Results of an Evidence-Based Care Bundle for Reducing Ventilator-Associated Pneumonia (VAP) in Neurosurgical Patients

Suphannee Triamvisit RN, MSN, APN*, Chatchanee Maneewan RN*, Prapassorn Bunturat RN, MSN*, Wassana Wongprasert RN*, Kriengsak Limpassatan MD**, Nongyao Kasatpibal RN, PhD***, Juntima Euathrongchit MD****

** Neurosurgical Critical Care Unit, Nursing Division, Maharaj Nakorn Chiang Mai Hospital, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand*
*** Neurosurgery Unit, Department of Surgery, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand*
**** Faculty of Nursing, Chiang Mai University, Chiang Mai, Thailand*
***** Diagnostic Radiology Section, Department of Radiology, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand*

Background: *Ventilator-associated pneumonia (VAP) is the most common intensive care unit-acquired infection, resulting in increased morbidity and mortality as well as increased hospital costs.*
Objective: *To determine the VAP rate before and after using the care bundle.*
Material and Method: *A pre- and intervention study was conducted in the Neurosurgical Critical Care Unit (NCCU) at a university hospital between April 2012 and February 2013. This was compared with the twelve-month period before intervention. The six-element VAP prevention bundle called Suandok Model was implemented. It included 30-degree head elevation, bedside hand hygiene, oral chlorhexidine mouth care, inflating of the cuff of the endotracheal tube maintaining 20 to 25 mmHg, checking residual gastric content before feeding, and implementing a weaning protocol.*
Results: *The samples before and after interventions were 66 and 68 cases, respectively. There were no significant differences between sex, age, GCS, diagnosis, and operation. The incidence rates of VAP in the intervention period showed a significant decrease (p = 0.001, 39.55 per 1,000 ventilator days vs. 13.30 per 1,000 ventilator days).*
Conclusion: *The Suandok Model reduced VAP in NCCU patients.*

Keywords: *Ventilator-associated pneumonia, Care bundle, Neurosurgical patients, NCCU*

J Med Assoc Thai 2016; 99 (9): 1014-9
Full text. e-Journal: *http://www.jmatonline.com*

Ventilator-associated pneumonia (VAP) is the most common intensive care unit-acquired infection. Any neurosurgical patient with a Glasgow Coma Score (GCS) of equal to or less than eight requires intubation and mechanical ventilator to protect the airway and promote oxygen to the brain. The intubated patients have a 6 to 21 times increased risk of VAP[1] due to the decreased level of consciousness, aspiration, and pathological bacterial colonization. Longer intubation and retention on a mechanical ventilator, produce a greater rate of infection. The infection rate increases as much as 1 to 3% per day[1,2] resulting in an increased morbidity and mortality as well as higher hospital costs[3-6]. VAP has been diagnosed in patients who had hospital-acquired pneumonia after intubation and ventilator support for 48 hours or more. Diagnosed VAP requires a combination of bedside examination, microbiologic analysis of respiratory secretions, and radiographic examination[7].

To control VAP, many practices were developed, such as good hand hygiene, control of the endotracheal pressure cuff, restriction of the residual gastric contents before feeding, improved oral mouth care to prevent aspiration, and facilitation of early weaning from the ventilator. The first care practice guideline of Maharaj Nakorn Chiang Mai Hospital was developed in 2004 and revised in 2007, including good hand hygiene, once a day testing of the endotracheal-pressure cuff at 20 to 25 mmHg, checking of residual gastric contents before feeding to prevent aspiration and oral care with a special mouth wash solution two times a day. Changing the respiratory circuit was not routine practice in our facility. The Neurosurgical Patient Care Team (NPCT) developed and implemented the first simple respiratory weaning protocol in 2007[8].

Correspondence to:
Euathrongchit J, Diagnostic Radiology Section, Department of Radiology, Faculty of Medicine, Chiang Mai University, Chiang Mai 50200, Thailand.
Phone: +66-53-945450
E-mail: juntima.eua@cmu.ac.th

However, the VAP incidence was still high. In 2009, the volume ventilator or Bird Mark 7 was used, and the VAP rate ranged from 10.75 to 43.8 per 1,000 ventilator days in the Neurosurgical Critical Care Unit (NCCU) [9]. The Clinical Practice Guidelines (CPGs) to reduce VAP were applied in June 2009, but the infection rate still increased to 45.49 per 1,000 ventilator days in the first quarter of 2010[9].

One of the multiple risk factors of VAP was retained secretions in a flat head position, producing colonization and/or aspiration[10]. To solve this problem, the care bundle system was developed by evidence-based practices. This system was composed of ventilator circuit changes only if specifically indicated, alcohol hand hygiene or hand washing, appropriately educated and trained staff, incorporation of sedation control, weaning protocol, oral care with chlorhexidine, thirty degrees head elevation, and checking residual gastric content before enteral feeding[11-14].

Due to the high incidence of VAP in NCCU, the NPCT created a care bundle that was appropriate to the NCCU environment and resource, called "Suandok Neurosurgical Critical Care Bundle" (SNCCB) protocol, which was six elements of 1) elevating the head of the bed at least 30 degrees, 2) practicing good hand hygiene not only using routine hospital equipment but also promoting good hand hygiene with 70% alcohol hand gel that was placed by every bed in NCCU, 3) cleaning patient's teeth and tongue with swabs, gauzes, and special mouth wash at least twice a day change to using 0.12% chlorhexidine instead of special mouth wash four times a day, 4) maintaining the pressure cuff of the endotracheal tube at 20 to 25 mmHg at least one time a day changed to three times a day, 5) checking for correct position of the nasogastric tube tip in the stomach and also checking for residual gastric contents before feeding to prevent aspiration, and 6) ventilator weaning utilizing a simple algorithm[8,11,14-19]. The new interventions in our study were indicated in numbers 2, 3, 4, 5, and 6. The SNCCB was approved by three experts (two medical staffs and one expert nurse), and had been utilized in the NCCU since April 2012.

The main objective of the present study was to determine the VAP rate before and after using the SNCCB and to compare the length of critical care stay, other medical costs, and total hospital expenses between these two groups.

Material and Method

After the Institute Review Board of Ethics approval, the quasi-experimental study was carried out in the NCCU of Maharaj Nakorn Chiang Mai Hospital. Two independent groups from before and after SNCCB intervention were recruited. All neurosurgeons and NCCU nursing staffs were educated regarding the SNCCB.

The study group was prospective study between April 2012 and February 2013. The routine group was retrospective study, reviewed from the electronic medical records, between April 2011 and March 2012.

Population and sample

All intubated-ventilated patients were the population in the present study. Retrospective data during the twelve month period before using SNCCB were reviewed from the electronic medical records, with inclusion criteria of being intubated-ventilated patient for at least twenty four hours, with the possibility of elevation of head of bed (e.g., no fracture of the cervical spine) and no wound or injury to the mouth. Exclusion criteria included end of life care patient, fracture of the cervical spine, prohibited mouth care with chlorhexidine and pneumonia before mechanical ventilation for the pre-intervention group. Among 159 intubated-ventilated patients in NCCU, the 44 transferred cases and 49 end-of-life cases were excluded. Only 66 cases were included in the pre-intervention section. The intervention group was enrolled between April 2012 and February 2013 from the NCCU, Maharaj Nakorn Chiang Mai Hospital with the same inclusion and exclusion criteria as the pre-intervention group. Written informed consents for all patients were obtained from their relatives. One hundred forty three cases of intubated-ventilated patients were evaluated during the study period. Twenty-five transferred cases, 30 end-of-life cases, and 20 cases with no written informed consent were excluded, resulting in 68 patients, who met the inclusion criteria (Fig. 1).

VAP diagnosis is hospital acquired pneumonia that occurs after using a mechanical ventilator over 48 hours. It was diagnosed by 10-year-experienced staff by using the CDC criteria[7], including a new persistent or progression of either opacity or cavitation on serial chest films together with high fever (>38.0°C), leukopenia (<4,000 WBC/mm^3) or leukocytosis (≥12,000 WBC/mm^3), altered mental status with no other causes in older than 70-years-old patients, and purulent sputum or change in sputum character or increased respiratory secretions, or increased required suction[7].

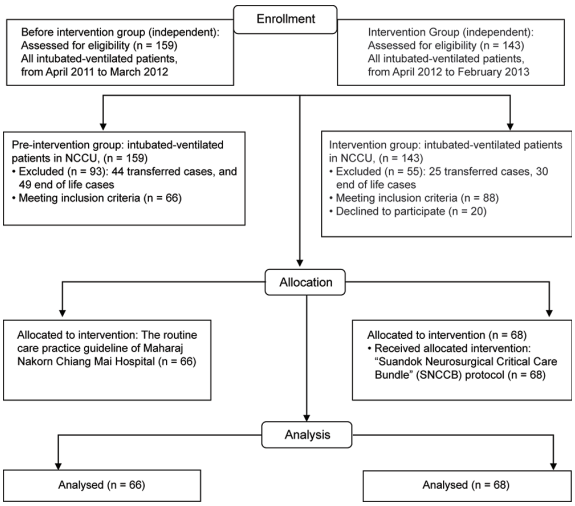

Fig. 1 Flow diagram of the whole study.

Data collection

All data of general demographic information such as age, sex, GCS, diagnosis, duration of retention on mechanical ventilator, length of critical care stay, cost of medicines, and total cost of hospital expenses were recorded. The chest radiographs of both groups were reviewed by an 18-year-experienced thoracic radiologist (Euathrongchit J).

Statistical analysis

The STATA 10 program was used to analyze the demographic data. The Chi-square statistic or Fisher's exact tests were used to compare categorical variables as appropriate. The VAP rate was analyzed by Fisher's exact probability test. The time and cost before and after intervention was analyzed using a t-test for normally distributed variables or the Mann Whitney U test for non-normally distributed variables.

Results

There were 66 and 68 cases of before and after intervention with the mean age of 53.77 and 53.94 years, respectively. There were no statistically significant differences between the two groups in sex, age, GCS, neurologic disease, and operation (Table 1). The VAP rate showed a significant decreased length of ventilator usage from 39.55 to 13.30 per 1,000 ventilator days at $p = 0.001$ (Table 2). There were slightly lower numbers of re-intubations in the intervention group than in the pre-intervention group. The number of ventilator days, length of stay in NCCU, all medications and total cost of hospital stay data in the intervention group showed a tendency to decrease when compared with the control group (Table 3), even though, there were no statistically significant differences.

Table 1. Pre- and intervention groups and characteristics comparison

	Pre-intervention group (n = 66)	Intervention group (n = 68)	*p*-value
Sex, n (%)			0.720
Male	44 (66.67)	43 (63.24)	
Female	22 (33.33)	25 (36.76)	
Age (year)			0.306
Mean (SD)	53.77 (21.09)	53.94 (19.67)	
≤59	34 (51.52)	41 (60.29)	
≥60	32 (48.48)	27 (39.71)	
GCS, n (%)			0.502
Mean (SD)	8.52 (1.87)	8.47 (2.07)	
≤8	24 (36.36)	21 (30.88)	
≥9	42 (63.64)	47 (69.12)	
Diagnosis, n (%)			0.871
Hemorrhagic stroke	29 (43.94)	29 (42.65)	
Head injury	26 (39.39)	25 (36.76)	
Brain tumor	9 (13.64)	10 (14.71)	
Others	2 (3.03)	4 (5.88)	
Operation, n (%)			0.837
No surgery	4 (6.06)	5 (7.35)	
Craniotomy	45 (68.18)	49 (72.06)	
EVD	9 (13.64)	6 (8.82)	
Others surgery	8 (12.12)	8 (11.77)	

EVD = external ventricular drain

Table 2. Ventilator-associated pneumonia (VAP) in pre- and intervention group and statistical test

	Pre-intervention group (n = 66)	Intervention group (n = 68)	95% CI	*p*-value
VAP, n (%)				0.001
Yes	22 (33.33)	7 (10.29)	1.484-7.065	
No	44 (66.67)	61 (89.71)	0.615-0.897	
Re-intubation, n (%)				0.205
Yes	17 (25.75)	11 (16.18)	0.808-3.139	
No	49 (74.25)	57 (83.82)	0.743-1.056	

Note: 22 (33.33%) = 39.55 per 1,000 ventilator days and 7 (10.29%) = 13.30 per 1,000 ventilator days

Table 3. Ventilator days, admission days in critical care unit, total medicine cost, and total hospital expenses by Mann-Whitney U test

	Pre-intervention group (n = 66)	Intervention group (n = 68)	*p*-value (2-tailed)
Ventilator days, mean (SD)	5.82 (9.32)	2.94 (3.02)	0.310
Admission days in critical care unit, mean (SD)	17.21 (10.88)	14.71 (10.19)	0.134
Total medicine cost, mean (SD)	40,876.59 (44,679.62)	37,396.57 (43,555.35)	0.437
Total hospital expenses, mean (SD)	180,130.33 (126,425.66)	165,657.01 (107,772.22)	0.586

Discussion

VAP is a common problem in ICU patients; in NCCU occurring from high 10.75 to 43.8 per 1,000 ventilator days[9]. VAP related factors in neurosurgical patients are composed of the level of consciousness, witness aspiration, failed subglottic aspiration or the supine position, receipt of enteral nutrition, and also re-intubation as well as prolonged intubation[3,4]. Preventive practices with strong supportive evidence for the reducing of VAP were semi-recumbent positioning, sucralfate instead of H_2-antagonists for stress ulcer prophylaxis, and selective digestive tract decontamination. Aspiration of subglottic secretions protection and oscillating beds may be useful. Selective digestive tract decontamination was not recommended because routine use may increase antimicrobial resistance[20]. Hand hygiene was one of the most effective methods for the prevention of hospital acquired infections. The systematic review of using alcohol-based hand rubs has been proven to be effective in the reduction of microorganisms on hands and also the weaning protocol was useful for reducing VAP[17,18]. Studies have confirmed that the utilization of more combination tools can assist in controlling VAP[11,12,21]. Six components were adopted as SNCCB which provided good results as shown.

There were no differences in cases between the pre and intervention groups. The percentage of re-intubations showed no significant decrease in the intervention group (16.18% vs. 25.75%). The VAP rate in the intervention group was significantly reduced. This could be due to the good aspiration prevention by routine head of bed elevation to equal or more than 30 degrees and checking the cuff of the endotracheal tube three times a day with 20 to 25 mmHg pressure cuff control. In our experience, once a day cuff checking was not sufficient, because there was often leakage especially in agitated neurosurgical patients. Oral swabbing with 0.12% chlorhexidine four times a day instead of a special mouth wash to control oral pathogenic bacteria was another application to reduce VAP. A study by Segers et al[19], recommended that application of 0.12% chlorhexidine gluconate to the buccal, pharyngeal, gingival and tooth surfaces four times a day and nose ointment applied four times a day in both nostrils, showed the nosocomial infection rate was significantly reduced ($p = 0.002$)[19]. Several studies have shown that using a care bundle together with chlorhexidine oral care, along with concurrent nursing interventions such as elevating the patient's head, consistently washing hands and prevention of aspiration can mitigate and prevent the occurrence of VAP[2,11,12,21,22]. A study of uncomplicated medical or trauma patients and neuroscience ICU cases, showed significantly decreasing early VAP with 0.12% chlorhexidine oral swabbing only twice a day[21]. When SNCCB was applied, the number of patients requiring re-intubation decreased from 25.78% in the pre-intervention group to 16.18% in the intervention group with the simple algorithm weaning protocol.

The average length of stay in NCCU was also reduced as well as decreased average ventilator days of about half. The average cost reduction was around fifteen thousand baht in the intervention group. However, there were no significant differences between the pre and intervention groups in terms of ventilator days, admission days in NCCU, all medication use, and total cost of the stay in hospital (Table 3). This was most likely due to the fact that each patient had multiple organs infection for example two other hospital acquired infections such as catheter-associated urinary tract infection (CAUTI) and meningitis. These might be one of the limitation of the present study.

Conclusion

The SNCCB protocol was performed and reduced the VAP rate in NCCU. In the case of VAP, using SNCCB also decreased ventilator days, admission days, cost of medication use in NCCU, and cost of overall hospital expenses even without statistically significance differences.

What is already known on this topic?

VAP is a common problem with patients who undergo intubation and ventilator treatment. Previous evidence-based studies have shown that employing "care bundles" with a combination of treatments produces better outcomes in VAP control compared to using only one intervention.

What this study adds?

Six components were adopted as the "Saundok Neurosurgical Critical Care Bundle" or SNCCB. When SNCCB was applied, the VAP rate was significantly reduced. The number of patients requiring re-intubation was reduced. The average length of stay in NCCU was also reduced. The average number of days of ventilator usage was approximately cut in half. The average saving per patient in the intervention group was about 293 baht. It was confirmed that using a bundle of interventions was more effective in controlling VAP. The SNCCB reduced ventilator days, length of stay in NCCU and cost per patient.

Acknowledgements

The present study was in financially supported by the Faculty of Medicine, Chiang Mai University. Chiang Mai, Thailand.

Potential conflicts of interest

None.

References

1. Craven DE. Epidemiology of ventilator-associated pneumonia. Chest 2000; 117 (4 Suppl 2): 186S-7S.
2. Fields LB. Oral care intervention to reduce incidence of ventilator-associated pneumonia in the neurologic intensive care unit. J Neurosci Nurs 2008; 40: 291-8.
3. Rello J, Ollendorf DA, Oster G, Vera-Llonch M, Bellm L, Redman R, et al. Epidemiology and outcomes of ventilator-associated pneumonia in a large US database. Chest 2002; 122: 2115-21.
4. Dodek P, Keenan S, Cook D, Heyland D, Jacka M, Hand L, et al. Evidence-based clinical practice guideline for the prevention of ventilator-associated pneumonia. Ann Intern Med 2004; 141: 305-13.
5. Goodman S. Implementing a protocol for weaning patients off mechanical ventilation. Nurs Crit Care 2006; 11: 23-32.
6. Astle S, Smith D. Taking your patient off a ventilator. RN 2007; 70: 34-9.
7. Centers for Disease Control and Prevention. National Healthcare Safety Network (NHSN). Device-associated module. Ventilator association event (VAE) for use in adult locations only [Internet]. 2014 [cited 2015 Sep 15]. Available from: http://www.cdc.gov/nhsn/PDFs/pscManual/ventilation/pcsManual-2014-valid.pdf
8. Triamvisit S, Watcharasaksilp W, Wongprasert W, Panjak J. Effectiveness of the evidence based clinical practice guidelines implementation for respirator weaning and explore factors determining the successful weaning in neurosurgical patient. Neurol Surg 2011; 2:127-36. [in Thai]
9. Medical records and statistics. Chiang Mai, Thailand: Maharaj Nakorn Chiang Mai Hospital, Faculty of Medicine Chiang Mai University; 2011. [in Thai]
10. Safdar N, Crnich CJ, Maki DG. The pathogenesis of ventilator-associated pneumonia: its relevance to developing effective strategies for prevention. Respir Care 2005; 50: 725-39.
11. Koeman M, van der Ven AJ, Hak E, Joore HC, Kaasjager K, de Smet AG, et al. Oral decontamination with chlorhexidine reduces the incidence of ventilator-associated pneumonia. Am J Respir Crit Care Med 2006; 173: 1348-55.
12. Tolentino-DelosReyes AF, Ruppert SD, Shiao SY. Evidence-based practice: use of the ventilator bundle to prevent ventilator-associated pneumonia. Am J Crit Care 2007; 16: 20-7.

13. Ely EW, Meade MO, Haponik EF, Kollef MH, Cook DJ, Guyatt GH, et al. Mechanical ventilator weaning protocols driven by nonphysician health-care professionals: evidence-based clinical practice guidelines. Chest 2001; 120 (6 Suppl): 454S-63S.
14. Chlebicki MP, Safdar N. Topical chlorhexidine for prevention of ventilator-associated pneumonia: a meta-analysis. Crit Care Med 2007; 35: 595-602.
15. Niel-Weise BS, Gastmeier P, Kola A, Vonberg RP, Wille JC, van den Broek PJ. An evidence-based recommendation on bed head elevation for mechanically ventilated patients. Crit Care 2011; 15: R111.
16. Morris AC, Hay AW, Swann DG, Everingham K, McCulloch C, McNulty J, et al. Reducing ventilator-associated pneumonia in intensive care: impact of implementing a care bundle. Crit Care Med 2011; 39: 2218-24.
17. Koff MD, Corwin HL, Beach ML, Surgenor SD, Loftus RW. Reduction in ventilator associated pneumonia in a mixed intensive care unit after initiation of a novel hand hygiene program. J Crit Care 2011; 26: 489-95.
18. Picheansathian W. A systematic review on the effectiveness of alcohol-based solutions for hand hygiene. Int J Nurs Pract 2004; 10: 3-9.
19. Segers P, Speekenbrink RG, Ubbink DT, van Ogtrop ML, de Mol BA. Prevention of nosocomial infection in cardiac surgery by decontamination of the nasopharynx and oropharynx with chlorhexidine gluconate: a randomized controlled trial. JAMA 2006; 296: 2460-6.
20. Collard HR, Saint S, Matthay MA. Prevention of ventilator-associated pneumonia: an evidence-based systematic review. Ann Intern Med 2003; 138: 494-501.
21. Munro CL, Grap MJ, Jones DJ, McClish DK, Sessler CN. Chlorhexidine, toothbrushing, and preventing ventilator-associated pneumonia in critically ill adults. Am J Crit Care 2009; 18: 428-37.
22. Berry AM, Davidson PM, Masters J, Rolls K, Ollerton R. Effects of three approaches to standardized oral hygiene to reduce bacterial colonization and ventilator associated pneumonia in mechanically ventilated patients: a randomised control trial. Int J Nurs Stud 2011; 48: 681-8.

ผลของการใช้ชุดการดูแลเพื่อลดการเกิดปอดอักเสบจากการใช้เครื่องช่วยหายใจในผู้ป่วยศัลยกรรมประสาท

สุพรรณี เตรียมวิศิษฎ์, ชัชณี มณีวรรณ, ประภัสสร บัณฑุรัตน์, วาสนา วงค์ประเสริฐ, เกรียงศักดิ์ ลิ้มพัสถาน, นงเยาว์ เกษตร์ภิบาล, จันทิมา เอื้อตรงจิตต์

ภูมิหลัง: *ปอดอักเสบจากการใช้เครื่องช่วยหายใจเป็นการติดเชื้อที่พบบ่อยในหอผู้ป่วยวิกฤต ทำให้เพิ่มความเสี่ยงต่อความพิการและการเสียชีวิต ตลอดจนต้องพักรักษาตัวในโรงพยาบาลนานขึ้นและเสียค่าใช้จ่ายเพิ่มขึ้น*

วัตถุประสงค์: *เพื่อเปรียบเทียบอัตราการเกิดปอดอักเสบก่อนและหลังการใช้ชุดการดูแล*

วัสดุและวิธีการ: *เป็นการศึกษาเปรียบเทียบอัตราการเกิดปอดอักเสบก่อนและหลังการใช้ชุดการดูแล ในหอผู้ป่วยวิกฤตศัลยกรรมประสาท โรงพยาบาลมหาราชนครเชียงใหม่ คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่ ตั้งแต่เดือนเมษายน พ.ศ. 2555 ถึง กุมภาพันธ์ พ.ศ. 2556 เทียบย้อนหลัง 12 เดือน เครื่องมือที่ใช้ในการศึกษาคือชุดการดูแล ซึ่งประกอบด้วย 6 องค์ประกอบ ได้แก่ การจัดท่านอนศีรษะสูง 30 องศา การทำความสะอาดมือ การเช็ก pressure cuff การทำความสะอาดช่องปากด้วยคลอเฮกซิดีน การป้องกันการสำลักก่อนให้อาหารทางสายยาง และข้อกำหนดในการหย่าเครื่องช่วยหายใจ*

ผลการศึกษา: *กลุ่มตัวอย่างก่อนและหลังการใช้ชุดการดูแลมีจำนวน 66 และ 68 ราย ตามลำดับ ไม่มีความแตกต่างกันในเรื่องเพศ อายุ ระดับความรู้สึกตัว การวินิจฉัย และการผ่าตัด อัตราการเกิดปอดอักเสบในกลุ่มหลังการใช้ชุดการดูแลลดลงอย่างมีนัยสำคัญทางสถิติ (p = 0.001; 39.55 ต่อ 1,000 วัน ที่ใช้เครื่องช่วยหายใจ vs. 13.30 ต่อ 1,000 วัน ที่ใช้เครื่องช่วยหายใจ)*

สรุป: *การใช้ชุดการดูแลสามารถลดอัตราการเกิดปอดอักเสบจากการใช้เครื่องช่วยหายใจในกลุ่มผู้ป่วยวิกฤตในหอผู้ป่วยศัลยกรรมประสาทได้*