

Original article

Pain severity and pain control following intracranial surgery

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Objective To explore the incidence and severity of acute post-craniotomy pain in Maharaj Nakorn Chiang Mai Hospital, including the adequacy of routine pain relief practices.

Methods Postoperative analgesia prescribed for patients undergoing elective intracranial surgery was classified into two surgical groups: the supratentorial and the infratentorial approaches. Demographic and perioperative clinical data, including the use of a scalp block and the dosage of fentanyl, were collected and analysed. Postoperative pain was assessed for three days following surgery using a numeric rating scale (NRS) or a revised non-verbal pain scale (NVPS-R). Pain medication treatment and side effects were recorded.

Results Of 251 patients, 190 underwent a supratentorial craniotomy, while 61 were treated with an infratentorial approach. On the first postoperative day, the incidence of a NRS score ≥ 4 (moderate to severe pain) was 18.2-31.8% with NRS versus 6.4-11.1% for NVPS-R. The incidence of a pain score of zero gradually increased over time, reaching 100% in patients assessed with NVPS-R and 87% in those with NRS on day three. In the infratentorial group, a pre-incisional scalp block decreased pain scores upon arrival at the ward and for the first four-hour period after surgery ($p=0.05$ and 0.042 , respectively). Over 90% of patients were prescribed intravenous tramadol every six hours on postoperative day one, but only 60% were given tramadol during the first 8-16 hours in the supratentorial group, while 75% of the infratentorial group received tramadol ($p=0.021$).

Conclusion Pain after intracranial surgery was effectively relieved with tramadol. NVPS-R should be investigated further to confirm its reliability as a tool for non-verbally communicating patients. **Chiang Mai Medical Journal 2019;58(4):199-209.**

Keywords: pain severity, pain control, tramadol, intracranial surgery

Introduction

The issue of pain control following a craniotomy has been underrecognized and has received inadequate treatment (1-5). Evidence has demonstrated that acute pain is common during the first two days after major intracranial surgery (6,7). A body of evidence has shown that opioids which

do reduce pain, can also affect the monitoring of postoperative neurological conditions (4,6,8) as well as the other aspects of the condition of the patient (9,10). Apprehension over that situation has resulted in controversy related to the use of opioids and patient safety issues following ma-

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for neurosurgery (11,12). The opioid tramadol is frequently prescribed to control pain after a craniotomy. Its benefits derive from sparing effects of clinically significant sedation, pupillary miosis, and respiratory depression (13-15). The major side effects of opioid use which have been reported in several studies are nausea and vomiting (6,13,16,17).

The validation tool most commonly used worldwide for self-reporting of pain severity in adults and children is the numeric rating scale (NRS). This tool requires patient cooperation to express their pain level in numbers from 0 (no pain) to 10 (worst pain imaginable) (18,19). However, the tools based on pain behaviour and physiological scales in non-communicative patients can be one of two versions. There are two versions of non-verbal physiological pain scales for use with non-communicative patients: the

original Non-Verbal Pain Scale (NVPS) and the Revised Non-verbal Pain Scale (NVPS-R) (20,21) (Table 1). One study comparing the validity and reliability of NVPS and NVPS-R with patients on mechanical ventilators in the intensive care unit (ICU) found that physicians were inclined to prefer NVPS-R (19).

The present prospective cohort study explored the incidence and severity of acute post-craniotomy pain in intracranial surgery patients our hospital, including the adequacy of routine practices for pain relief following major intracranial surgery.

Methods

The study protocol received ethics approval from the Institutional Review Board. Adult patients (age 18-70 years) scheduled for elective

Table 1. Adult nonverbal pain scale (20,21)

Category	Pain level		
	0	1	2
1. Face	No particular expression or smile	Occasional grimace, tearing, frowning, wrinkled forehead	Frequent grimace, tearing, frowning, wrinkled forehead
2. Activity (movement)	Lying quietly, normal position	Seeking attention through movement or slow, cautious movement	Restless, excessive activity and/or withdrawal reflexes
3. Guarding	Lying quietly, no positioning of hands over areas of body	Splinting areas of the body, tense	Right, stiff
4. Physiological I (vital Signs)	Stable vital signs (no change in past 4 hours)	Change over past 4 hours in any of the following: SBP >20 mmHg, HR >20/min, RR >10/min	Change over past 4 hours in any of the following: SBP >30 mmHg, HR >25/min, RR >20/min
5A*. Physiological II (pupil reaction, diaphoresis, Pallor)	Warm, dry skin	Dilated pupils, perspiring, flushing	Diaphoretic, pallor
5B†. Respiratory (RR, ventilator compliance) (21)	Baseline RR/SpO ₂ Compliant with ventilation	RR >10 above baseline, or 5% decrease, SpO ₂ mild asynchrony with ventilation	RR >20 above baseline, or 10% decrease, SpO ₂ severe asynchrony with ventilation

Adapted from Table 1: Adult Nonverbal Pain Scale[20] and Table: Adult Nonverbal Pain Scale University of Rochester Medical Center [21]

*5A. Physiological II: the fifth component of non-verbal pain scale[20]; †5B. Respiratory: the fifth component of revised non-verbal pain scale[21]

HR; heart rate, RR; respiratory rate, SBP; systolic blood pressure, SpO₂; pulse oximeter oxygen saturation

intracranial surgery from June 1, 2015 to May 31, 2016 were recruited for the study. Patients unable to understand and sign the informed consent form were excluded.

Demographic and clinical data collected included age, sex, underlying diseases, Glasgow Coma Scale (GCS) score, body mass index (BMI), and American Society of Anesthesiologists (ASA) physical status classification. Intraoperative data collected included pre-incisional scalp block use, total fentanyl administered, operation type and surgical site, duration of surgery, duration of administration of anaesthetic, and suitability for immediate extubation. Postoperative pain was assessed and data collected by bedside nurses in the post-anaesthesia care unit (PACU), the neurosurgical ICU or the in-patient ward, depending on where the patient was admitted. During a preoperative visit, all patients were informed about how to rate their pain severity in the postoperative period. For patients who were successfully extubated, NRS was used for pain assessment. NVPS-R was used for non-verbally communicating patients, primarily patients who remained intubated. Pain assessment was conducted every four hours for three days. Pain severity measured with both scoring systems, NRS and NVPS-R, was categorized into three levels: no pain [0], mild pain [1-3], and moderate to severe pain [4-10].

The NVPS includes five categories of data: facial movement, body movement, guarding, physiological I (blood pressure, heart rate, and respiratory rate), and physiological II (pupil reaction, diaphoresis, and pallor) (20). In this study the physiological II category was found to be unreliable and was judged invalid, so the fifth component in NVPS-R was replaced with respiratory parameters (respiratory rate and ventilator compliance) (21).

Data are presented as number plus percentage, mean $\pm$ SD or median with range. Statistical Package for the Social Science, version 20 (SPSS 20, IBM, Armonk, NY, USA) was used for statistical analysis. Chi-square or Fisher's exact test were used to assess statistical differences among categorical variables, while the independent t-test or the

Mann-Whitney U test was used for continuous data. *P*-values less than 0.05 were considered statistically significant

Results

A total of 251 patients were enrolled; 190 (75.7%) underwent supratentorial craniotomy and 61 (24.3%) had the infratentorial approach. The majority (156, 62.1%) were female. Patients in the supratentorial group had a median age of 50 years (range 18-82), while those of in the infratentorial group had a median of 54 years (range 18-72), $p=0.04$. Demographic and perioperative clinical data are presented in Table 2. The successful immediate extubation rate was significantly higher in patients whose lesions were located in the supratentorial compartment ($p=0.031$). The number of patients who had a pain score evaluation with NVPS-R decreased over time due to later extubation. The number of patients using NRS increased in days two to three following surgery (Table 3). Pain scores of a few patients at some time intervals are missing due to incomplete data collection and recording.

The pain intensity scores derived from the NVPS-R and the NRS scoring systems are presented in Figures 1 and 2. The percentage of patients reporting an NRS score ≥ 4 (moderate to severe pain) was greater than for those assessed with NVPS-R at each time interval. The highest incidence of an NRS score ≥ 4 (moderate to severe pain), 31.8%, occurred immediately upon arrival at the postoperative ICU/ PACU, while the highest score for patients assessed with NVPS-R, 11.1%, occurred within the first 24 hours following the operation. The incidence of NVPS-R scores ≥ 4 decreased to less than 10% on day two and became zero at most time intervals on day three. The mean incidence of NRS scores ≥ 4 was 14.7% on day two and 9.1% on day three. The incidence of a pain score equal to zero gradually increased over time, on day three reaching up to 100% for patients assessed with NVPS-R and 87% for those with NRS.

Postoperative pain medication ordered by the neurosurgeons is summarized in Table 4. There

Table 2. Demographic and perioperative clinical data

	Total (n=251)	Supratentorial approach (n = 190)	Infratentorial approach (n = 61)	<i>p</i> -value*
Age (years)	50 (18-82)	50 (18-82)	54(18-72)	0.040 [‡]
BMI	22.8±3.7	23.0±3.8	21.9±3.2	0.056 [†]
GCS	15 (3-15)	15 (3-15)	15 (11-15)	0.271 [‡]
Sex				
Male	95 (37.6%)	79 (41.6%)	16 (26.2%)	0.032
Female	156 (62.4%)	111 (58.4%)	45 (73.8%)	
ASA classification				
I	74 (31.0%)	55 (28.9%)	19 (31.1%)	0.059
II	149 (58.0%)	108 (56.8%)	41 (67.2%)	
III	27 (10.2%)	26 (13.7%)	1 (1.6%)	
IV	1 (0.4%)	1 (0.5%)	0 (0.0%)	
Operation				
Aneurysm/AVM surgery	23 (9.2%)	22 (11.6%)	1 (4.3%)	0.000
Vascular bypass	11 (4.4%)	9 (4.7%)	2 (3.3%)	
Meningioma removal	64 (25.5%)	56 (29.5%)	8 (13.1%)	
Other tumor removal	107 (42.7%)	67 (64.4%)	40 (35.6%)	
Cranioplasty	28 (11.2%)	24 (12.6%)	4 (6.6%)	
Other	18 (7.2%)	12 (6.3%)	6 (9.8%)	
Scalp block				
Yes	136 (54.2%)	104 (54.7%)	32 (52.5%)	0.756
No	115 (45.8%)	86 (45.3%)	29 (47.5%)	
Intraoperative fentanyl dosage (mcg)	255 (50-1050)	250 (50-1050)	300 (100-800)	0.400 [‡]
Anesthetic duration (min)	313.8 (18-804)	315.6 (18-804)	313.2 (61-684)	0.637 [‡]
Operative duration (min)	247.2 (54-744)	252 (78-744)	243 (54-615)	0.37 [‡]
Operating room extubation				
Yes	141 (55.3%)	114 (60%)	27 (44.3%)	0.031
No	110 (44.7%)	76 (40%)	34 (55.7%)	
Postoperative admission ward				
Neurosurgical ICU	228 (88.2%)	170 (89.5%)	58 (95.1%)	0.187
PACU	23 (11.8%)	20 (10.5%)	3 (4.9%)	

ASA; American Society of Anesthesiologists, AVM; Arteriovenous Malformation, BMI; body mass index

GCS; Glasgow Coma Scale, ICU; Intensive Care Unit, PACU; Post-Anesthesia Care Unit

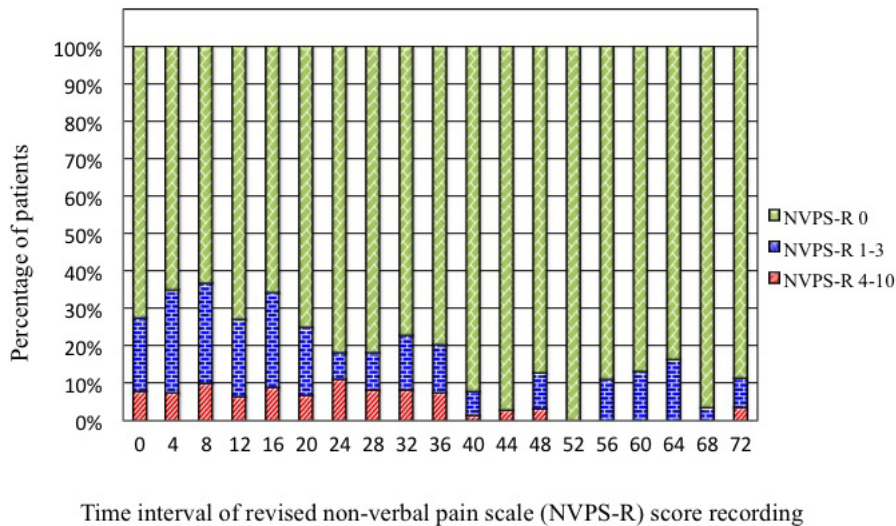
*Chi-square test if not stated otherwise, [†]Independent t-test, [‡]; Mann-Whitney U test, bold font indicates *p* < 0.05.

was no significant difference in pain rescues on any day between the two surgical approach groups. On postoperative day one, over 90% of patients in both groups were scheduled to receive intravenous (IV) tramadol every six hours. However, only 60% of patients in the supratentorial group actually received tramadol, while 75% received tramadol in the infratentorial group (*p* = 0.021). The percentage of patients receiving

tramadol decreased to 15-18% in both groups after between 16 and 24 hours (Figure 3). On postoperative day two, tramadol and acetaminophen were commonly ordered for pain control at each patient's request. Less than 4% of patients had intravenous tramadol ordered regularly every six hours, which declined to zero on day three. The percentage of patients receiving acetaminophen was about 10% in both groups on day two and less

Table 3. Frequency of pain assessment tool at each time interval

Time (hrs)	NVPS-R (n)	NRS (n)	Total
On arrival	185	66	251
4	131	120	251
8	116	134	250
12	110	140	250
16	99	151	250
20	72	176	248
24	54	187	241
28	49	199	248
32	48	201	249
36	39	209	248
40	36	212	248
44	32	217	249
48	31	214	245
52	29	217	246
56	36	210	246
60	30	216	246
64	30	215	245
68	26	214	240
72	26	206	232

**Figure 1.** Percentage of patients by NVPS-R score at postoperative time periods

than 10% on day three (Figure 4). Three patients (1.2%) received metoclopramide postoperatively for treatment of nausea and vomiting.

The advantage of a pre-incisional scalp blockade with 0.5% plain bupivacaine was most clearly evident in patients in the infratentorial approach group. That medication significantly decreased

pain scores on arrival at the ICU/ PACU as well as for the next four hours ($p=0.05$ and 0.042 , respectively). Nonetheless, the scalp blockade had no effect on the intraoperative fentanyl requirement ($p=0.822$). In the supratentorial group, a pre-incisional scalp block did not decrease total intraoperative fentanyl usage ($p=0.873$). Moreover,

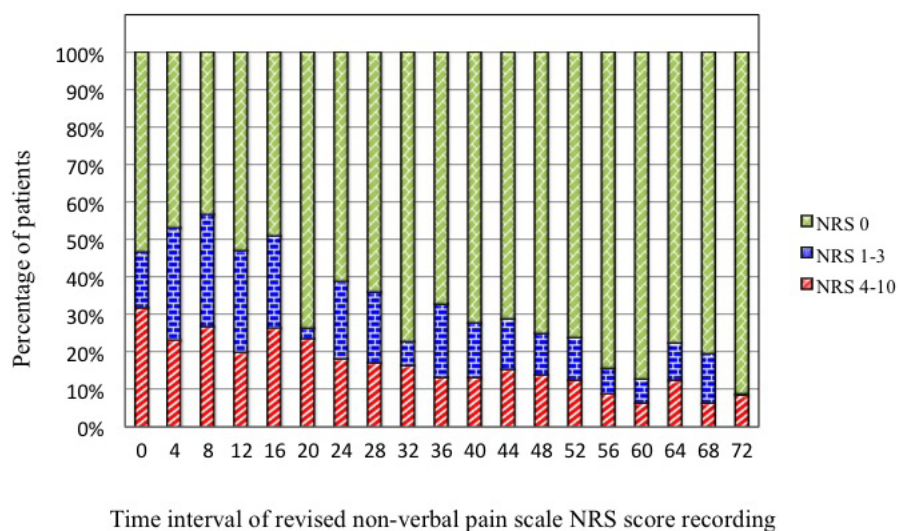


Figure 2. Percentage of patients by NRS score at postoperative time periods

Table 4. Pain medication order

Medication Order	Total (n = 251)	Supratentorial approach (n = 190)	Infratentorial approach (n = 61)	p-value
Day 1				
None ordered	0	0	0	0.844
Tramadol (50 mg) i.v. every 6 hrs.	235 (93.6%)	177 (93.15%)	58 (95.08%)	
Tramadol (50 mg) i.v.p.r.n. every 6 hrs.	1 (0.4%)	1 (0.53%)	0	
Acetaminophen (500 mg) 1-2 tab oral p.r.n.every 6 hrs.	0	0	0	
Tramadol (50 mg) i.v. and Acetaminophen (500 mg) p.r.n. every 6 hrs.	15 (6.0%)	12 (6.32%)	3 (4.92%)	
Day 2				
None ordered	22 (8.8%)	17 (8.95%)	5 (8.19%)	0.545
Tramadol (50 mg) i.v. every 6 hrs.	9 (3.6%)	5 (2.63%)	4 (6.56%)	
Tramadol (50 mg) i.v.p.r.n. every 6 hrs.	50 (19.9%)	36 (18.95%)	14 (22.95%)	
Acetaminophen (500 mg) 1-2 tab oral p.r.n. every 6 hrs.	156 (62.2%)	123 (64.74)	33 (54.10%)	
Tramadol (50 mg) i.v. and Acetaminophen (500 mg) p.r.n. every 6 hrs.	14 (5.6%)	9 (4.73%)	5 (8.19%)	
Day 3				
None ordered	22 (8.8%)	15 (7.89%)	7 (11.67%)	0.798
Tramadol (50 mg) i.v. every 6 hrs.	0	0	0	
Tramadol (50 mg) i.v. p.r.n. every 6 hrs.	20 (8.0%)	15 (7.89%)	5 (8.19%)	
Acetaminophen (500 mg) 1-2 tab oral p.r.n. every 6 hrs.	207 (82.5%)	159 (83.68%)	48 (78.69%)	
Tramadol (50 mg) i.v.and Acetaminophen (500 mg) p.r.n. every 6 hrs.	2 (0.8%)	1 (0.53%)	1 (1.64%)	

hrs; hours, i.v.; intravenous

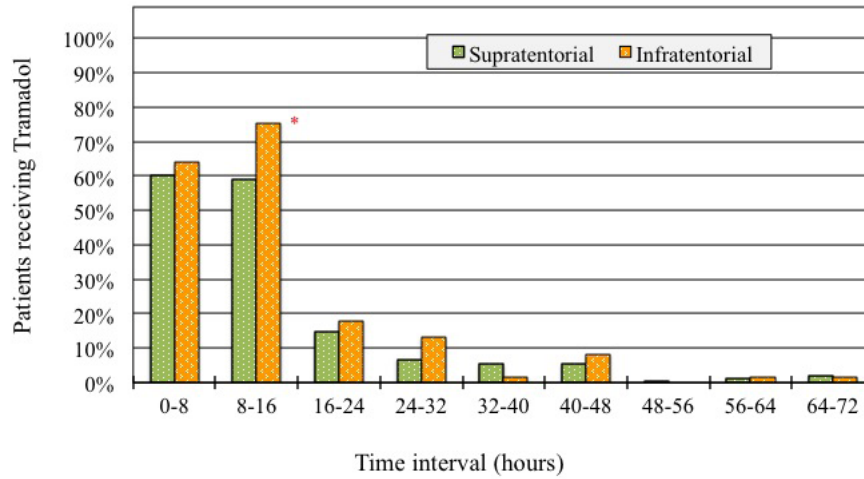


Figure 3. Percentage of patients receiving tramadol by supratentorial and infratentorial group at postoperative time periods

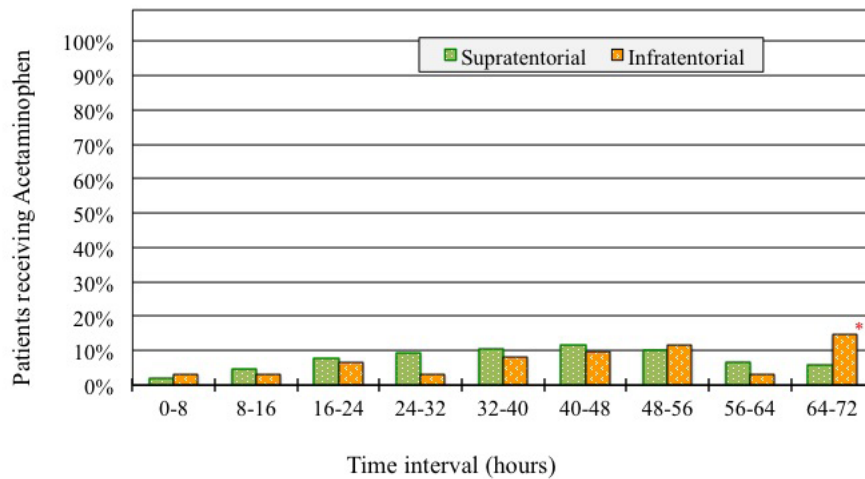


Figure 4. Percentage of patients receiving acetaminophen by supratentorial and infratentorial group postoperative time periods

the pain score assessed upon arrival at the ICU/PACU and at four hours postoperatively did not differ from patients who did not receive a scalp block ($p=0.535$, and 0.376 , respectively).

Discussion

This study found that on the first postoperative day more than 60% of patients had low pain scores (NRS or NVPS-R <4), but 60-75% of them received IV tramadol around the clock for 16 hours after surgery. On the second and third postoperative days, most patients ($>75\%$) had NVPS-R or NRS scores of 0-3, and received tramadol or

acetaminophen only on request. These findings agree with previous studies. Dunbar et al. reported in 1999 that most intracranial surgery patients required less fentanyl during surgery, had lower pain scores, and received less morphine in PACU than maxillofacial surgery and lumbar laminectomy patients (3). Jeffrey et al. found most patients (92.8%) had pain scores in the range of 0-2 after intracranial surgery (13). However, a controversy still exists. Many other studies have reported that the incidence of moderate to severe post-craniotomy pain is greater than 60% (2,3,6,7,17,25,26) and that more than 50% of neurosurgical patients

receive inadequate pain treatment (1,2).

We interpreted the results of our study that the severity of post-craniotomy pain was sufficiently mild that it could be adequately relieved with tramadol. However, tramadol has been reported to present a risk of seizures, nausea and vomiting (N and V) (27). A previous study found that 7.4% of patients experienced N and V after receiving 50 mg of tramadol (13,27). The authors of that study recommended that doses of 75 mg of tramadol should be avoided in intracranial surgery (13). Fentanyl has also been reported to have a significant N and V effect, with a incidence of 23.4% during the first 24 hours following craniotomy surgery (6). We did not include an N and V assessment in this study, but we did find that only a small percentage of patients (1.2%) received an antiemetic drug. This finding, however, might not represent the true incidence of postoperative N and V in craniotomy patients. Tramadol and nalbuphine have been shown to provide adequate analgesia for postoperative pain in neurosurgery and to be safe for use on a regular time schedule (14,22), a treatment regimen similar to that used by neurosurgeons who prefer to prescribe IV tramadol injection around the clock for postoperative pain control during the first 24 hours following intracranial surgery. For the two days following surgery, tramadol is usually administered on an on-demand basis. The authors found that infratentorial craniotomy patients experience more pain and require more tramadol at specific periods of time. The site of the surgery also seems to affect postoperative craniotomy pain. The differences in pain is explained by the fact that infratentorial surgery involves posterior cervical muscle damage resulting from extensive muscle resection which causes more pain than other approaches where the incision is made without involving the muscle (27-29).

A scalp block has been shown to be beneficial in providing transitional pain control in the immediate postoperative period, especially following remifentanyl-based anesthesia (30,31). One study reported on the effectiveness of pre-incision scalp blocks with either 0.25% or 0.5% bupivacaine

with 1:200,000 epinephrine in decreasing the intraoperative fentanyl requirement, but stated that it did not reduce either post-craniotomy pain or morphine consumption (32). The present study found different results. In this study, a pre-incisional scalp block provided no additional advantage to the supratentorial approach in terms of pain relief, but it did lower pain scores for two to three hours after an infratentorial approach craniotomy. Although multimodal analgesia is generally recommended to optimize pain control and lessen undesired side effects (33), the postoperative effect of scalp infiltration is of short duration when given either as a pre-incisional or as a repeated injection procedure (11).

There have been a number of reports regarding the best method for evaluating pain. A previous study by Topolovec-Vranic et al. supported using NVPS-R as a primary assessment tool in critically ill trauma and neurosurgical patients (34). Wibbenmeyer et al. reported a poor correlation between NVPS and NRS (35). Another study stated that although NVPS-R and NRS are both scaled from 0 to 10, an observational behaviour pain score cannot be assumed to be equivalent to self-reporting (36). Other studies have suggested that self-reporting of pain should be selected as the primary instrument, and that pain evaluation should be done regularly (33,37). Some studies have concluded that there is no validated pain assessment tool for evaluating pain in either verbally or non-verbally communicating patients (19,34), while others state that a non-verbal pain assessment tool provides a potential method for use with patients who remain intubated postoperatively and those who have a depressed GCS score.

There are several limitations in this study. First, the zero value of NVPS-R may not indicate "no pain". Second, pain assessment in this study was done only when patients were at rest. To further validate NVPS-R, patients should be tested both at rest and during daily activities. Third, data regarding preoperative corticosteroid administration was lacking. Corticosteroids can provide effective anti-inflammatory effects and can also

relieve postoperative headaches (36,38) and post-craniotomy pain (7,23). Additionally, in this study some risk factors previously reported as being associated with postoperative pain were not investigated, e.g., preoperative pain severity, age group, surgical procedure and psychological profile (24,39,40). Finally, patient outcomes and patient satisfaction of sufficient pain control were not collected.

Conclusions

This study shows the results of clinical practices for pain control using tramadol and acetaminophen in neurosurgical patients. Further studies are required to establish best practices guidelines and standard pain assessment tools for determining appropriate and adequate pain management in post-craniotomy patients.

Acknowledgements

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Conflicts of interest

None

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ความรุนแรงของการปวดและการควบคุมความปวดหลังจากการผ่าตัดเปิดกะโหลกศีรษะ

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วัตถุประสงค์ เพื่อหาอุบัติการณ์และความรุนแรงของความปวดหลังการผ่าตัดเปิดกะโหลกศีรษะในโรงพยาบาลมหาราชนครเชียงใหม่ รวมถึงความเพียงพอของเวชปฏิบัติในการระงับปวดที่ทำเป็นกิจวัตร

วิธีการ การระงับปวดที่สั่งให้หลังการผ่าตัดเปิดกะโหลกศีรษะแบบนัดหมายในผู้ป่วย 2 กลุ่ม คือ การผ่าตัดในตำแหน่ง supratentorial และ infratentorial ข้อมูลทั่วไปและข้อมูลทางคลินิก รวมถึงการทำ scalp block ปริมาณยา fentanyl ที่ได้รับ ถูกรวบรวมและวิเคราะห์ ความปวดหลังการผ่าตัดถูกประเมินเป็นเวลา 3 วัน โดยใช้เครื่องมือ numeric rating scale (NRS) หรือ revised non-verbal pain scale (NVPS-R) ยาที่ใช้ระงับปวดและผลข้างเคียงถูกบันทึก

ผลการศึกษา ผู้ป่วย 251 คน มี 190 คน ที่เป็นการผ่าตัดในตำแหน่ง supratentorial ในขณะที่ 61 คน เป็นตำแหน่ง infratentorial หลังการผ่าตัดวันแรก อุบัติการณ์ที่คะแนนความปวด NRS มากกว่าหรือเท่ากับ 4 (ระดับความปวดปานกลางถึงมาก) คือ ร้อยละ 18.2-31.8 ในขณะที่ผู้ป่วยที่มีคะแนน NVPS-R มากกว่าหรือเท่ากับ 4 คือ ร้อยละ 6.4-11.1 อุบัติการณ์ที่คะแนนความปวดเท่ากับ 0 เพิ่มขึ้นเรื่อย ๆ เมื่อเวลาผ่านไป โดยเป็นร้อยละ 100 เมื่อประเมินด้วย NVPS-R และร้อยละ 87 เมื่อประเมินด้วย NRS ในวันที่สามหลังการผ่าตัด ในกลุ่ม infratentorial การทำ scalp block ก่อนการลงมีดผ่าตัด ช่วยลดคะแนนความปวดเมื่อผู้ป่วยมาถึงหอผู้ป่วยและในระยะเวลา 4 ชั่วโมงหลังการผ่าตัด (ค่า p เท่ากับ 0.05 และ 0.042 ตามลำดับ) มากกว่าร้อยละ 90 ที่ผู้ป่วยได้รับการสั่งยา tramadol ทางหลอดเลือดดำทุก 6 ชั่วโมงในวันแรก แต่มีผู้ป่วยเพียงร้อยละ 60 ในกลุ่ม supratentorial ที่ได้รับ tramadol ในช่วง 8-16 ชั่วโมงหลังการผ่าตัด ในขณะที่กลุ่ม infratentorial คิดเป็นร้อยละ 75 (p เท่ากับ 0.021)

สรุป ความปวดหลังการผ่าตัดเปิดกะโหลกศีรษะได้รับการบรรเทาอย่างมีประสิทธิภาพด้วยยา tramadol ควรมีการศึกษาเพิ่มเติมถึงความน่าเชื่อถือของ NVPS-R ในแง่การเป็นเครื่องมือประเมินความปวดในผู้ป่วยที่ไม่สามารถสื่อสารด้วยคำพูดได้ **เชียงใหม่เวชสาร 2562; 58(4):199-209.**

คำสำคัญ: ความรุนแรงของการปวด การควบคุมความปวด การผ่าตัดเปิดกะโหลกศีรษะ

