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Intraoperative pain assessment: the use of anesthetized patient pain scale and cerebral state monitor

Sylvanus Kampo[1, 3, *], Jun Han[2], Juventus Benogle Ziem[4], Faraja Mpemba[5, 6], Yabasin Iddrisu Baba[1], Peng Gao[1], Qingping Wen[2]

[1]Department of Anesthesiology, Dalian Medical University, 9 Western Section, Lvshun South Road, Lvshunkou District Dalian City, Liaoning, P. R. China
[2]Department of Anesthesiology, First Affiliated Hospital of Dalian Medical University, Dalian City, Liaoning, P.R. China
[3]Department of Anesthesia, School of Medicine and Health Science, University for Development Studies, Tamale, Ghana
[4]Department of Clinical Laboratory Sciences, School of Medicine & Health Sciences, University for Development Studies, Tamale, Ghana
[5]School of Nursing, Dalian Medical University, Dalian, Liaoning P.R. China
[6]School of Nursing, St. John's University of Tanzania, Dodoma, Tanzania

Email address:

sylvanuskampo@yahoo.com(S. Kampo), hanjun760312@sina.com(J. Han), jbziem@yahoo.com(J. B. Ziem), fmpemba@yahoo.com(F. Mpemba), farai46@yahoo.com (Y. I. Baba), dalianpeople@163.com(P. Gao), wqp.89@163.com(Q. Wen)

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Abstract: Background - Pain control in surgical patients remains problematic globally. Intraoperative pain assessment poses significant challenge to many anesthesiologists in poorly resourced countries where monitors and experts are limited. Due to poor intraoperative pain assessment and management, many patients wake up from anesthesia after surgery experiencing moderate to severe pain. It has been reported that about 56% of surgical patients cite pain as their primary concern after surgery. The aim of this study was to use a novel intraoperative pain assessment tool (APPS) and depth of anesthesia monitor (CSM) to assess and score pain in patients undergoing orthopedic procedures under general anesthesia. Methods - Data was prospectively collected for 12-months from 246 patients, aged 20 - 81 years who were undergoing orthopedic surgical procedures. Initial pain intensity was scored using Anesthetized Patients Pain Scale (APPS). The depth of anesthesia was assessed using a CSM prior to pain assessment during surgery. Fentanyl was administered and the pain and depth of anesthesia re-evaluated after 5 to 10min. Results - About 75.6% of patients scored moderate to severe pain with their depth of anesthesia ranging 37-89 score. While 20.7% scored moderate pain with a mean score of 9.56 at the initial pain assessment. A dose of fentanyl, 30 - 50 mcg was administered for pain treatment intraoperatively. Pain was re-evaluated after treatment. About 31.3% scored no pain 49.6% scored moderate pain and 19.1% scored moderate to severe pain. The mean pain intensity scored after treatment was 7.30. Conclusions - Despite adequate depth of anesthesia observed during surgery about 68.7% of surgical patients experienced moderate to severe pain. The use of both APPS and CSM offered adequate intraoperative pain and anesthesia management. Our novel model, APPS has great prospects with clinical application for intraoperative pain assessment.

Keywords: Anaesthetized Patient Pain Scale, Cerebral State Monitor, Intraoperative, Pain Assessment

1. Introduction

Pain control in surgical patients remains problematic globally.[1] Intraoperative pain assessment poses significant challenge to many anesthesiologists in poor resource countries where pain monitors and expertise are limited. Despite the many attempts made to assess and manage pain using different assessment tools such as the Critical care Pain Observation Tool (CPOT) [2, 3] and Post-Anesthesia Care Unit (PACU) behavioral pain rating scale, [4, 5] pain management is still a challenge to many health care providers. Marks and Sacher documented under treatment of pain in 73% of hospital patients.[6] Apfelbaum *et al* (2003) reported that 80% of surgical patients experienced acute

pain after surgery, with 11-20% experiencing moderate to extreme pain.[1,7] Studies done on rates indicated that surgical pain stress increased blood-brain barrier permeability in comparison to acute adrenalin induced hypertension.[8] Pain caused by surgical incision puts patients at risk of developing numerous complications.[9] Beside the psychological, social and cultural factors that influence the perception of individual pain, autonomic pain reflexes are known to cause physiological and behavioral changes which directly affect other body systems including the cardiovascular, gastrointestinal, immune, endocrine and metabolic systems.[10] The cardiovascular response to the stress of pain produces variety of unwanted effects during intraoperative and postoperative periods [10,11] which leads to significant cardiac morbidity associated with anesthesia and surgery related mortality.[12] Psychologically, patients' health seeking behavior is affected by inadequate pain control during surgery, as they may later be reluctant to seek medical care for other health problems.[13] Insufficient intraoperative pain alleviation or inadequate depth of anesthesia may lead to anesthesia related complications.[14] The first measure taken to relieve pain during surgery is to ensure that patients are properly assessed for pain.[15]

Physiological and behavioral pain responses are some of the nonverbal pain indicators use to assess pain in unconscious patient during painful procedures.[16, 17, 18] Gélinas et al, 2006 used behavioral pain indicators to assess and score pain in critical ill unconscious patients in the intensive care unit. Each behavioral indicator was given a score ranges from 0-2 depending on patient responds. A minimal total score of 0 indicated no pain and a maximum total score of 8 represented severe pain.[3] Despite its reliability in clinical usage,[19] heavy sedation and the use of muscle relaxants during anesthesia may limit its usage during intraoperative pain assessment.

Anesthetized patient pain scale (APPS) is a novel intraoperative pain assessment model, which consist of physiological (blood pressure, pulse rate, respiratory rate) and behavioral (facial expression, muscle tension, and body movements) pain indicators.[7] Each item in the category of pain response on the scale is given a score ranges from 1-3. A minimum total score of 6 represented no pain and a maximum total score of 18 represented severe pain. In short, using the APPS, pain is assessed based on physiological and behavioral factors and the intensity of pain scored as no pain (total score of 6), moderate pain (7-8) moderate to severe pain (9-12) and severe pain (13-18).

The difference between pain and inadequate depth of anesthesia responses remained a major concern to many anesthesiologists.[20] Modern anesthetic monitors such as the CSM, monitor the hypnotic state of the brain by data acquisition of electroencephalogram (EEG) signals of the anesthetized or sedated patient. The CSM was used to determine the depth of anesthesia of patients each time pain intensity was assessed. The readings and interpretations of the CSM are 90-100 (awake state), 80-90 (drowsy state), 60-80 (light anesthesia), 40-60 (adequate for surgical anesthesia), 10-40 (deep anesthesia in most cases accompanied by burst suppression), 0-10 (close to coma).[21]

The evaluation of intraoperative pain experienced by pain score ratings and analgesic requirements seems necessary if we are to improve the quality of postoperative pain management rendered to patients after surgery.[22] The use of many of the available pain assessment tools seem impractical during intraoperative pain assessment due to sedation and intubations that render patients unconscious and make them unable to communicate verbally of their pain. The use of the APPS will add to the available pain assessment tools and help improve intraoperative and postoperative pain management. The aim of this study was to use a novel intraoperative pain assessment tool (APPS) and depth of anesthesia monitor (CSM) to assess and scored intraoperative pain in patients undergoing orthopedic procedures under general anesthesia.

2. Methods

This prospective study was carried out at the First Affiliated Hospital of Dalian Medical University, P.R. China. The hospital ethics committee approved the study protocol. Informed consent and/or assent were waived because the study protocol did not differ from the normal clinical practice of the hospital.

Data was prospectively collected for 12 months. This study recruited 250 orthopedic patients who were indicated for surgery. All the patients were preoperatively assessed and classified according to the American Society of Anesthesiologist (ASA) physical status classification. Basic intraoperative monitoring (EKG, SPO_2, and non-invasive blood pressure) was applied and the base line vital signs checked and recorded. All selected patients had stable hemodynamic and no history of any co-morbidity. General anesthesia with intubation was used for all patients. Induction of anesthesia was established with 0.02 mg/kg of Midazolam, 30-50 mcg of fentanyl, 1-2.5 mg/kg of Propoful and 0.3mg/kg of cis-atracurium. Intubation was done and subsequently, anesthesia was maintained with Isoflurane 2-3% in oxygen, intravenous pump of Propoful 50-150 mcg/kg/min and cis- atracurium 1 mg/ml at 8-10 ml/hr.

As part of normal anesthetic practice of the hospital, a cerebral state monitor, model CSM 2 (Kildemosevej 13, DK-5000 Odense C, Denmark) was connected to the patients to monitor the depth of anesthesia. The CSM 2 was used to measure the hypnotic state of the brain through data acquisition of EEG signals of the anesthetized patients.

Prior to the study, three anesthesiologists were trained on the use of the APPS and CSM to assess and score pain. Each time a patient was anesthetized and surgery started, the three anesthesiologists independently observed the various pain indicators outlined on the APPS and the patient monitor. Pain was first scored if $\geq$ 30% increase in two or more baseline vital signs were observed as recorded on the patient's monitor. At the same time, the CSM was

used to determine the depth of anesthesia (aiming at 40-60) for necessary intervention. Following the initial pain intensity score, all observers were blinded to fentanyl (30-50 mcg) treatment. After 5-10 minutes of treatment, the observers re-evaluated pain and depth of anesthesia. Each time, the pain intensity scored and the depth of anesthesia were given by the average score between the anesthesiologists. A total score of 6 represented no pain, 6-8 moderate pain, 9-12 moderate to severe pain and 13-18 represented severe pain. The APPS pain score and the cerebral state monitor readings were recorded once for each patient intraoperatively.

3. Data Analysis

The data obtained was double entered into Microsoft excel version 2007 for Windows and data validated for data entry errors. Data analysis was carried out using SPSS version 16.01 for Windows. Paired t-test was used to compare the statistical means of pain intensity scored and depth of anesthesia before and after pain treatment. Statistical significance was set at $P < 0.05$. Frequencies and percentages are presented for the various variables.

4. Results

Of the 250 patients recruited for the study, data for 246 patients comprising 170 (69.1%) males and 76 (30.9%) females with average age of 42years was included in the analysis. Data for 4 patients were excluded in the analysis because cardioselective $beta_1$ receptor blocker (Esmolol) was used perioperatively to lower the heart rate (60-80 bpm). Of the 246 patients, 136 (55%) had open reduction and internal fixation of the femur under general anesthesia, 78 (32%) had knee arthroplasty and 32 (13%) had hip arthroplasty under general anesthesia. Duration of surgery ranges from 1-3 hours. None of the patients had any history of co morbidities.

5. Pain Intensity Score before Treatment

The APPS scored an initial pain intensity ranges from 7 to 13 with a mean score of 9.56. Pain scored was classified as, no pain (6), moderate pain (6-8), moderate to severe pain (9-12) and severe pain (13-18). For the initial pain assessment, 0% (0) experienced no pain, 20.7% (51) experienced moderate pain, 75.6% (186) experienced moderate to severe pain and 3.7% (9) experienced severe pain (Table 1).

With regards to the depth of anesthesia as measured by the CSM, a minimum of 37 and a maximum of 89 depths were recorded for the initial pain assessment. The mean depth of anesthesia recorded was 56.5 (IQR=49 to 67). Depth of anesthesia measured by the CSM showed that adequate anesthesia was established in 61.0% (150) of patients, 2.4% (6) had deep anesthesia. Prior to extubation, pain was assessed in 90 patients, 35.4% (87) had light anesthesia and 1.2% (3) of patients were in the drowsy state when the initial pain score was carried out (Table 2).

Of the 150 patients who had adequate anesthesia, moderate pain was scored in 47 (31.3%) and moderate to severe pain scored in 103 (68.7%) of the patients. All of the 6 patients who were in deep anesthesia scored moderate pain. Those with light anesthesia prior to extubation, 4 (4.6%) scored moderate pain, 77 (88.5%) scored moderate to severe pain and 6 (6.9%) scored severe pain. Whereas the 3 patients who were in drowsy state all scored severe pain (Table 3).

6. Pain Intensity Scored after Treatment

After fentanyl was given for treatment, the re-evaluation of pain intensity ranges from 6 to 11 with a mean pain intensity of 7.30. Overall, 31.3% (77) did not experience pain, however, 49.6% (122) and 19.2% (47) experienced moderate and moderate to severe pain respectively. No patient experienced severe pain after treatment of pain with fentanyl (Table 1).

The depth of anesthesia varied from 37 to 98 (fully awake) after fentanyl was given. The mean depth was 49. Adequate anesthesia was established in 64.6% (159) of patients, 0.8% (2) had deep anesthesia. Prior to extubation, 3.7% (9) had light anesthesia, 11.4% (28) of patients were in drowsy state and 19.5% (48) of patients were fully awake (Table 2).

Among those with adequate anesthesia, 73 (45.9%) had no pain, 83 (52.2%) had moderate pain and 3 (1.9%) had moderate to severe pain. Prior to extubation, only 3 (33.3%) and 6 (66.7%) patients in light anesthesia, scored moderate pain and moderate to severe pain respectively. Two patients in deep anesthesia scored moderate pain (table 3). Of the patients in drowsy state anesthesia, 8 (28.6%) and 20 (71.4%) of them scored moderate pain and moderate to severe pain respectively prior to extubation. When the pain score was applied to patients in fully awake state after fentanyl treatment, no pain was scored in 4 (8.3%) patients, moderate pain was scored in 26 (54.2%) patients and moderate to severe pain was scored in 18 (37.5%) of patients (Table 3). When the initial pain scored was compared with the pain scored after fentanyl treatment, a *P* value of 0.001 was realized. There was a statistically significant difference between the pain intensities scored before and after treatment using the APPS and CSM to assess pain intraoperatively (Table 4).

Table 1: *Pain classification, number of patients and percentage score of pain intensity before and after treatment and dosages of fentanyl administered.*

Pain classification	Number of patient	Dosage of fentanyl	Number of patient
	scored before	administer	scored after
	fentanyl treatment N (%)	(mcg)	fentanyl Treatment N(%)
No pain	0(0)	0	77(31.3)*
Moderate pain	51(20.7)	10-20	122(49.6)*
Moderate to severe pain	186(75.6)	20-40	47(19.1)*
Severe pain	9(3.7)	30-50	0(0)*
Total	246(100)	10-50	246(100)

*p<0.05, comparison of pain score before and after treatment

Table 2: *Scores of depth of anesthesia during pain assessment, before and after pain treatment*

Depth of Anesthesia	Initial depth of Anesthesia n (%)	Depth of Anesthesia after pain treatment n (%)
Deep anesthesia	6 (2.4)	2 (0.8)*
Adequate anesthesia	150 (61.0)	159 (64.6)*
Light anesthesia	87 (35.4)	9 (3.7)*
Drowsy state	3 (1.2)	28 (11.4)*
Awake state	0 (0)	48 (19.5)*
Total	246 (100)	246 (100)

*p<0.05, comparison of depth of anesthesia scored before and after treatment

Table 3: *Depth of anesthesia scored and percentage scored of pain intensity before and after pain treatment.*

Depth of anesthesia	No pain	Moderate pain	Moderate to severe pain	Severe pain	Total
Number of patients (%) with initial pain score before treatment					
Deep anesthesia	0 (0)	6 (100)	0 (0)	0 (0)	6 (100)
Adequate anesthesia	0 (0)	47 (31.3)	103 (68.7)	0 (0)	150 (100)
Light anesthesia	0 (0)	4 (4.6)	77 (88.5)	6 (6.9)	87 (100)
Drowsy state	0 (0)	0 (0)	0 (0)	3 (100)	3 (100)
Total	0 (0)	57 (23.2)	180 (73.2)	9 (3.7)	246 (100)
Number of patients (%) with pain score after treatment					
Deep anesthesia	0 (0)	2 (100)	0 (0)	0 (0)	2 (100)
Adequate anesthesia	73 (45.9)	83 (52.2)	3 (1.9)	0 (0)	159 (100)
Light anesthesia	0 (0)	3 (33.3)	6 (66.7)	0 (0)	9 (100)
Drowsy state	0 (0)	8 (28.6)	20 (71.4)	0 (0)	28 (100)
Awake state	4 (8.3)	26 (54.2)	18 (34.5)	0 (0)	48 (100)
Total	77 (31.3)*	122 (49.6)*	47 (19.1)*	0 (0)*	246 (100)*

*Column percentages do not add up to 100%

Table 4: *Comparative data for the pain intensity scored / the depth of anesthesia scored between initial and after fentanyl treatment.*

Measurements (Scores)	Mean	SD	*P*
IPS & PST	2.26	1.27	0.001*
IDS & DST	-3.59	14.4	0.001*

IPS, initial pain score PST, pain score after treatment IDS, initial depth of anesthesia scored DST, depth of anesthesia scored after treatment SD, standard deviation

* p<0.05, comparison of pain intensity and depth of anesthesia scored pre and post-fentanyl treatment using APPS and CSM

7. Discussion

To achieve adequate postoperative pain management, patients undergoing surgery should be adequately assessed and managed for pain; [22] otherwise, moderate or severe pains may persist at the immediate postoperative period.[1] Without proper pain assessment tools, pain may go unnoticed or undertreated during surgery. The APPS and CSM used in this study demonstrated that 75.6% of patient experienced moderate to severe pain during surgery. A similar report was made by Apfelbaum *et al,* (2003)[1] when assessing pain in post surgical patients. Due to the poor

nature of assessment and under treatment of pain during surgery, many patients wake up from anesthesia experiencing moderate or severe pain after surgery. With systematic use of pain assessment tools, consistent pain assessment and documentation during surgery, many anesthesiologist can achieve good pain management at the postoperative period.[14, 15] APPS offered a better transition of pain management from intraoperative period to postoperative period. This study recorded a minimum average pain intensity score of 7 and a maximum average score of 13 representing moderate or severe pain at the initial assessment. APPS coupled with CSM was able to detect the presence of pain during surgery that could have gone unnoticed or undertreated leading to moderate or severe immediate postoperative pain. A survey demonstrated that about 60% of post surgical patients are significantly undertreated and 57% of them complain of pain as their primary concern after surgery.[5] In this study, it was realized that 68.7% of surgical patients who were adequately anesthetized were experiencing moderate or severe pain and needed immediate intervention for pain reliever. The study further revealed that, pain could persist during surgery and even among those who show signs of adequate anesthesia. Therefore, the use of pain assessment tools such as the APPS at any time in surgery was mandatory to detect early pain. Detection of pain using the APPS and CSM simultaneously can provide adequate pain and anesthesia management during surgery. After treatment with fentanyl, there were indications of pain relief in some patients. Pain was re-evaluated and the minimum average score reduced to 6 indicating no pain as outlined on the APPS (Table 1), however, the maximum score remained high indicating moderate to severe pain and needed further pain relievers. We observed that, at the initial pain assessment, none of the patients scored zero (no pain) using the APPS model. However, after treatment with fentanyl, 33.1% scored zero (no pain) and none of the patients recorded experiencing severe pain using the same APPS to re-evaluate pain. This argues that, the physiological and behavioral indicators that were outlined on the APPS were specific to pain even though it was difficult to distinguish between indicators of pain and inadequate depth of anesthesia. Similar findings were reported by Stomberg *et al* (2001).[20] We further found that, during the assessment, the physiological indicators outlined on the APPS were the most scored by the anesthesiologists, an observation Stomberg *et al*, (2003) [23] had also earlier submitted. Some physiological indicators determined for 10 patients were non-specific to pain and indicated other pathological changes (hypotension or dehydration) due to excessive blood lost or inadequate fluid management during surgery. In another vain, the behavioral indicators were less scored in this study possibly due to the excessive use of long acting muscle relaxants (Cis-atracurium) to achieve good muscle relaxation during surgery. Notwithstanding these minor challenges, both physiological and behavioral indicators outlined on the APPS for pain assessment were responsive to fentanyl. Fentanyl has been shown as an effective perioperative pain reliever.[22] According to our findings for the CSM model, 61.0% of patients who received adequate or surgical anesthesia scored between the ranges of 40-60 for the depth of anesthesia during the initial assessment of pain (Table 2). It has been reported that trauma patients have a much higher incidence of awareness during surgery probably due to the common practice of limiting the dosages of anesthetics to these patients.[23-25] Our study indicated that 35.4% of patients had light anesthesia and 1.2% of them were in the drowsy state during the initial assessment of pain. Inadequate depth of anesthesia may result in awareness[26, 27] which, may be revealed as implicit memory of intra-operative events in the postoperative period, and may come with a risk of postoperative stress disorders; [28] an opininion shared by Heier and Steen (1996) when reporting on the incidence of awareness during anesthesia for surgery.[29] Sandin *et al* (2000), also reported awareness in cases anesthetized with techniques including neuromuscular drugs and patients not receiving muscle relaxants.[30] Combining both APPS and CSM simultaneously were effective in differentiating pain responses and inadequate depth of anesthesia during the intraoperative pain assessment. It also helped with the choice of drugs to administer in addition to anesthetics during the intraoperative period. Among those adequately anesthetized and recorded experiencing moderate to severe pain, they were administered with only fentanyl for pain treatment and it was adequate to relieve pain and maintain adequate anesthesia for surgery among many of the patients without administering any further anesthetics. This helped prevent over-sedation and prolonged recovery after surgery. Many of the patients were extubated early in the operation room after surgery.

8. Conclusions

The collective data and evidences from our work strongly suggest that detecting pain during surgery using the APPS and CSM models offered adequate intraoperative pain and anesthesia management. Therefore, we present a novel pain assessment tool with clinical utility during the intraoperative period to help anesthesiologists detect and predict in advance any unnoticed pain on the part of surgical patients so as to offer adequate interventions to treat and prevent its related complications.

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