Spontaneous Breathing Trial with Low Pressure Support Protocol for Weaning Respirator in Surgical ICU

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Objective: *Compare the effectiveness between spontaneous breathing trial with low-pressure support protocol and liberal or non-protocol directed method.*
Material and Method: *The authors conducted a retrospective study involving 577 patients who were arranged and appropriate to weaning from mechanical ventilation on general surgical intensive care unit between July 1, 2004 to June 30, 2007. Two hundred and twenty two patients were weaned by their host surgeons or team (liberal group). Three hundred and fifty five patients underwent once daily spontaneous breathing trial with low-pressure support protocol. Patients assigned to this protocol had the pressure support level decreased to 5-7 cm of water for up to two hours each day. If signs of intolerance occurred, the process was restrained while patients who tolerated the two-hour trial without signs of distress were extubated. The authors collected demographic data, cause of ICU admission, APACHE II score at arranged time to weaning, weaning process time, ventilator day, and ICU length of stay.*
Results: *There was statistical difference between liberal and protocol in age (59.2 $\pm$ 19.3 vs. 55.6 $\pm$ 19.8; p = 0.03) but there was no statistical difference in gender (male 74.3 vs. 67.9%; p = 0.2) and APACHE II score at arranged time to wean (14.7 $\pm$ 7.4 vs. 15.3 $\pm$ 6.3; p = 0.2). The median (inter-quartile) range duration of weaning process (29.5 (48) vs. 2.25 (2.9), p < 0.001), ventilator day (3 (4) vs. 2 (3), p < 0.001), and length of ICU stay (5 (5) vs. 3 (3), p < 0.001) were shorter in the protocol group than the liberal group. Multivariate linear regression model also revealed significantly less duration of weaning process in the protocol group than the liberal group in terms of weaning time (-63.6 (-74.7 to -2.6) hours), ventilator day (-3.0 (-3.7 to -2.2) days), and length of ICU stay (-2.9 days (-3.7 to -2.0); p < 0.001) (95% confidence interval).*
Conclusion: *Spontaneous breathing trial with low-pressure support protocol for liberal from mechanical ventilator was effective to reduce weaning time, ventilator day, and length of ICU stay in general surgical intensive care units.*

Keywords: *Intensive care units, Length of stay, Respiration, Artificial, Respiratory mechanics, Time factors, Ventilator weaning*

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To discontinue a patient from a mechanical ventilator is important because most critically ill patients need mechanical ventilation; however, these patients spend 40% of their time in the weaning process[1]. Mode or methods of weaning also affect the duration of these processes. Once daily trial of spontaneous breathing (SBT) was proved to be the most effective process that shorten the time to extubation approximately three times that of intermittent mandatory ventilation and about twice as quickly as step down pressure support ventilation[2]. However, when comparing SBT process between T tube system and low-pressure support ventilation of 7 cm H_2O, results were similar in terms of extubation outcomes[3]. Nevertheless, low-pressure support ventilation is more convenient and needs less

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equipment. In addition to the process of weaning, the service system also affects weaning outcomes. Surgical intensive care units, most of which are open units and primary responsibilities depend on the host surgeon, have unique characteristics that differ from medical intensive care, especially surgeons' time spent with patients is shorter. These factors might affect duration of the weaning process. The purpose of the present study was to evaluate the effectiveness of the weaning process between low-pressure support protocol and conventional process, which managed all steps of weaning by host surgeons in a retrospective fashion.

Material and Method

Patient selection

The authors retrospectively collected data between July 1, 2004 and June 30, 2007 in the general intensive care unit in a tertiary care university hospital in Chiang Mai, Thailand. Weaning from mechanical ventilator protocol was implemented in the ICU during these periods however, not every patient followed this protocol. The patients who underwent the protocol processes were only allowed from individual host surgeons. These patients were assigned to the protocol group. The remaining patients whose surgeons did not enroll into the authors' protocol as well as patients who were discontinued from mechanical ventilator support were classified as the liberal group. The authors excluded patients who had active heart disease, neurological disorder that cause unconsciousness, recent myocardial infarction, chronic pulmonary disease that needed chronic pulmonary care, and patients with a tracheotomy to be subjects of the present study.

Protocol

The authors adjusted and implemented protocol based on recommendations of the systematic review from American College of Chest Physicians (ACCP), the American Association of Respiratory Care (AARC), and the American College of Critical Care Medicine (ACCM)[4]. To enroll patients, the authors assessed candidate-patients daily for discontinuing from the mechanical ventilator. The parameter and criteria that the authors observed prior to protocol initiation were as follows: 1) the causes of intubation were resolved. 2) Stable hemodynamic awakening and no further need for vasoactive agents. 3) Ventilator setting FiO_2 less than 0.4 and PEEP less than 5 cmH_2O. 4) Patient respiratory rate less than 30 breaths per minute and heart rate less than 120 beats per minutes. 5) Forceful cough when tube suction. The inception cohort began if the patient met all of the above criteria and received permission from the host surgeons. If the patient was allowed to follow the protocol, the volume targeted or pressure targeted assist-control-ventilation was stopped and changed to pressure support mode 5-7 cmH_2O while each patient breathed spontaneously for 3 minutes by this low pressure protocol, with the FiO_2 set at the same level as that used during the previous setting. Tidal volume and respiratory frequency were measured and recorded from mechanical ventilator monitor screen. Pulse oximetry, heart rate, and blood pressure were measured and recorded from the monitoring screen. At anytime during the trial, if the patient had any of the signs of poor intolerance, previous mechanical ventilation was reinstituted. The signs of poor tolerance were as follows: 1) a respiratory frequency of more than 30 breaths per minute. 2) Pulse oximetry oxygen saturation less than 90. 3) Heart rate above 120 beats per minute or a sustained increase or decrease in the heart rate of more than 20%. 4) Systolic blood pressure above 160 mmHg or below 90 mmHg. 5) Respiratory rate to tidal volume ratio or rapid shallow breathing index more than 105. 6) Agitation, diaphoresis, or anxiety. Patients who had none of these features at the end of three minute trial were continued on low-pressure support ventilation up to 30-120 minutes[5]. Patients who still had none of these features at the end of the trial were immediately extubated. The summarized protocol is shown as Fig. 1.

Data collection and statistical analysis

At inception period, we recorded patient demographic data (age, gender, and admission diagnosis) and APACHE II. Finally, at the end of the protocol, the authors measured total weaning time in hours, ventilator day, and length of ICU stay in days, re-intubation, and its cause.

All data were analyzed by STATA 10.0 software. These were presented as mean with standard deviation in normal distribution continuous data and revealed as medians with the 25^{th}-75^{th} percentile ranges in non-normal distribution with wide boundary of outlier. During univariate analysis to determine the difference between groups, all categorical variables were analyzed by Chi-square tests, except for those small size variables, which required the use of Fisher's exact test. Comparison of continuous variables among groups was performed using Student's t test for variables with normal distribution and the Mann-Whitney U test for variables with non-normal distribution. To analyze main outcomes (weaning time,

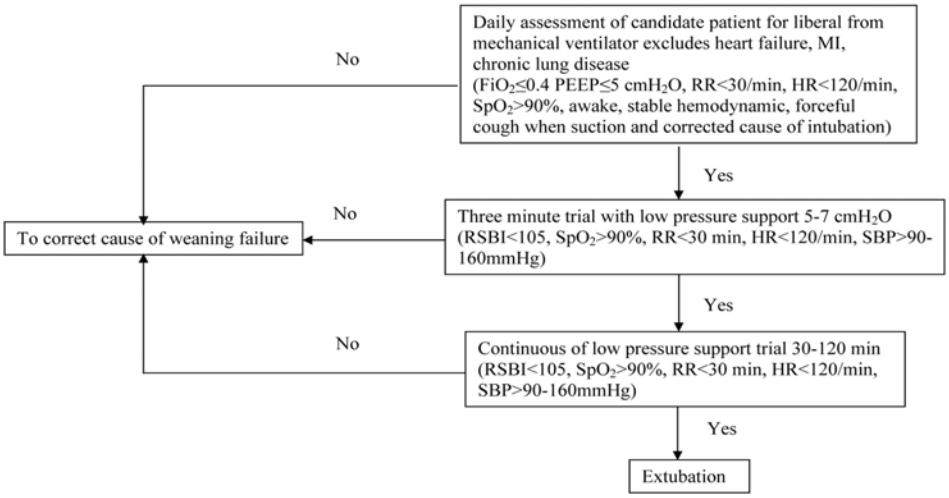

Fig. 1 Summary of steps for low pressure support protocol

ventilator days, and length of ICU stay) of correlation between liberal and protocol group, linear regression analysis was used for this purpose. The authors also analyzed the main outcomes with multivariate analysis because the nature of observation study hardly controls confounder. The parameters that were taken to multivariate regression model were those considered from a significant level in univariate analysis or clinical theoretical important parameters that affected main outcomes. The statistical significant level was considered when p less than 0.05.

Results

Of the 577 patients, 355 patients underwent low-pressure support spontaneous breathing trial protocol (protocol group) and 222 patients followed host surgeon to wean (liberal group). Both groups of patients were similar in gender and severity of disease, which was measured by APACHE II score (Table 1) but, the liberal group was older than the protocol group with statistical significance. In addition, the proportion of main diagnosis for ICU admission was different between the groups. The authors categorized the main diagnosis for ICU admission into three domains (general surgery or post-operative patient, trauma, and sepsis or septic shock). Ninety one percent of patients in the protocol group were general surgery and trauma while only about eighty-two percent in the liberal group. These categorized status distinct significantly ($p = 0.04$).

Table 1. Demographic data between liberal and protocol group at the beginning of inception

	Liberal group (222; 38.5%)	Protocol group (355; 61.5%)	p-value
Gender (% within group)			
Male	165 (74.3%)	241 (67.9%)	0.2
Female	57 (25.7%)	114 (32.1%)	
Age	59.2 $\pm$ 19.3	55.6 $\pm$ 19.8	0.04
Status in admission (% within group)			
General surgery	112 (50.5%)	224 (63.1%)	<0.01
Trauma	71 (32.0%)	99 (27.9%)	
Sepsis or shock	39 (17.6%)	32 (9%)	
APACHE II score	14.7 $\pm$ 7.4*	15.3 $\pm$ 6.3*	0.17**

* Mean $\pm$ SD, ** Mann Whitney U test

Table 2. Demonstrate main outcomes between liberal and protocol group at the end of cohort

Main outcomes	Liberal group	Protocol group	p-value
Weaning time (hrs)	29.5 (24-72)*	2.3 (1.7-4.6)*	<0.001**
Ventilator day (day)	3.0 (2-6)*	2.0 (1-4)*	<0.001**
Length of ICU stay (day)	5.0 (3-8)*	3.0 (2-5)*	<0.001**

* Median (25^{th}-75^{th} percentile), ** Mann Whitney U-test

The authors reported main outcome parameters in median and 25th to 75th percentile (Table 2) because of non-normal distribution and wide range of outlier in main outcome parameters, which are shown as Fig. 2-4. Mean and standard deviation would result in lower or higher value in this type of data analysis. It was found that weaning time, ventilator day, and length of ICU stay were distinctly statistical significant. Protocol followed patients had shorter median weaning time when compared to the liberal group [2.3 vs. 29.5; (inter-quartile range; iqr) 2.9 vs. 48 hours: $p < 0.001$]. Median time of ventilator day and length of ICU stay also altered in the same direction. [Ventilator day (median; iqr) 2.0; 3.0 vs. 3.0; 4.0: $p < 0.001$ and length of ICU stay 3.0; 3.0 vs. 5.0; 5.0: $p < 0.001$.]

Analysis of correlation is showed in Table 3. Linear regression model of univariate analysis revealed protocol group with significantly shorter weaning time (64.4 hours; 95% CI; -75.2 to -53.6; $p < 0.001$), ventilator day (3.0 days; 95% CI; -3.7 to -2.2; $p < 0.001$), and length of ICU stay (2.8days; 95% CI; -3.7 to -2.0; $p < 0.001$). The authors realized that confounder effect for causal model were different in some demographic data (Table 1) as well as parameters that might affect outcomes especially severity of disease[6]. For these reasons, the authors performed multivariate analysis for controlling these parameters. Age, status or reason of admission and APACHE II score were the three parameters which encompassed to model for controlling main outcomes. With these multivariate models, the main results were also significantly shifted to the same direction.

Overall re-intubation rate in the present series were 4.5 percent. Although there was a slight increased incidence in the protocol group, there were not significantly different [protocol vs. liberal; 17/355 (4.8%) vs. 9/213 (4.2%); $p = 0.68$]. Two main causes of re-intubation are respiratory failure (37.5%) and upper airway obstruction (63.5%). There was no ICU mortality in the present series.

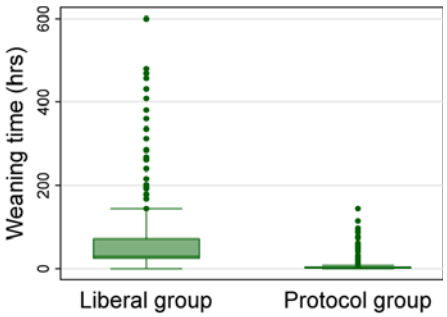

Fig. 2 Demonstrate distribution of boxplot of weaning time in hour of two groups

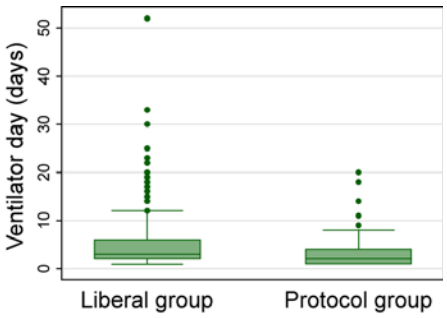

Fig. 3 Demonstrate distribution of boxplot of ventilator day of two groups

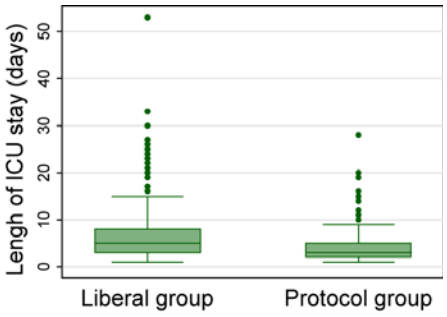

Fig. 4 Demonstrate distribution of boxplot of length of ICU stay in day of two groups

Table 3. Demonstrate univariate and multivariate analysis compare protocol group to liberal group

Main outcomes	Univariate (95% CI)	p-value	Multivariate (95% CI)	p-value
Weaning time (hrs)	-64.4 (-75.2 to -53.6)	<0.001	-63.6 (-74.7 to -52.6)	<0.001
Ventilator day (day)	-3.0 (-3.7 to -2.2)	<0.001	-3.0 (-3.7 to -2.2)	<0.001
Length of ICU stay (day)	-2.8 (-3.7 to -2.0)	<0.001	-2.9 (-3.7 to -2.0)	<0.001

95% CI = 95% confidence interval

Discussion

The success of weaning patients from a mechanical ventilator is influenced by three major factors[7]. First is the selective patient criteria ready to wean[8,9]. Second is method or process to wean[2] and finally is the system of ICU pattern[10]. The recommendation for the selected patient to be weaned was promulgated by evidence-based guidelines for weaning of ventilator support[4]. However, one parameter that is different from the present study was heart rate. The authors determined the heart rate level was lower than recommendation (120 vs. 140 bpm), which affected the authors' concern for re-intubation because this might lead to an increase in mortality and worsen the outcomes[3,11]. For the weaning method, daily spontaneous breathing trial (SBT) was proclaimed as the most effective method for selected patients to discontinue mechanical ventilation[2]. A later study comparing between T-piece and low-pressure support about 7 cmH_2O found comparable results[3]. The presented working team have selected low pressure support method to the protocol process because it is convenient to assess parameters of weaning and tolerance to discontinue from mechanical ventilator screen as well as no necessity to change the circuit from mechanical ventilator to T-piece.

For the ICU model that might affect the outcomes of weaning, Krishnan et al found that efficacy of protocol based strategy to discontinue mechanical ventilation when compared to protocol based weaning in a closed-based weaning to usual, physician-directed weaning in a closed medical intensive care unit with high physician staffing levels and structured, system-based rounds were equivocal outcomes[10]. However, there might be distinction in surgical intensive care units because they have some unique characteristics. Most surgical intensive care units especially in developing countries are open or semi-closed units. In these types of unit, all prescriptions depend on host physicians or teams so the unity and patterns are different individually. Protocol of treatment process might compensate these advantages. The present study has testified these hypotheses. We found that low-pressure support protocol based strategy could reduce weaning time, ventilator day, and ICU length of stay significantly while there were no differences in adverse outcomes (re-intubation and mortality). In addition, to request physicians explained reasons for continuing mechanical ventilation in candidates to wean patients was associated with a sustained improvement in extubation rate in surgical intensive care unit[12].

In the present series, rate of re-intubation in patients was only 4.5%. This figure was different from previous studies that ranged from about 6% to 18%[3,10,12]. These differences might be due to a higher hemodynamic threshold especially lower heart rate and higher systolic blood pressure threshold when selecting patients to be candidates for discontinuation of mechanical ventilator and tolerance of SBT.

Mode of ventilator support for weaning in the liberal group was varied and non-pattern. For these reasons, the authors could observe the inter-quartile range as well as wider outlier border for these patients compared to protocol directed patients (Fig. 2-4).

There were many limitations in the present study. Firstly, this was a retrospective study, which might have systemic errors and led to hardly controlled unrecognized confounder even though the authors attempted to adjusted outcomes by multivariate analysis. Secondly, enrolling patients were non-randomization and depended on host surgeons or team, which resulted in selection bias. Finally, hospital mortality could not be concluded in both groups of study because of missing and unreliable records. However, the present study revealed the benefit of low-pressure support with 5-7 mmHg protocol to extubated patients from mechanical support in terms of weaning time, ventilator day, and length of ICU stay.

Conclusion

Low-pressure support protocol for weaning from a mechanical ventilator was effective in surgical ICU and could reduce weaning time, ventilator day, and length of ICU stay without re-intubation difference.

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เกณฑ์วิธีการหย่าเครื่องช่วยหายใจด้วยการช่วยหายใจแบบความดันต่ำในหออภิบาลผู้ป่วยหนักศัลยกรรมทั่วไป

กวีศักดิ์ จิตตวัฒนรัตน์, ฉวีวรรณ ธงชัย

วัตถุประสงค์: *เพื่อศึกษาเปรียบเทียบประสิทธิภาพการหย่าเครื่องช่วยหายใจระหว่างแบบเกณฑ์วิธีและแบบอิสระในการสิ้นสุดการช่วยการหายใจด้วยเครื่องช่วยหายใจ*

วัสดุและวิธีการ: *เป็นการศึกษาแบบย้อนหลังระหว่างวันที่ 1 กรกฎาคม พ.ศ. 2547 ถึง 30 มิถุนายน พ.ศ. 2550 ในหออภิบาลผู้ป่วยหนักศัลยกรรมทั่วไป ผู้ป่วยทั้งหมดจำนวน 577 คน (222 คน เป็นกลุ่มอิสระ และ 355 คน เป็นกลุ่มเกณฑ์วิธี) ผู้ป่วยเกณฑ์วิธีจะใช้การช่วยการหายใจแบบความดันต่ำไม่เกิน 2 ชั่วโมงหากผู้ป่วยสามารถทนได้จะทำการหยุดการช่วยหายใจ และถอดท่อช่วยหายใจ*

ผลการศึกษา: *ไม่พบความแตกต่างของเพศและความรุนแรงทางสรีรศาสตร์จากการประเมินด้วย APACHE II ระหว่างกลุ่มตัวอย่าง แต่มีความแตกต่างในอายุและสาเหตุของการนอนในหออภิบาลผู้ป่วยหนักอย่างมีนัยสำคัญ ค่ามัธยฐานและพิสัยระหว่างควอร์ไทล์ของระยะเวลาที่ใช้ถอดเครื่องช่วยหายใจ ระยะเวลาที่ใช้เครื่องช่วยหายใจ และจำนวนวันที่นอนในหออภิบาลผู้ป่วยหนัก ในผู้ป่วยเกณฑ์วิธีน้อยกว่ากลุ่มอิสระอย่างมีนัยสำคัญทางสถิติ เมื่อทำการวิเคราะห์การถดถอยเชิงเส้นแบบควบคุมหลายตัวแปรพบว่าระยะเวลาที่ใช้ถอดเครื่องช่วยหายใจ ระยะเวลาที่ใช้เครื่องช่วยหายใจ และจำนวนวันที่นอนในหออภิบาลผู้ป่วยหนัก ในกลุ่มเกณฑ์วิธีน้อยกว่ากลุ่มอิสระอย่างมีนัยสำคัญทางสถิติ (ระยะเวลาที่ใช้เครื่องช่วยหายใจ และจำนวนวันที่นอนในหออภิบาลผู้ป่วยหนัก [ร้อยละ 95 ของความเชื่อมั่น: -63.6 (-74.7 ถึง -2.6) ชั่วโมง, -3.0 (-3.7 ถึง -2.2) วัน, -2.9 (-3.7 ถึง -2.0)วัน; $p < 0.001$ ตามลำดับ]*

สรุป: *เกณฑ์วิธีการหย่าเครื่องช่วยหายใจด้วยการช่วยหายใจแบบความดันต่ำมีประสิทธิภาพในการลดระยะเวลาที่ใช้เครื่องช่วยหายใจ จำนวนวันที่ใช้เครื่องช่วยหายใจและ จำนวนวันนอนในหออภิบาลผู้ป่วยหนักศัลยกรรมทั่วไป*