Patterns and Clinical Correlates of Pain Among Brain Injury Patients in Critical Care Assessed with the Critical Care Pain Observation Tool

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**Abstract:**
This study was conducted to assess the patterns and clinical correlates of acute pain in brain injury patients during the critical care period using the Critical Care Pain Observation Tool (CPOT). Data were collected from 31 brain-injury patients admitted to an intensive care unit (ICU) at a university hospital located in Incheon, Republic of Korea. Glasgow Coma Scale and CPOT scores were assessed on days 1, 3, 6, 9, and 14 after ICU admission. Results showed that temporal changes in pain intensity displayed a consistent pattern in critical care patients with a brain injury during the first 14 days of ICU admission. Mean pain score was highest on day 1, decreased rapidly to reach a minimum on day 3 or 6, and then increased on day 9. In most patients, pain reduced slightly on day 14. Mean CPOT scores were significantly higher in the nonsurgery group than in the surgery group. There was also a nonsignificant trend of higher pain intensity scores among patients with moderate brain injury compared with those with severe injury. CPOT scores immediately after endotracheal suctioning were significantly higher than before endotracheal suctioning, but CPOT scores 20 minutes after suctioning were similar to those before suctioning. The present study may be meaningful in terms of presenting valid clinical information regarding the patterns and characteristics of acute pain in brain injury patients who are often unable to self-report on the presence and intensity of pain.

Critically ill patients in intensive care units (ICUs) may experience moderate to severe pain (Puntillo, White, Morris, Perdue, Stanik-Hutt, Thompson, & Wild, 2001) due to surgery, trauma, invasive procedures, therapeutic devices, and certain nursing interventions (Morrison et al., 1998; Puntillo et al., 2001). Of these nursing interventions, endotracheal suctioning, blood sample collection, drain
removal procedures, and turning or repositioning have been previously identified to be major sources of pain (Siffleet, Young, Nilolletti, & Sharr, 2007).

Studies have shown that ICU nurses rate pain intensity at consistently lower levels than patients do and have concluded that this is likely to cause inadequate pain relief (Kwekkeboom & Herr, 2001; Labus, Kecfe, & Jensen, 2003; Puntillo, Miaskowski, Kehrle, Stannard, Gleeson, & Nye, 1997). In addition, pain is often underestimated during critical periods, because the priority in critically ill patients is resuscitation and pain assessments are incomplete and difficult (Hamill-Ruth & Marohn, 1999).

Much pain research in brain injury patients has focused on the rehabilitation or management of chronic pain, because the physical and psychosocial sequelae of chronic pain include depression, anxiety, decreased socialization, sleep disturbance, and job loss, which all affect overall health outcome. On the other hand, acute pain in brain injury patients during critical periods has received little research attention.

Unrelieved acute pain can initiate stress responses that alter neuroendocrine secretions, which causes oxygen consumption to increase, prolonged catabolism, hyperglycemia with insulin resistance, immune function alterations, blood pressure changes, heart rate increases, arrhythmia, sodium retention, and urine volume reductions (Hamill-Ruth & Marohn, 1999), which in turn, exerts a negative effect on recovery. Therefore, ICU nurses need to be aware of the importance of precise pain assessment and appropriate management.

Although pain is usually assessed with the use of self-reports, critically ill patients, particularly patients with a brain injury, are often unable to provide a self-report on the presence and intensity of pain, because of a reduced level of consciousness, tracheal intubation, or the administrations of sedatives, paralyzing agents, or muscle relaxants (Aissaoui, Zeggwagh, Zekraoui, Abidi, & Abouqul, 2005). Herr et al. (2006) advocated that all patients have the right to have pain assessed and treated immediately, and therefore special considerations are necessary for patients who cannot communicate their pain. Furthermore, even though self-reporting is the most reliable way of assessing pain, other valid and reliable measures are clearly required to assess pain in nonverbal patients.

A number of studies have shown that behavioral assessments provide a relatively valid and reliable means of assessing pain in nonverbal patients (Anand & Craig, 1996; Herr et al., 2006; Kwekkeboom & Herr, 2001; Li, Puntillo, & Miaskowski, 2008), and concurrently various behavioral pain assessment tools have been developed, e.g., the Behavioral Pain Rating Scale, the Behavioral Pain Scale, the Pain Behavior Assessment Tool, the Critical Care Pain Observation Tool (CPOT), the Pain Assessment and Intervention Notation Algorithm, the Pain Algorithm, and the Nonverbal Pain Scale. The majority of these tools include facial expression, body movement, muscle tension, and ventilator compliance as behavioral pain indicators.

The CPOT was originally developed based on the findings of a literature review and reviews of the medical records of cardiopulmonary and neurosurgery patients and of physicians’ and nurses’ notes (Gelinas, Fortier, Viens, Fillon, & Puntillo, 2004). This tool evaluates four behavioral domains: facial expression, body movement, muscle tension, and ventilator compliance/vocalization. Li, Puntillo, and Miaskowski (2008) provided good evidence for face, constructive, and criterion validity and the interrater reliability of this scale in nonverbal adult patients, including brain injury patients. Therefore, CPOT appears to be suitable for use in brain-injured nonverbal patients.

The present study was conducted to assess the patterns and clinical correlates (brain injury severity, brain surgery, and particular nursing procedures, such as endotracheal suctioning) of acute pain in brain injury patients during the critical period with the use of the CPOT. The specific aims were: 1) to assess the intensities and temporal patterns of acute pain in brain injury patients during the critical period; 2) to compare pain according to injury severity and whether the patients underwent brain surgery or not; and 3) to compare pain before and after endotracheal suctioning, a major nursing activity in brain injury patients in ICUs.

METHODS

Study Design and Participants
The present study adopted a descriptive design for the correlation analysis. Data were collected from a convenience sample of brain-injury patients admitted to an ICU at a university hospital located in Incheon, Republic of Korea, between September 2008 and February 2009. Inclusion criteria were age >18 years and Glasgow Coma Scale (GCS) score of 3-12. Patients with previous experience of paralysis, neuropathic pain, impaired consciousness, and dementia were excluded. Patients on a neuromuscular blocking medication were also excluded. A total of 31 subjects were included. The sample size of the present study was determined by a power analysis. The result of power analysis indicated that a sample size of 85 was the number needed for the present study (θ = 0.05; 1 – β = 0.08). Because repeated measurements (five times) were conducted, a constant of 0.32 was multiplied (Faul, Erdfelder, Buchner, & Lang, 2009), resulting in the final estimated sample size of 29-30.
Procedures

This study was approved by the Human Research Committee of the university hospital (Ethics Committee of the institution). The purposes and procedures of the study were explained to the patients and the medical staff involved with each patient. Informed consents were obtained from patients or family members when a patient was unable to provide consent owing to loss of consciousness.

General (age, gender, influence of alcohol at time of admission, past medical history), diagnostic, and medication-related data (at time of admission) were collected at ICU admission. GCS scores were assessed on days 1, 3, 6, 9, and 14 after ICU admission. Pain assessments were performed twice per day (at 13:00-15:00 and 21:00-23:00) on days 1, 3, 6, 9, and 14 after ICU admission with the use of CPOT. The reason for evaluating pain intensity for up to 14 days after admission was that the average length of ICU stay for brain injury patients is ~8-14 days (Kim, 2004). Therefore, this period was defined as the critical period for brain injury patients in the present study, although no clear consensus has been reached regarding such a time frame. To assess endotracheal suction–induced pain, pain intensities (CPOT scores) were determined before, immediately after, and 20 minutes after endotracheal suctioning on days 1, 3, 6, 9, and 14 after ICU admission. Endotracheal suction was chosen as a representative major ICU nursing activity responsible for pain, as has been previously reported (Puntillo et al., 2001; Siefke et al., 2007). Pain was evaluated 20 minutes after endotracheal suctioning because the stress hormones, epinephrine and norepinephrine, which both have half-lives in the 1-3 minutes range, are presumably released by a stressful procedure such as endotracheal suctioning but are known to return to normal levels after 15-20 minutes (Berne & Lery, 1983). Occasionally, endotracheal suctioning was reperformed owing to the presence of a mucous plug or respiratory distress symptoms, such as restlessness, cough, hyperventilation, respirator alarm sounds, or decreased oxygen saturation (Ahn, 2005). In such cases, pain was reassessed before, immediately after, and 20 minutes after resuctioning. All data collections and measurements were conducted by the first author.

Measurements

Brain injury severity was measured using the GCS, which was originally developed by Teasdale and Jennett (1974) to assess levels of consciousness. However, it is also used as a standard measure of acute brain injury severity (Bahloul et al., 2004; Rovlias & Kotsou, 2004). The GCS is a 15-point scale and comprises three measurements: eye opening (4 points), verbal (5 points), and motor responsiveness (6 points). Commonly, scores of 3-8, 9-12, and 13-15 are considered to indicate severe, moderate, and mild brain injury, respectively (Bahloul et al., 2004). The GCS has been demonstrated to have adequate construct validity, prognostic value (Jagger, Jane, & Rimel, 1983; Teasdale & Jennett, 1974), and interrater reliability (*r* = 0.86-0.95) (Rowley & Fielding, 1991).

Pain was assessed with the use of the CPOT, which was originally developed based on a literature review and reviews of 52 medical records of cardiopulmonary and neurosurgery patients and of 12 physician’s and 48 nurse’s notes. The developers of CPOT demonstrated its reliability and validity in critically ill adults (Gelinas & Johnston, 2007; Gelinas, Viens, Fortier, & Fillion, 2006). Its construct validity was confirmed by a significant increase in CPOT scores associated with the turning procedure, and criterion validity was demonstrated by a moderate correlation between CPOT scores and patient Verbal Descriptive Scale scores (Gelinas et al., 2006). The content validity of the CPOT was also established through expert review (four physicians and 13 critical care nurses) by obtaining all content validity indices >0.80 (Gelinas, Harel, Fillion, Puntillo, & Johnston, 2009). In addition, the CPOT was found to have good specificity (83%-97%) but lower sensitivity (47%-63%) for the detection of pain in intubated adults (Gelinas et al., 2009). Its interrater reliability falls in the range of 0.80-0.93 (Gelinas & Johnson, 2007). The CPOT is a unidimensional measure that evaluates four behavioral domains: facial expression, body movement, muscle tension, and ventilator compliance (for intubated patients) or vocalization (for extubated patients). Each domain is scored from 0 (no response) to 2 (normal response), and total scores therefore range from 0 (no pain) to 8 (extreme pain).

Data Analysis

Statistical analysis was performed using SPSS version 17.0. Descriptive analysis was used to analyze general subject characteristics and disease-, health-, and treatment-related characteristics. To assess the intensities and temporal patterns of acute pain in brain injury patients during the critical period, repeated-measures analysis of variance (RM-ANOVA) and post hoc comparisons were conducted. To compare pain according to injury severity and whether the patients underwent brain surgery or not, RM-ANOVA was used; to compare pain before and after endotracheal suctioning, the paired *t* test was used.
FINDINGS

Descriptive Analysis

Of the 31 subjects, 14 (45.2%) were male and 17 (54.8%) were female. Mean subject age was 58.26 ± 17.37 years (range 22-85 years). Regarding diagnoses, ten (32.3%) subjects had a subarachnoid hemorrhage, eight (25.8%) an intracerebral hemorrhage, five (16.1%) a subdural hemorrhage, seven (22.6%) a brain infarction, three (9.7%) a contusional hemorrhage, two (6.5%) an intraventricular hemorrhage, and two (6.5%) a brain tumor.

Most (93.6%; n = 29) were admitted to the hospital through the emergency department. At admission, no subject was found to be under the influence of alcohol. Hypertensive subjects accounted for 41.9% (n = 13), diabetes mellitus 16.1% (n = 5), and atrial arrhythmia 3.2% (n = 1). Thirteen subjects (41.9%) were taking antihypertensive drugs and 5 (16.1%) hypoglycemic agents.

Of the 22 (71.0%) subjects that underwent brain surgery on at least one occasion after admission, ten (31.8%) received craniectomy, four (18.1%) craniotomy, eight (36.3%) coil-embolization, six (27.3%) extraventricular drainage (EVD), two (9.1%) extralesional drainage (ELD), and one (4.3%) burr-hole drainage (the overall percentage exceeds 100% because some patients underwent brain surgery more than once).

Twenty-nine subjects (93.5%) were endotracheally intubated, and of these, 26 were put a mechanical ventilator. The majority of the subjects had at least one invasive tube or catheter inserted, that is, an EVD, an ELD, a hemovac, a Jackson-Pratt suction drain, a tracheostomy tube, a nasogastric tube, a central or peripheral venous catheter, an urinary catheter, or a thoracic tube (number of tubes or catheters inserted per subject ranged from 2 to 9). Mean subject GCS scores were 6.58 ± 2.00 on day 1, 6.69 ± 2.24 on day 3, 6.38 ± 2.03 on day 6, 7.71 ± 2.16 on day 9, and 8.03 ± 2.10 on day 14 after ICU admission.

Twenty-two of the 31 subjects underwent brain surgery at least once. Their mean CPOT scores were 0.64 ± 1.14, 0.14 ± 0.47, 0.32 ± 0.72, 0.55 ± 0.86, and 0.18 ± 0.50 on days 1, 3, 6, 9, and 14 after ICU admission, respectively (Table 2; Fig. 1B). The highest mean CPOT score was observed on day 1, but this decreased (0.29 ± 0.64, range 0-2) rapidly to reach a minimum on day 3. Subsequently, it increased on day 9, but was much reduced on day 14.

For the nine subjects that did not undergo brain surgery, mean CPOT scores were 1.89 ± 1.76, 0.67 ± 0.87, 0.22 ± 0.44, 0.89 ± 1.27, 1.44 ± 1.13) on days 1, 3, 6, 9, and 14 after ICU admission (Table 2; Fig. 1B). The highest mean CPOT score was observed on day 1 (1.89 ± 1.76), but this started to decrease on day 3 (0.67 ± 0.87), reached a minimum on day 6 (0.22 ± 0.44), and then increased to reach 1.44 ± 1.13 on day 14.

Overall, mean CPOT scores were higher in the nonsurgery group than in the surgery group, and this difference was significant (group x time: F = 2.55; p = .04), specifically on day 1 (t = 2.36; p = .05), on day 3 (t = 2.22; p = .04), and on day 14 (t = 4.37; p < .01; Table 2). For this analysis, analgesic and sedative use was treated as a covariate, because analgesics and sedatives play vital roles in controlling pain and their dosages were probably affected by surgery type.

GCS scores of 3-8, 9-12, and 13-15 are considered to indicate severe, moderate, and mild brain injury, respectively, according to the literature (Bahloul et al., 2004; Demetriades, Kuncir, Murray, Velmahos, Rhee, & Chan, 2004; Schreiber, Aoki, Scott, & Beck, 2002). However, no subject had a GCS score of 13-15 in the present study.

Study Aim 1: Intensities and Temporal Patterns of Acute Pain

The highest mean CPOT score (1.00 ± 1.44, range 0-5) was observed on day 1 (Table 1). This started to decrease on day 3 after ICU admission (0.29 ± 0.64, range 0-2), maintained a minimum from day 3 to day 6 (0.29 ± 0.64, range 0-2), increased to 0.65 ± 0.99 (range 0-3) on day 9, and reduced slightly on day 14 (0.55 ± 0.93, range 0-3; Fig. 1A). Furthermore, these temporal changes in pain intensity were significant (F = 3.23; p = .04; Table 1). Specifically, mean CPOT scores were significantly different between days 1 and 3 (p = .01), days 1 and 6 (p = .01), and days 6 and 9 (p = .05). Mean CPOT scores reduced slightly on day 14 (range 0.29-1.00).

Study Aim 2: Pain According to Injury Severity and Whether the Patients Underwent Brain Surgery or Not

Twenty-two of the 31 subjects underwent brain surgery at least once. Their mean CPOT scores were 1.89 ± 1.76, 0.67 ± 0.87, 0.22 ± 0.44, 0.89 ± 1.27, 1.44 ± 1.13) on days 1, 3, 6, 9, and 14 after ICU admission, respectively (Table 2; Fig. 1B). The highest mean CPOT score was observed on day 1, but this decreased (0.29 ± 0.64, range 0-2) rapidly to reach a minimum on day 3. Subsequently, it increased on day 9, but was much reduced on day 14.

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In those with severe brain injury (GCS 3-8; n = 21), mean CPOT scores were 0.57 ± 0.87, 0.24 ± 0.63, 0.01 ± 0.3, 0.43 ± 0.93, and 0.43 ± 0.87 on days 1, 3, 6, 9, and 14 after ICU admission, respectively. The highest mean CPOT score was recorded on day 1, but this started to decrease on day 3, reached a minimum on day 6, increased on day 9, and then slightly decreased on day 14 (Table 3; Fig. 1C).

In those with moderate injury (GCS 9-12; n = 10), mean CPOT scores were 1.90 ± 1.97, 0.40 ± 0.70, 0.70 ± 0.95, 1.10 ± 0.99, and 0.80 ± 1.03 on days 1, 3, 6, 9, and 14, respectively. The highest mean CPOT score was recorded on day 1, but this was markedly decreased on day 3, and then increased continuously until day 9 (Table 3; Fig. 1C).

Overall CPOT scores in those with moderate injury were higher than in those with severe injury group, but differences were not significant (group × time: F = 1.62; p = .20; Table 3). For this analysis, analgesics and sedative use was treated as a covariate because analgesics and sedative play a vital role in controlling pain and their dosage was probably affected by injury severity. When subjects were divided into two groups based on injury severity regardless of time, a significant difference in CPOT scores was observed between subjects with moderate and severe injury (group: F = 13.95, p < .001; Table 3).

### Study Aim 3: Pain Before and After Endotracheal Suctioning

To compare pain intensities before and after endotracheal suctioning, CPOT scores were assessed before, immediately after, and 20 minutes after endotracheal suctioning on days 1, 3, 6, 9, and 14 after ICU admission (Table 4). Without exception, CPOT scores were significantly higher immediately after suctioning ($t = -8.00, p < .01$ for day 1; $t = -10.48, p < .01$ for day 3; $t = -8.28, p < .01$ for day 6; $t = -10.81, p < .01$ for day 9; $t = -11.37, p < .01$ for day 14). However, CPOT scores at 20 minute after suctioning were not significantly different from those before suctioning, except on day 1 ($t = 2.01, p = .05$ for day 1; $t = -1.30, p = .20$ for day 3; $t = 1.43, p = .16$ for day 6; $t = 1.00, p = .32$ for day 9; $t = -0.49, p = .62$ for day 14).

**DISCUSSION**

In the present study, pain assessments were conducted in critical care patients with brain injury throughout the first 14 days of ICU admission with the use of the CPOT to provide descriptive data on patterns of temporal change in pain during this critical period. Regarding overall pain intensity, subjects in the present study exhibited a relatively low level of pain, which is consistent with the findings reported by Gelinas et al. (2006), who found that unconscious intubated and conscious extubated brain injury patients had CPOT scores of 0.55-0.67 and 0.69-0.87, respectively.

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Temporal changes in pain intensities displayed a consistent pattern in the present study. For the 31 study subjects, mean pain score was highest on day 1, decreased rapidly to reach a minimum on day 3 or 6, then increased on day 9 and, in most cases, reduced slightly on day 14. Furthermore, these changes in pain intensity were significant. Because few studies have been conducted on the temporal pattern of pain in brain injury patients during the critical period, direct comparisons between our results and those of others are difficult. However, after general surgery, such as an abdominal operation, pain has been reported to decrease continuously with time (Park, 2004; Woo, 2006).

The nature of the ICU environment often leads physicians and nurses to underestimate pain (Kwekkeboom & Herr, 2001; Labus et al., 2003; Puntillo et al., 1997).
The finding that pain intensity scores were highest on day 1 should be noted by those involved in critical nursing practice in cases of acute brain injury. Importantly, it should be remembered that although ICU patients may not be able to self-report pain, they may still have pain. Therefore, ICU patients need to be continuously assessed for the presence and level of pain. Table 2 shows the temporal pattern of pain according to brain surgery.

**Table 2.** Temporal Pattern of Pain According to Brain Surgery (n = 31)

<table>
<thead>
<tr>
<th>Group × Time</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>1.89 (1.79)</td>
<td>0.64 (1.14)</td>
</tr>
<tr>
<td>Day 3</td>
<td>0.67 (0.97)</td>
<td>0.14 (0.47)</td>
</tr>
<tr>
<td>Day 6</td>
<td>0.22 (0.44)</td>
<td>0.22 (0.72)</td>
</tr>
<tr>
<td>Day 9</td>
<td>0.89 (2.77)</td>
<td>0.88 (2.30)</td>
</tr>
<tr>
<td>Day 14</td>
<td>9.27 (0.01)</td>
<td>4.37 (0.01)</td>
</tr>
</tbody>
</table>

*Independent t-test.* †Repeated-measures analysis of one-way variance. Covariates: dosage of analgesics and sedative because covariate should be continuous, total dosages of analgesics and sedative were summed regardless of types of analgesics and sedatives.

**FIGURE 1.** (A) Pain scores in critical period. (B) Pain scores according to brain surgery. (C) Pain scores according to severity of brain injury.
pain to ensure that pain control is adequate, as well as monitored for other vital physiologic variables, such as respiration rate, heart rate, ICP, and blood pressure. In addition, the present findings suggest a need for more aggressive pain management during critical period, particularly on day 1. However, more detailed studies are required to confirm this issue.

We also examined the relationship between pain intensity and analgesics use and consciousness level. The proportions of subjects that required analgesics on days 1, 3, 6, 9, and 14 after ICU admission were 80.6%, 74.2%, 71.0%, 74.2%, and 51.6%, respectively. This temporal pattern differs from the temporal pattern of pain intensity and indicates that pain changes observed in this study are unlikely to have been related to analgesics use.

On the other hand, temporal pain changes could be associated with consciousness levels. Findings of the present study show that GCS scores varied during the first 6 days after ICU admission, but then consistently improved, which was in line with pain perception. It has been reported that secondary brain insults (brain edema and intracranial hypertension) can occur immediately after primary brain injury and produce further neurologic deterioration and reduced levels of consciousness (Donkin & Vink, 2010; Elliott &

### Table 3.

<table>
<thead>
<tr>
<th>Day</th>
<th>Mod</th>
<th>Sev</th>
<th>Mean (SD)</th>
<th>t (p)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>Mod</td>
<td>1.00 (1.44)</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sev</td>
<td>3.26 (1.84)</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.52 (1.06)</td>
<td>2.01 (.05)</td>
<td></td>
</tr>
<tr>
<td>Day 2</td>
<td>Mod</td>
<td>0.29 (0.64)</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sev</td>
<td>2.58 (1.46)</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.45 (0.68)</td>
<td>1.30 (.20)</td>
<td></td>
</tr>
</tbody>
</table>

*Paired t test: before × immediately after endotracheal suctioning and before × 20 minutes after endotracheal suctioning.
Therefore, it could be inferred that the decreases in CPO Ter scores observed over day 3 to day 6 were caused by a diminished level of consciousness due to secondary neuronal injuries.

In the present study, the mean CPO Ter scores of those that did not undergo surgery were significantly higher than the scores of those that did. This may have been due to analgesic use, because a higher proportion of subjects in the surgery group were administered analgesics (55%-91% vs. 44%-65%). Furthermore, most of those that underwent brain surgery were given barbiturate or midazolam for ICP control, and these agents may have affected pain perception.

In terms of brain injury severity, overall CPO Ter scores in patient with moderate injury tended to be higher than in patients with severe injury, though this was without significance. A similar finding was obtained in patients with severe traumatic brain injury, who were found to complain of pain less frequently than those with a mild-moderate brain injury (Beetar, Guilmette, & Sparadeo, 1996; Szymanski & Linn, 1992; Wilkinson & Gilchrist, 1980). Beetar et al. (1996) also reported that 70% of their subjects with a mild brain injury complained of pain, whereas only 40% of those with a mild-moderate brain injury did so. A further detailed study on pain at different severity levels is needed.

Throughout the 14-day ICU admission period, CPO Ter scores immediately after suctioning were significantly higher than those before suctioning, without exception. However, CPO Ter scores at 20 minutes after suctioning did not differ significantly from those before suctioning. This finding is in accordance with that found by Gelin as and Johnson (2007), who found that significant increments in pain level occur after endotracheal suctioning in intubated brain injury patients with diverse disease types. In addition, endotracheal suctioning has been repeatedly reported to induce hypoxia, and it is generally accepted that oxygen should be provided to prevent endotracheal suctioning-induced hypoxia (Oh & Seo, 2003; Wainwright & Gould, 1996). Similarly, our finding of higher CPO Ter scores immediately after suctioning suggests the need for routine pain relief before suctioning.

The present study is meaningful because it presents valid clinical information about patterns and characteristics of acute pain in brain injury patients who are often unable to self-report on the presence and intensity of pain. In addition, the study provides useful evidence on the need for acute pain management and raises clinical concerns regarding pain control in critically ill brain injury patients.

**CONCLUSIONS AND STUDY LIMITATIONS**

Temporal changes in pain in critical care patients with a brain injury were found to display a consistent pattern during the first 14 days of ICU admission. Mean pain score was highest on day 1, decreased rapidly to reach a nadir on day 3 or 6, and then increased on day 9. In most cases, pain reduced slightly between days 9 and 14. Furthermore, these temporal changes in pain intensity were found to be significant. It can be speculated that these temporal changes are probably associated with level of consciousness and that they are unlikely to be related to analgesics use. In addition, mean CPO Ter scores in the nonsurgery group were significantly higher than in the surgery group, and the mean CPO Ter scores of those with moderate brain injury were nonsignificantly higher than the scores of those with severe injury. Finally, CPO Ter scores immediately after endotracheal suctioning were significantly higher than before endotracheal suctioning, but scores 20 minutes after suctioning were similar to those before suctioning.

Pain is a stressor in critical care patients and exerts a negative influence on patient recovery. Therefore, the assessment and management of pain requires priority in critical care practice. In particular, acute pain causes sympathetic stimulation and thus affects ICP in brain injury patients. Unfortunately, estimates of acute pain are often inaccurate, and therefore the relief of pain is inadequate in these patients. For this reason, more precise measurement tools are required to determine pain severities in these patients, and they should be repeatedly tested for validity and reliability. Most importantly, the first step toward providing adequate pain relief is the collection of valid clinical information about patterns and characteristics of pain in defined patient groups. For this reason, the present study was conducted to provide descriptive information about pain patterns after brain injury during the critical period as well as present evidence that CPO Ter provides a useful measure of pain in brain injury patients during this period.

However, it should be borne in mind that this study is limited by the small number of patients recruited and by a lack of empirical evidence confirming the sensitivity of CPO Ter in nonverbal patients. To confirm the findings of this study, it is suggested that a large-scale study be conducted with other verified behavioral pain scales, such as the Behavioral Pain Rating Scale, the Behavioral Pain Scale, and the Pain Behavior Assessment Tool, in nonverbal patients.
REFERENCES


