventy consecutive patients who underwent cardiac surgery (coronary artery bypass graft or valvular surgery) and were admitted to the intensive care unit at Rajaie cardiovascular medical and research center (Tehran, Iran) from April to October 2015 were enrolled in the study.

The inclusion criteria were age > 18 years, inability to use verbal communication due to an endotracheal tube, having undergone coronary artery bypass surgery or valve replacement/repair via median sternotomy, a sedation-agitation scale (SAS) (12) score of 2 or 3, and no history of neurological disease or drug abuse. The exclusion criteria were the use of narcotics, sedatives, or neuromuscular relaxants after surgery during the study period, cardiac arrest and CPR in the operating room or ICU, ischemic or hemorrhagic neurological events, encephalopathy, and prolonged intubation time (> 8 hours).

This study was approved by the local ethics committee according to the Helsinki declaration of the world medical association (2000). All patients were informed about

the study and provided written consent prior to being enrolled. After surgery, all patients were transferred to the ICU with an endotracheal tube. During the first hours after admission to the ICU, when the effects of the anesthetics, neuromuscular relaxants, and opioid drugs used during the operation disappeared but the patients were still intubated and under mechanical ventilation, their pain was assessed.

Pain evaluations using the two different pain tools (BIS and CPOT) were independently performed at the same time. The pain assessments were done three times: 1) at baseline (immediately before any painful procedure, including tracheal suctioning or change in position), 2) during the painful procedure, and 3) five minutes after the procedure (recovery time). All patients were assessed for pain scores by one investigator.

### 3.1. Bispectral Index (BIS)

BIS was recorded continuously with the portable Bispectral index monitor (Model A-2000 software version 3.20, Aspect Medical System). The BIS uses a sensor (Datemere A/S Kildemosevej 13, Denmark) that is placed on the patient's forehead (frontal, left temporal, and left mastoid bone). The sensor sends different signals, including the BIS index score, EMG activity, and electroencephalographic data (EEG). The range of BIS values is from 0 (complete suppression of EEG or coma) to 100 (fully awake) (13).

### 3.2. Critical-Care Pain Observation Tool (CPOT)

The CPOT has four sections, each containing items scored from 0 to 2 (for a possible total score of 0 - 8). The four sections are facial expressions, body movements, muscle tension, and compliance with the ventilator for intubated patients. The levels of pain intensity based on CPOT scores are: 0 - 2 (no pain or mild pain), 3 - 5 (moderate pain), and 6 - 8 (severe pain) (9).

### 3.3. Vital Signs

MAP and HR were assessed at baseline and during painful procedures.

### 3.4. Statistical Analyses

Statistical analyses were performed with SPSS 21.0 for Windows (SPSS Inc., Chicago, IL, USA). All variables were tested for normal distribution with the Kolmogorov-Smirnov test. Repeated-measures ANOVA followed by the Bonferroni post-hoc test was used to assess changes in numerical variables over time. The correlations between pain-assessment-tool scores were assessed by Spearman's correlation test. P values of  $\leq 0.05$  were considered statistically significant.

#### 4. Results

The study sample included 70 patients who underwent cardiac surgery; 46 (65.7%) of the patients had coronary artery bypass graft (CABG) surgery and 24 (34.3%) underwent valvular surgery. The mean age of the study population was  $56.02 \pm 14.2$  years; 44 (62.9%) were male and 26 (37.1%) were female.

The mean values of the changes in CPOT, BIS, MAP, and HR at the three times (baseline, during painful stimulation, and at recovery time) are shown in [Table 1](#). The mean CPOT, BIS, and MAP values were significantly changed over time, increasing during suctioning or repositioning, and decreasing at recovery time (five minutes after the procedure) ( $P < 0.05$ ). Changes in HR were not significant over time ( $P = 0.34$ ).

The correlations between CPOT and BIS with vital signs and other parameters of pain assessment are depicted in [Tables 2 - 4](#). CPOT had a significant positive correlation with BIS at baseline, during painful stimulation, and after recovery time, but it was not correlated with HR and MAP (except at baseline). The BIS scores were significantly correlated with MAP, but not with HR.

#### 5. Discussion

The BIS index and CPOT scores were found to be higher during painful procedures. CPOT, BIS, and MAP were significantly correlated at baseline, during painful stimulus, and at recovery time. The BIS index and CPOT scores seemed to be more sensitive indicators of pain than the vital signs, which remained quite stable.

In the current study, CPOT scores peaked during suctioning or repositioning, and declined five minutes after the onset of the painful stimulus. The trends of these changes were significant. These results are quite similar to those obtained in a report by Gelinas et al. ([6](#)), who showed that CPOT scores were increased during painful procedures, such as turning and endotracheal suctioning, compared with rest. In another study by the same authors ([8](#)), 113 unconscious ICU patients with different diagnoses were evaluated. The average CPOT score during repositioning, with or without endotracheal suctioning, was 2.23.

In our study, the BIS scores were increased during repositioning and endotracheal suctioning compared with baseline. Brocas et al. ([14](#)) showed that in patients who had not received analgesia prior to procedures such as suctioning, the BIS scores increased during the painful stimulation and decreased significantly five, 10, and 15 minutes later. They suggested that the BIS variations reflected cortical reactivity to painful intervention in critically-ill sedated

and ventilated patients. The BIS index may help to optimize analgesia during invasive events. However, in a study by Li et al. ([15](#)), the BIS index was increased during endotracheal suctioning, but remained unchanged three and five minutes after the painful stimulation.

In the current study, the trend of changing MAP values was significant; during the painful situation, MAP was increased, and then began to decline over time. On the other hand, the changes in HR were not significant. This may indicate that vital signs alone cannot be used to assess pain in patients who are unable to express pain. Several studies show that vital signs, including MAP and HR, were increased significantly during painful procedures in conscious or unconscious sedated and ventilated patients ([16, 17](#)). However, Gelinas et al. showed that vital signs for pain assessment in ICU patients are not recommended, and that vital signs must be used concomitantly with other valid pain-assessment tools ([18](#)). Vital signs are not considered valid indicators for pain assessment because the majority of ICU patients receive sympathetic-system-suppressing drugs, beta blockers, calcium-channel blockers, and angiotensin-converting enzyme inhibitors. These factors can all inhibit the physiological responses to some extent ([19, 20](#)).

Compared to baseline values, the BIS scores increased more than 39% during patient-turning and endotracheal suctioning, and decreased approximately 25% by the recovery time ([Figures 1 and 2](#)). In the study by Li et al. ([18](#)), the BIS index increased approximately 10% during painful situations compared to baseline. It should be noted that in that study, all patients received analgesia prior to the procedure, and they were under deep sedation. It is clear that opioids play a significant role in modulating the sensitivity of BIS monitoring ([21](#)). Brocas et al. ([14](#)) demonstrated that a bolus dose of alfentanil reduced BIS scores in response to painful stimulation, so significant changes in BIS were not seen. Also, in the control group that had not received alfentanil, a significant increase was observed in the BIS scores during the painful stimulation, with an average increase from 60 to 88.

In a study by Gelinas et al. ([6](#)), the BIS index increased 20% -30% and vital signs decreased approximately 10% during turning and endotracheal suctioning. That study concluded that vital signs, in comparison with BIS and CPOT, have a low sensitivity for pain assessment in ill ICU patients. Our findings are also in line with these ([Figures 1 and 2](#)).

##### 5.1. Conclusions

According to the results of this study, as pain sensation has an influence on brain arousal status, BIS monitoring

**Table 1.** Mean CPOT, BIS, MAP, and HR Values at Baseline, During the Painful Stimulus, and at Recovery Time

	<b>Baseline</b>	<b>During Painful Stimulation</b>	<b>At RECOVERY Time</b>	<b>P Value</b>
<b>CPOT</b>	0.94 ± 0.52	3.98 ± 1.65	1.31 ± 1.07	< 0.001
<b>BIS</b>	60.78 ± 10.95	84.94 ± 10.52	63.48 ± 12.17	< 0.001
<b>MAP, mmHg</b>	87.65 ± 15.00	92.88 ± 15.37	89.77 ± 14.72	0.003
<b>HR, bpm</b>	94.04 ± 16.73	95.68 ± 16.78	93.61 ± 16.56	0.346

Abbreviations: BIS, bispectral index; CPOT, critical-care pain observation tool; HR, heart rate; MAP, mean arterial pressure.

**Table 2.** Correlation Between CPOT, BIS, MAP, and HR Scores at Baseline

	<b>BIS (Baseline)</b>		<b>HR (Baseline)</b>		<b>MAP (Baseline)</b>	
	<b>r</b>	<b>P Value</b>	<b>r</b>	<b>P Value</b>	<b>r</b>	<b>P Value</b>
<b>CPOT</b>	0.666	< 0.001	-0.015	0.902	0.268	0.025
<b>BIS</b>	-	-	-0.025	0.835	0.321	0.007

Abbreviations: BIS, bispectral index; CPOT, critical-care pain observation tool; HR, heart rate; MAP, mean arterial pressure.

**Table 3.** Correlation Between CPOT, BIS, MAP, and HR Scores During Painful Stimulus

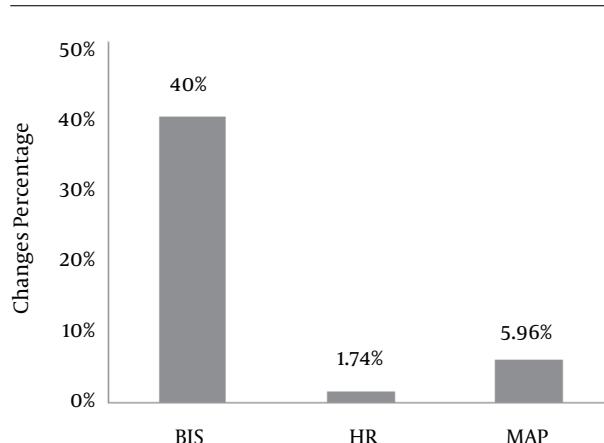
	<b>BIS</b>		<b>HR</b>		<b>MAP</b>	
	<b>r</b>	<b>P Value</b>	<b>r</b>	<b>P Value</b>	<b>r</b>	<b>P Value</b>
<b>CPOT</b>	0.612	< 0.001	-0.190	0.116	0.211	0.080
<b>BIS</b>	-	-	-0.025	0.835	0.321	0.007

Abbreviations: BIS, bispectral index; CPOT, critical-care pain observation tool; HR, heart rate; MAP, mean arterial pressure.

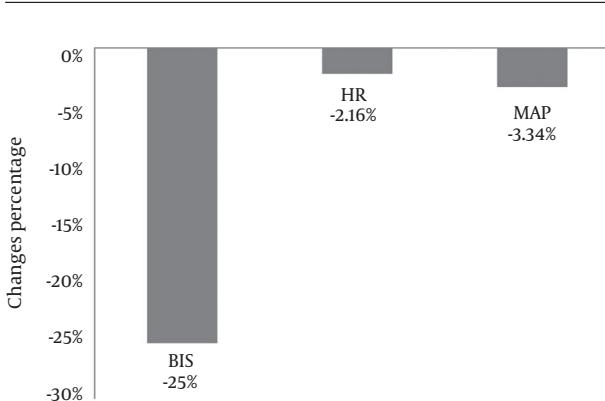
**Table 4.** Correlation Between CPOT, BIS, MAP, and HR Scores at Recovery Time

	<b>BIS (Recovery Time)</b>		<b>HR (Recovery Time)</b>		<b>MAP (Recovery Time)</b>	
	<b>r</b>	<b>P Value</b>	<b>r</b>	<b>P Value</b>	<b>r</b>	<b>P Value</b>
<b>CPOT</b>	0.738	< 0.001	-0.122	0.1314	0.211	0.079
<b>BIS</b>	-	-	0.0175	0.147	0.231	0.054

Abbreviations: BIS, bispectral index; CPOT, critical-care pain observation tool; HR, heart rate; MAP, mean arterial pressure.

**Figure 1.** Changes in BIS, HR, and MAP During Suctioning or Changing Position Compared With Baseline Time

can be used for pain assessment along with the CPOT in intubated and sedated patients, and it is much more sensitive than hemodynamic changes. It appears that BIS monitoring can be used more efficiently in patients under deep sedation or those who have received muscle relaxants, in whom the physical symptoms of pain sensation are depressed.



**Figure 2.** Changes in BIS, HR, and MAP at Recovery Time Compared to During Painful Stimulation

## Acknowledgments

We would like to thank all of the cardiac anesthesiology staff at Rajaie cardiovascular research center for assisting with this manuscript.

## Footnote

**Authors' Contribution:** Study concept and design: Zahra Faritous; conduction of the project: Mostafa Alavi; revision of the manuscript: Rasoul Azarfarin, Zahra Faritous; data collection and literature review: Arvin Barzanji, Mohsen Ziyaeifard, Mostafa Alavi, Nahid Aghdaei; data analysis and manuscript preparation: Behshid Ghadrdoost, Arvin Barzanji.

## References

- Marmo I, Fowler S. Pain assessment tool in the critically ill post-open heart surgery patient population. *Pain Manag Nurs.* 2010;11(3):134–40. doi: [10.1016/j.pmn.2009.05.007](https://doi.org/10.1016/j.pmn.2009.05.007). [PubMed: 20728062].
- Imani F. Postoperative pain management. *Anesth Pain Med.* 2011;1(1):6–7. doi: [10.5812/kowsar.22287523.1810](https://doi.org/10.5812/kowsar.22287523.1810). [PubMed: 25729647].
- Imani F, Safari S. "Pain Relief is an Essential Human Right", We Should be Concerned about It. *Anesth Pain Med.* 2011;1(2):55–7. doi: [10.5812/kowsar.22287523.2306](https://doi.org/10.5812/kowsar.22287523.2306). [PubMed: 25729655].
- Arroyo-Novoa CM, Figueroa-Ramos MI, Puntillo KA, Stanik-Hutt J, Thompson CL, White C, et al. Pain related to tracheal suctioning in awake acutely and critically ill adults: a descriptive study. *Intensive Crit Care Nurs.* 2008;24(1):20–7. doi: [10.1016/j.iccn.2007.05.002](https://doi.org/10.1016/j.iccn.2007.05.002). [PubMed: 17689249].
- Arif-Rahu M, Grap MJ. Facial expression and pain in the critically ill non-communicative patient: state of science review. *Intensive Crit Care Nurs.* 2010;26(6):343–52. doi: [10.1016/j.iccn.2010.08.007](https://doi.org/10.1016/j.iccn.2010.08.007). [PubMed: 21051234].
- Gelinas C, Tousignant-Laflamme Y, Tanguay A, Bourgault P. Exploring the validity of the bispectral index, the Critical-Care Pain Observation Tool and vital signs for the detection of pain in sedated and mechanically ventilated critically ill adults: a pilot study. *Intensive Crit Care Nurs.* 2011;27(1):46–52. doi: [10.1016/j.iccn.2010.11.002](https://doi.org/10.1016/j.iccn.2010.11.002). [PubMed: 21169020].
- Gelinas C, Fillion L, Puntillo KA, Viens C, Fortier M. Validation of the critical-care pain observation tool in adult patients. *Am J Crit Care.* 2006;15(4):420–7. [PubMed: 16823021].
- Gelinas C, Harel F, Fillion L, Puntillo KA, Johnston CC. Sensitivity and specificity of the critical-care pain observation tool for the detection of pain in intubated adults after cardiac surgery. *J Pain Symptom Manage.* 2009;37(1):58–67. doi: [10.1016/j.jpainsyman.2007.12.022](https://doi.org/10.1016/j.jpainsyman.2007.12.022). [PubMed: 18599262].
- Herr K, Coyne PJ, Key T, Manworren R, McCaffery M, Merkel S, et al. Pain assessment in the nonverbal patient: position statement with clinical practice recommendations. *Pain Manag Nurs.* 2006;7(2):44–52. doi: [10.1016/j.pmn.2006.02.003](https://doi.org/10.1016/j.pmn.2006.02.003). [PubMed: 16730317].
- Guignard B. Monitoring analgesia. *Best Pract Res Clin Anaesthesiol.* 2006;20(1):161–80. [PubMed: 16634423].
- Takamatsu I, Ozaki M, Kazama T. Entropy indices vs the bispectral index for estimating nociception during sevoflurane anaesthesia. *Br J Anaesth.* 2006;96(5):620–6. doi: [10.1093/bja/ael050](https://doi.org/10.1093/bja/ael050). [PubMed: 16531443].
- Icu delirium . Riker Sedation-Agitation Scale (SAS) 2012. Available from: <http://www.icudelirium.org/docs/SAS.pdf>.
- Robleda G, Roche-Campo F, Urrutia G, Navarro M, Sendra MA, Castillo A, et al. A randomized controlled trial of fentanyl in the pre-emptive treatment of pain associated with turning in patients under mechanical ventilation: research protocol. *J Adv Nurs.* 2015;71(2):441–50. doi: [10.1111/jan.12513](https://doi.org/10.1111/jan.12513). [PubMed: 25168967].
- Brocas E, Dupont H, Paugam-Burtz C, Servin F, Mantz J, Desmonts JM. Bispectral index variations during tracheal suction in mechanically ventilated critically ill patients: effect of an alfentanil bolus. *Intensive Care Med.* 2002;28(2):211–3. doi: [10.1007/s00134-001-1189-y](https://doi.org/10.1007/s00134-001-1189-y). [PubMed: 11907667].
- Li D, Miaskowski C, Burkhardt D, Puntillo K. Evaluations of physiologic reactivity and reflexive behaviors during noxious procedures in sedated critically ill patients. *J Crit Care.* 2009;24(3):472 e9–13. doi: [10.1016/j.jcrc.2008.07.005](https://doi.org/10.1016/j.jcrc.2008.07.005). [PubMed: 19327307].
- Young J, Siffleet J, Nikoletti S, Shaw T. Use of a Behavioural Pain Scale to assess pain in ventilated, unconscious and/or sedated patients. *Intensive Crit Care Nurs.* 2006;22(1):32–9. doi: [10.1016/j.iccn.2005.04.004](https://doi.org/10.1016/j.iccn.2005.04.004). [PubMed: 16198570].
- Payen JF, Bru O, Bosson JL, Lagrasta A, Novel E, Deschaux I, et al. Assessing pain in critically ill sedated patients by using a behavioral pain scale. *Crit Care Med.* 2001;29(12):2258–63. [PubMed: 11801819].
- Gelinas C, Arbour C. Behavioral and physiologic indicators during a nociceptive procedure in conscious and unconscious mechanically ventilated adults: similar or different? *J Crit Care.* 2009;24(4):628 e7–17. doi: [10.1016/j.jcrc.2009.01.013](https://doi.org/10.1016/j.jcrc.2009.01.013). [PubMed: 19327961].
- Arbour C, Gelinas C. Are vital signs valid indicators for the assessment of pain in postoperative cardiac surgery ICU adults?. *Intensive Crit Care Nurs.* 2010;26(2):83–90. doi: [10.1016/j.iccn.2009.11.003](https://doi.org/10.1016/j.iccn.2009.11.003). [PubMed: 20044256].
- Kiavar M, Azarfarin R, Totonchi Z, Tavakoli F, Alizadehhasl A, Teymouri M. Comparison of Two Pain Assessment Tools, "Facial Expression" and "Critical Care Pain Observation Tool" in Intubated Patients After Cardiac Surgery. *Anesth Pain Med.* 2016;6(1):e33434. doi: [10.5812/aapm.33434](https://doi.org/10.5812/aapm.33434). [PubMed: 27110536].
- Alavi SM, Ferasat-Kish R, Farsad F, Imani F, Sheikhvatan M. Intra-venous sufentanil and morphine for post-cardiac surgery pain relief using patient-controlled analgesia (PCA) device: A randomized double-blind clinical trial. *Pak J Med Sci.* 2010;26(1):137–41.