Factors Associated with Operating-Room Extubation after Emergency Craniotomy

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Objective: *To determine clinical factors and outcomes associated with operating-room extubation.*
Material and Method: *Three hundred seventy three medical records of emergency craniotomy were reviewed. The author categorized by whether the patients underwent operating-room extubation (ORE) or not (nORE). Demographic and perioperative factors were reviewed for association with ORE, e.g. Glasgow coma scale score (GCS), brain edema, and duration of anesthesia. Outcomes included clinical status, and duration in intensive care unit and hospital stay.*
Results: *Of the 373 patients, 130 (35%) had been extubated in the operating room. The strongest factors associated with ORE were no perioperative brain edema (adjusted odds ratio [OR] = 76.44 [95% confidence interval 9.46-617.50], p<0.001), high GCS score from 13 to 15 (adjusted OR = 3.74 [1.99-7.01], p<0.001), and better ASA physical class IE or IIE (adjusted OR = 2.09 [1.21-3.59], p = 0.008). The median lengths of time in the intensive care unit (ICU) were significantly shorter among OREs (3 days, range 2-5) than nOREs (4 days, range 3-8), p<0.001, as well as for duration of hospital stay (7 days, range 4-10 vs. 8 days, range 5-13, respectively, p = 0.008).*
Conclusion: *After emergency neurosurgery, ORE is associated with absent cerebral edema, high GCS score, and better ASA status.*

Keywords: *Operating room, Extubation, Emergency craniotomy*

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There are pros and cons of extubating patients undergoing emergency craniotomy while still in the operating room versus after leaving it for either the post-anesthesia care unit (PACU) or the intensive care unit (ICU). Possible advantages of operating-room extubation (ORE) include earlier awakening, earlier neurological examination and re-intervention, if necessary, and less patient stress and hypertension[1,2]. Possible disadvantages include increased hypoxemia and hypercarbia, and difficult respiratory monitoring during transfer to the PACU or ICU[1,2].

There are no reports on the frequency of ORE after emergency neurosurgery. In a similar university teaching hospital as ours in Thailand, it was reported that 89% patients undergoing emergency or elective craniotomy and craniectomy were extubated within six hours after surgery in either the operating room or the ICU[3]. We studied the frequency, clinical, and outcome factors of ORE compared to later extubation (nORE) in the ICU in the major teaching hospital of northern Thailand.

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Material and Method

Upon approval of the study by the Institutional Review Board for Ethics of the Faculty of Medicine of Chiang Mai University, medical records of 536 patients undergoing emergency craniotomy or craniectomy between January 1, 2009 and December 31, 2013 were reviewed. Applying exclusion criteria of 1) being younger than 18 years, 2) intubation or tracheostomy before arriving to the operating room, 3) Glasgow coma scale (GCS) score less than 8, 4) no other associated injury, 5) no reversal of neuromuscular blockade, and 6) those with incomplete perioperative data, 373 patients remained for analysis. These were then categorized according to whether they underwent ORE or not (nORE).

Adapting a published definition[4], we defined successful ORE as not experiencing the need for reintubation within 24 hours after extubation because of respiratory failure, inability to protect the airway, or deteriorating consciousness. Such indication for reintubation could occur in the operating room itself, the PACU, or the ICU. A similar definition for successful extubation was applied to nOREs extubated in the PACU or ICU (excluding those never extubated before death or discharge). Tracheostomy performed while intubated did not qualify as extubation.

The demographic and clinical data collected included age, sex, underlying diseases, GCS score, lowest mean arterial pressure measured in the emergency room, and physical status according to American Society of Anesthesiologists (ASA) class. Additional intraoperative factors included and analyzed were operation type and surgical site, presence of brain edema, mannitol use, presence of hypotension, vasopressor use, volume of crystalloid and colloid infusions, estimated blood loss, blood transfusion, anesthetic technique and duration, and body temperature at emergence. Other factors assessed were postoperative complications, clinical status, extubation status, and length of ICU and hospital stays.

The associations of variables with ORE versus nORE were compared by univariate analysis with Chi-square or Fisher's exact test. Variables with univariate p-value <0.05 were entered into multivariate analysis using logistic regression to identify factors, with p-value <0.05 considered statistically significant. Statistical Package for the Social Science, version 20 (SPSS 20, IBM, Armonk, NY, USA) was used to perform statistical analysis.

Results

Of the 373 patients who underwent emergency neurosurgery (365 craniotomies and 8 craniectomies), 130 patients (35%) were extubated in the operating room. On univariate analysis, there were nine variables significantly associated with ORE, of which three remained significant upon multivariate analysis compared to nORE. They were absent perioperative brain edema, better GCS score 13 to 15 in the emergency room, and better ASA class IE or IIE (Table 1).

The overall incidence of postoperative complications was lower in the ORE group than in nORE group (25% vs. 45%, $p<0.001$) (Table 2). Respiratory problems were among the causes of postoperative complications in both groups, 6% in ORE, and 14.6% in nORE. Fully conscious neurologic status at 72 hours postoperative was more frequent in ORE (99%) than nORE (76%, $p<0.001$), and similarly at one week (99% vs. 82%, respectively, $p<0.001$). Discharged alive and physically independent were significantly more frequent among ORE (78%) than nORE (40%), $p<0.001$.

Despite a 1-to-5 ratio, there was no significant difference in mortality: ORE 2% and nORE 5% (Table 2). Two of the ORE group required reintubation, the former was due to deteriorating consciousness and the latter due to unstable hemodynamics. One of the nORE was reintubated after intensive-care-unit extubation, due to inadequate ventilation. One patient in ORE underwent tracheostomy, while 13 (5%) did so in the nORE group ($p = 0.007$). The median lengths of ICU and hospital stays were significantly shorter in ORE group, compared to nORE group, $p<0.001$ and $p = 0.008$, respectively.

Discussion

The frequency of extubation in the operating room after the emergency craniotomy in the present study seemed low (35%), although we could not find any prior reports for comparison. In general, indications for extubation are that the patient be awake, neuromuscular blockade be fully reversed, spontaneous breathing be restored, be stable hemodynamically, and be normothermic[5]. Intracranial surgery patients with a normal level of consciousness before the operation, and who have uneventful procedures, can be awakened and extubated in either the operating room, the PACU, or the ICU[1,6,7].

We found better ASA status (i.e., a lower class) to be associated with ORE after emergency craniotomy, which was consistent with a study reported by Cata et al in which more patients in a delayed extubation group had higher ASA status after elective infratentorial craniotomy[4]. Callaghan et al found patients with worse ASA (higher) status to be more likely to remain intubated during transfer to the ICU after major aortic surgery[8]. A study by Rabadán et al of patients undergoing craniotomy for brain tumor found that higher ASA score was associated with more likely surgical and nonsurgical complications[9].

Better GCS was found as a predictor of ORE, similar to a previous finding that GCS score of less than 8 was associated with extubation failure[10]. The explanation offered was that brain dysfunction could contribute to extubation failure by causing hypoventilation or by decreased capacity to protect the airway. Nevertheless, another study of brain-injured patients found no relationship between extubation failure and GCS: neurologic ICU patients with a GCS score less than 4, with a cough or gag reflex, and without high airway care requirements or pneumonia were safely extubated[11].

Table 1. Univariate and multivariate analyses of factors associated with operating-room extubation (ORE) versus later extubation (nORE)

Factor	ORE No. (%) (n = 130)	nORE No. (%) (n = 243)	Univariate analysis crude OR		Multivariate analysis adjusted OR	
			95% CI	*p*-value*	95% CI	*p*-value
Pre-operative						
Sex						
- Male	107 (82)	196 (81)	1.12 (0.64-1.94)	0.70	-	-
- Female	23 (18)	47 (19)				
Age						
- <65 years	119 (92)	195 (80)	2.66 (1.33-5.33)	0.004†	1.35 (0.57-3.18)	0.492
- >65 years	11 (8)	48 (20)				
History of diabetes						
- No	123 (95)	233 (96)	0.754 (0.28-2.03)	0.58	-	-
- Yes	7 (5)	10 (4)				
History of cardiac disease						
- No	127 (98)	228 (94)	2.79 (0.79-9.80)	0.10‡	-	-
- Yes	3 (2)	15 (6)				
History of respiratory disease						
- No	127 (98)	239 (98)	0.71 (0.16-3.21)	0.65‡	-	-
- Yes	3 (2)	4 (2)				
GCS score at ER						
- 13-15	111 (85)	124 (51)	5.61 (3.24-9.70)	<0.001†	3.74 (1.99-7.01)	<0.001†
- 8-12	19 (15)	119 (49)				
Lowest MAP at ER						
- ≥80 mm Hg	118 (91)	234 (96)	0.38 (0.16-0.92)	0.03†	0.61 (0.19-1.92)	0.397
- <80 mm Hg	12 (9)	9 (4)				
ASA physical class						
- IE-IIE	77 (59)	74 (30)	3.32 (2.13-5.17)	<0.001†	2.09 (1.21-3.59)	0.008†
- IIIE-IVE	53 (41)	169 (70)				
Intraoperative						
Operation						
- Craniotomy	124 (95)	239 (98)	1.20 (0.55-2.61)	0.66†	-	-
- Craniectomy	5 (4)	3 (1)				
- Redo-craniotomy	1 (1)	1 (1)				
Surgical site						
- Supratentorial	120 (92)	221 (91)	1.20 (0.55-2.61)	0.23†	-	-
- Infratentorial	10 (8)	22 (9)				
Brain edema						
- No	129 (99)	145 (60)	87.00 (11.99-634.10)	<0.001‡	76.44 (9.46-617.50)	<0.001†
- Yes	1 (1)	98 (40)				
Mannitol use						
- No	111 (85)	203 (84)	1.15 (0.64-2.08)	0.64	-	-
- Yes	19 (15)	40 (16)				
Crystalloid volume						
- <3000	130 (100)	240 (99)	0.65 (0.60-0.70)	0.28‡	-	-
- ≥3000 ml	0	3 (1)				
Colloid volume						
- <1,000 mL	118 (91)	182 (75)	3.30 (1.70-6.38)	<0.001†	1.49 (0.65-3.41)	0.343
- ≥1,000 mL	12 (9)	61 (25)				

Adjusted OR = adjusted odds ratio; ASA = American Society of Anesthesiologists; BT = body temperature; CI = confidence interval; Crude OR = crude odds ratio; ER = emergency room; GCS = Glasgow Coma Scale; MAP = mean arterial pressure; TIVA = total intravenous anesthesia; 95% CI = 95% confidence interval

* Unless stated otherwise, values determined by Chi-square test

† *p*-value <0.05 considered significant

‡ Fisher's exact test

Table 1. (cont.)

Factor	ORE No. (%) (n = 130)	nORE No. (%) (n = 243)	Univariate analysis crude OR		Multivariate analysis adjusted OR	
			95% CI	*p*-value*	95% CI	*p*-value
Intraoperative						
Blood transfusion						
- No	96 (74)	120 (49)	2.89 (1.82-4.61)	<0.001†	1.14 (0.63-2.06)	0.664
- Yes	34 (26)	123 (51)				
Intraoperative hypotension						
- No	95 (73)	144 (59)	1.87 (1.17-2.97)	0.008†	1.68 (0.93-3.01)	0.084
- Yes	35 (27)	99 (41)				
Intermittent vasopressor administration						
- No	105 (81)	157 (65)	2.30 (1.38-3.83)	0.001†	1.35 (0.51-3.56)	0.544
- Yes	25 (19)	86 (35)				
Continuous vasopressor infusion						
- No	129 (99)	236 (97)	3.83 (0.47-31.44)	0.18‡	-	-
- Yes	1 (1)	7 (3)				
Estimated blood loss						
- <1,000 ml	119 (92)	206 (85)	1.94 (0.96-3.95)	0.06	-	-
- >1,000 ml	11 (8)	37 (15)				
Anesthetic technique						
- Volatile	69 (53)	68 (28)	2.91 (1.87-4.54)	<0.001†	-	-
- TIVA with propofol	61 (47)	175 (72)				
Anesthetic duration						
- <300 minutes	125 (96)	208 (86)	4.21 (1.61-11.02)	0.002†	3.48 (0.92-13.14)	0.066
- ≥300 minutes	5 (4)	35 (14)				
BT at emergence						
- ≥36°C	112 (94)	207 (90)	1.78 (0.74-4.27)	0.19	-	-
- <36°C	7 (6)	23 (10)				

Adjusted OR = adjusted odds ratio; ASA = American Society of Anesthesiologists; BT = body temperature; CI = confidence interval; Crude OR = crude odds ratio; ER = emergency room; GCS = Glasgow Coma Scale; MAP = mean arterial pressure; TIVA = total intravenous anesthesia; 95% CI = 95% confidence interval

* Unless stated otherwise, values determined by Chi-square test

† *p*-value <0.05 considered significant

‡ Fisher's exact test

Our patients who received volatile agents as their main anesthetic were more likely to be ORE on univariate analysis, compared to patients anesthetized with propofol via total intravenous anesthesia (TIVA), but this factor was discarded by the multivariate model. This may result from confounding, as propofol is preferred by anesthesiologists for patients with intracranial hypertension such as brain edema[12,13]. Thus, we assumed that propofol was not the causative factor for nORE. Our finding that patients classified as nORE had higher incidence of brain edema (40%), compared to 1% in ORE patients, suggests that those with brain edema should, in general, continue to receive mechanical ventilation post-operatively[14].

In other studies, the unsuccessful extubation or reintubation rate varied between 2% and 25%, but these used different definitions and populations than our study[15-17]. A reported rate of reintubation was 0.42% within 48 hours in one study[18], and in another was 4.9% within 72 hours after elective intracranial surgery[19]. Coplin et al reported that 25% of intubated brain-injured patients who fulfilled standard weaning criteria still needed continued intubation[11]. Our study found the reintubation rate within 24 hours after extubation was 2% in ORE and 0.4% in nORE groups. Unsuccessful extubation may followed by tracheostomy[20,21], which in our study was 1% in ORE and 5% in nORE.

Delaying extubation until the patient can follow commands may cause prolonged intubation and its complications[22]. Patients with delayed or failed extubation had more pneumonia, longer ICU stay, longer hospital stay, and higher in-hospital mortality[11,17,23,24]. These reported results were quite similar to ours, except that we found no difference in mortality rates between ORE and nORE groups.

Table 2. Postoperative clinical factors and outcomes

Outcome	ORE No. (%) (n = 130)	nORE No. (%) (n = 243)	*p*-value*
Postoperative complications	33 (25)	110 (45)	<0.001†
Respiratory	8 (6)	36 (14)	0.020†
Cardiac	9 (7)	39 (16)	0.012†
Urinary	0	1 (1)	0.465
Other	16 (12)	34 (14)	0.653
None	97 (75)	133 (55)	<0.001†
Status 72 hours postoperative			
Full consciousness	129 (99)	185 (76)	<0.001†
Impaired consciousness	0	12 (5)	0.010†
Ventilator-dependent	1 (1)	46 (19)	<0.001†
Status 1 week postoperative			
Full consciousness	128 (98)	198 (82)	<0.001†
Impaired consciousness	0	10 (4)	0.019†
Ventilator dependent	2 (2)	35 (14)	<0.001†
Discharge status			
Alive, physically independent	101 (77)	98 (40)	<0.001†
Alive, physically dependent	27 (21)	127 (52)	<0.001†
Vegetative	0	7 (3)	0.051
Death	2 (2)	11 (5)	0.134
Extubation			
Successful	128 (98)	218 (89.6)	0.002†
Not successful	2 (2)	1 (0.4)	0.246
Never extubated	n/a	24 (10)	-
Postoperative tracheostomy			
Yes	1 (1)	13 (5)	0.007†
No	129 (99)	230 (95)	0.007†
Median ICU stay [days (IQR)]	3 (2-5)	4 (3-8)	<0.001‡
Median hospital stay [days (IQR)]	7 (4-10)	8 (5-13)	0.008‡

ICU = intensive care unit; IQR = interquartile range; n/a = not applicable, (nORE includes both those extubated after leaving the operating room and those never extubated at death or discharge)

* Unless stated otherwise, values determined by Chi-square test of proportion (z test)

† *p*-value <0.05 considered significant

‡ Mann-Whitney U test

However, we could not conclude that later extubation was the primary cause of adverse outcomes; nevertheless, we assumed that worse neurological condition and clinical status delayed extubation and led to its negative consequences.

Some limitations of the present study were that it was retrospective and subject to resulting bias, it did not explore the effect on restored consciousness by use of perioperative opioid and sedative drugs and presence of acid-base and electrolyte disturbances, as commented by Zacko et al[5]. Moreover, the hospital does not routinely monitor the bispectral index (BIS) of patients to determine depth of anesthesia achieved, and brain surgeons did not routinely complete the Glasgow Outcome Scale (GOS)[25] for many patients.

Conclusion

Absence of brain edema, better GCS score, and better ASA physical status were related to ORE. Patients remaining intubated upon transfer to the ICU (nORE) seemed to have more complications, and longer ICU and hospital stays.

What is already known on this topic?

Criteria to help making decision for delayed extubation after intracranial surgery have been described in review articles. Additionally, the incidence of the early extubation after intracranial surgery was reported in some previous studies, but performed in elective neurosurgery.

What this study adds?

The present study provided the incidence and factors associated with successful extubation in the operating room after emergency craniotomy.

Ethical approval

The study was approved by the Institutional Review Board, Faculty of Medicine, Chiang Mai University, study protocol numbers ANE-112-1222 EX/research ID 1222.

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Potential conflicts of interest

None.

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ปัจจัยที่สัมพันธ์กับการถอดท่อช่วยหายใจในห้องผ่าตัดเทียบกับการถอดท่อช่วยหายใจในเวลาต่อมา ภายหลังการผ่าตัดเปิดกะโหลกศีรษะในภาวะฉุกเฉิน

อานันท์ชนก ศฤงคารินกุล, สุชัญญา สุวรรณจิตร, ยอดยิ่ง ปัญจสวัสดิ์วงศ์

วัตถุประสงค์: *เพื่อศึกษาปัจจัยทางคลินิกและผลที่ตามมาที่สัมพันธ์กับการถอดท่อช่วยหายใจในห้องผ่าตัด*

วัสดุและวิธีการ: *เวชระเบียนของผู้ป่วยจำนวน 373 ราย ที่ได้รับการผ่าตัดเปิดกะโหลกศีรษะ ในภาวะฉุกเฉินได้รับการทบทวน จากนั้นผู้นิพนธ์จัดผู้ป่วยเข้าประเภทถอดท่อช่วยหายใจในห้องผ่าตัด (กลุ่ม ORE) หรือไม่ได้ถอดท่อช่วยหายใจ (กลุ่ม nORE) ข้อมูลพื้นฐานและปัจจัยที่เกี่ยวข้อง ถูกทบทวนเพื่อหาความสัมพันธ์กับการถอดท่อช่วยหายใจในห้องผ่าตัด เช่น ระดับคะแนน Glasgow coma scale (GCS) ภาวะสมองบวมและระยะเวลาการดมยาสลบ เป็นต้น ผลที่ตามมาที่ศึกษา ได้แก่ สภาวะผู้ป่วยทางคลินิก และระยะเวลาการอยู่ในหอผู้ป่วยวิกฤตและการนอนโรงพยาบาล*

ผลการศึกษา: *จากผู้ป่วยจำนวน 373 ราย ผู้ป่วย 130 ราย (ร้อยละ 35) ถูกถอดท่อช่วยหายใจในห้องผ่าตัด ปัจจัยที่สัมพันธ์กับการถอดท่อช่วยหายใจในห้องผ่าตัด คือ ไม่มีภาวะสมองบวม (ค่า odds ratio = 76.44 [95% confidence interval 9.46-617.50], ค่า* $p<0.001$*) คะแนน GCS 13-15 (ค่า OR = 3.74 [1.99-7.01], ค่า* $p<0.001$*) และระดับ ASA physical class ที่ IE-IIE (ค่า OR = 2.09 [1.21-3.59], ค่า* $p = 0.008$*) ค่ากลางของระยะเวลาการอยู่ในหอผู้ป่วยวิกฤต สั้นกว่าอย่างมีนัยสำคัญในผู้ป่วยกลุ่ม ORE (3 วัน, ช่วง 2-5) เทียบกับกลุ่ม nORE (4 วัน, ช่วง 3-8 วัน) โดยมีค่า* $p<0.001$ *เช่นเดียวกับระยะเวลานอนโรงพยาบาล (7 วัน, ช่วง 4-10 เทียบกับ 8 วัน, ช่วง 5-13 ตามลำดับ, ค่า* $p = 0.008$*)*

สรุป: *ภายหลังการผ่าตัดเปิดกะโหลกศีรษะในภาวะฉุกเฉิน การถอดท่อช่วยหายใจในห้องผ่าตัดสัมพันธ์กับไม่มีภาวะสมองบวม คะแนน GCS ที่สูงและระดับ ASA ที่ดีกว่า*