PREDICTING FACTORS FOR SUCCESSFUL WEANING FROM MECHANICAL VENTILATION

PANAPORN RATTANAPANADDA

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....
Miss.Panaporn Rattanapanadda
Candidate

....
Asst. Prof. Krongdai Unhasuta,
Ed.D.
Major-Advisor

....
Assoc. Prof. Saipin Gasemgitvatana,
D.N.S.
Co-Advisor

....
Asst. Prof. Suporn Danaidutsadeekul,
D.N.S.
Co-Advisor

....
Asst. Prof. Patiparn Toomtong, M.D.,
F.R.C.A.T.
Co-Advisor

....
Assoc. Prof. Rassmidara Hoonsawat,
Ph.D.
Dean
Faculty of Graduate Studies

....
Assoc. Prof. Kobkul Phancharoenworakul,
Ph.D.
Chair
Master of Nursing Science
Faculty of Nursing

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April 9, 2003

....
Miss Panaporn Rattanapanadda
Candidate

....
Asst. Prof. Krongdai Unhasuta, Ed.D.
Chair

....
Assoc. Prof. Saipin Gasemgitvatana,
D.N.S.
Member

....
Asst. Prof. Orapan Thosingha,
D.N.S.
Member

....
Asst. Prof. Suporn Danaidutsadeekul,
D.N.S.
Member

....
Assoc. Prof. Khun-Ying
Puttipannee Vorrakitpokatorn,
M.D., F.R.C.A.T.
Member

....
Asst. Prof. Patiparn Toomtong, M.D.,
F.R.C.A.T.
Member

....
Assoc. Prof. Rassmidara Hoonsawat,
Ph.D.
Dean
Faculty of Graduate Studies
Mahidol University

....
Assoc. Prof. Kobkul Phancharoenworakul,
Ph.D.
Dean
Faculty of Nursing
Mahidol University

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Panaporn Rattanapanadda

PREDICTING FACTORS FOR SUCCESSFUL WEANING FROM MECHANICAL VENTILATION

PANAPORN RATTANAPANADDA 4336777 NSAN/M

M.N.S. (ADULT NURSING)

THESIS ADVISORS: KRONGDAI UNHASUTA, Ed.D., SAIPIN GASEMGITVATANA, D.N.S., SUPORN DANAIDUSADEEKUL, D.N.S., PATIPARN TOOMTONG, M.D., F.R.C.A.T.

ABSTRACT

This study was a descriptive research aiming to examine the predicting factors for successful weaning from mechanical ventilation. The population were patients receiving mechanical ventilation who had a good level of consciousness. Weaning from mechanical ventilation with T-piece or CPAP mode was initiated by a physician's order. The total samples were 119 patients who were admitted to the medical intensive care unit, medical intermediate care unit, and surgical intensive care unit at Chaoprayayomaraj Hospital and to the intensive care unit of the 17th Somdejprasangkaraj Hospital. The instruments for data collection consisted of demographic data record, weaning trial data record, assessment of severity of illness (APACHE II), assessment of readiness for weaning, and successful weaning record.

The results of the study revealed that 119 patients were divided into 2 groups: 107 patients achieved successful weaning while 12 patients who did not achieve successful weaning. The average age of the patients was 61.80 years, the average length of time receiving mechanical ventilation was 3.49 days, the average severity of illness score was 11.68 and the average readiness for weaning score was 15.29. The majority of the patients received SIMV with pressure support mode of mechanical ventilation before weaning. Pearson's product moment correlation coefficient between variables found that length of time receiving mechanical ventilation, the SIMV with pressure support mode, and age had a negative relationship with successful weaning from mechanical ventilation at a statistically significant level ($r = -0.316$, $p < 0.01$; $r = -0.234$, $p < 0.05$; $r = -0.181$, $p < 0.05$, respectively). On the other hand, readiness for weaning and the mode of mechanical ventilation before weaning with A/C mode had a positive relationship with successful weaning from mechanical ventilation at a statistically significant level ($r = 0.347$, $p < 0.01$; $r = 0.199$, $p < 0.05$, respectively). More than half of the variations (54.30%) could be explained by the logistic equation. The variables that could be used as predicting factors for successful weaning are length of time receiving mechanical ventilation and readiness for weaning.

These findings suggest that patients should have immediate weaning from mechanical ventilation when the underlying pathological process is significantly reversed. Nurses and health care teams should ensure in patients both physiological readiness and psychological readiness for successful weaning from mechanical ventilation.

KEY WORDS: AGE/ LENGTH OF TIME RECEIVING MECHANICAL VENTILATION/ MODE OF MECHANICAL VENTILATION BEFORE WEANING/ SEVERITY OF ILLNESS/ READINESS FOR WEANING/ SUCCESSFUL WEANING FROM MECHANICAL VENTILATION

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พนาภรณ์ รัตนปนัดดา 4336777 NSAN/M

พย.ม. (การพยาบาลผู้ใหญ่)

คณะกรรมการควบคุมวิทยานิพนธ์ : กรองได อุณหสูต, กศ.ด. (การอุดมศึกษา), สายพิณ เกษมกิจวัฒนา, พย.ด., สุพร ดนัยดุษฎีกุล, พย.ด., ปฏิภาณ ตุ้มทอง, พ.บ., ว.ว. (วิสัญญีวิทยา)

บทคัดย่อ

การศึกษาครั้งนี้เป็นการวิจัยเชิงบรรยาย เพื่อศึกษาปัจจัยทำนายความสำเร็จในการหย่าเครื่องช่วยหายใจ ทำการศึกษาในผู้ป่วยที่รู้สึกตัวดีที่ได้รับการพิจารณาจากแพทย์ให้หย่าเครื่องช่วยหายใจด้วยวิธี T-piece หรือ วิธี CPAP ซึ่งเข้ารับการรักษาตัวในหอผู้ป่วยหนักอายุรกรรม หอผู้ป่วยหนักอายุรกรรม 2 และหอผู้ป่วยหนักศัลยกรรม โรงพยาบาลเจ้าพระยายมราช และหอผู้ป่วยหนัก โรงพยาบาลสมเด็จพระสังฆราช องค์ที่ 17 จำนวน 119 ราย เครื่องมือที่ใช้ในการเก็บรวบรวมข้อมูล ประกอบด้วย แบบบันทึกข้อมูลพื้นฐานของผู้ป่วย แบบบันทึกเกี่ยวกับการหย่าเครื่องช่วยหายใจ แบบวัดความรุนแรงของการเจ็บป่วย (APACHE II) แบบประเมินความพร้อมก่อนการหย่าเครื่องช่วยหายใจ และแบบบันทึกความสำเร็จในการหย่าเครื่องช่วยหายใจ

ผลการศึกษาพบว่า กลุ่มตัวอย่างทั้งหมด 119 ราย แบ่งเป็นกลุ่มที่หย่าเครื่องช่วยหายใจสำเร็จ 107 ราย และกลุ่มที่หย่าเครื่องช่วยหายใจไม่สำเร็จ 12 ราย โดยกลุ่มตัวอย่างทั้งหมดมีอายุเฉลี่ย 61.80 ปี ระยะเวลาที่ใช้เครื่องช่วยหายใจเฉลี่ย 3.49 วัน ความรุนแรงของการเจ็บป่วยเฉลี่ย 11.68 คะแนน ความพร้อมในการหย่าเครื่องช่วยหายใจเฉลี่ย 15.29 คะแนน และส่วนใหญ่ใช้วิธีการช่วยหายใจก่อนการหย่าเครื่องช่วยหายใจด้วยวิธี SIMV ร่วมกับ pressure support สำหรับค่าสัมประสิทธิ์สหสัมพันธ์ระหว่างตัวแปร พบว่า ระยะเวลาที่ใช้เครื่องช่วยหายใจ วิธีการช่วยหายใจก่อนการหย่าเครื่องช่วยหายใจด้วยวิธี SIMV ร่วมกับ pressure support และอายุ มีความสัมพันธ์ทางลบกับความสำเร็จในการหย่าเครื่องช่วยหายใจอย่างมีนัยสำคัญทางสถิติ ($r = -0.316$, $p < 0.01$; $r = -0.234$, $p < 0.05$; $r = -0.181$, $p < 0.05$ ตามลำดับ) ส่วนความพร้อมในการหย่าเครื่องช่วยหายใจ และวิธีการช่วยหายใจก่อนการหย่าเครื่องช่วยหายใจด้วยวิธี A/C มีความสัมพันธ์ทางบวกกับความสำเร็จในการหย่าเครื่องช่วยหายใจอย่างมีนัยสำคัญทางสถิติ ($r = 0.347$, $p < 0.01$; $r = 0.199$, $p < 0.05$ ตามลำดับ) โดยตัวแปรที่สามารถทำนายความสำเร็จในการหย่าเครื่องช่วยหายใจได้ คือ ระยะเวลาที่ใช้เครื่องช่วยหายใจ และความพร้อมในการหย่าเครื่องช่วยหายใจ ซึ่งสามารถร่วมกันอธิบายความผันแปรในสมการโลจิสติกได้ร้อยละ 54.30

จากผลการศึกษาในครั้งนี้มีข้อเสนอแนะว่า ผู้ป่วยควรได้รับการหย่าเครื่องช่วยหายใจโดยเร็วที่สุดหลังจากภาวะที่เป็นสาเหตุให้ต้องใช้เครื่องช่วยหายใจดีขึ้น โดยพยาบาลและเจ้าหน้าที่ทีมสุขภาพเตรียมความพร้อมของผู้ป่วยทั้งทางด้านร่างกายและด้านจิตใจก่อนที่จะทำการหย่าเครื่องช่วยหายใจให้แก่ผู้ป่วย เพื่อให้การหย่าเครื่องช่วยหายใจประสบความสำเร็จ

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CHAPTER I
INTRODUCTION

Background and Significance of the Study

Weaning from mechanical ventilation is a process of gradual reducing in mechanical ventilation until the patient can independently breathe with no need of an artificial ventilator. Although a mechanical ventilator is essential in assisting respiration of critically ill patients who suffer from dyspnea, respiratory muscle weakness, or respiratory failure due to insufficient oxygenation, impairment of gas exchange, and abnormal alveolar ventilation (Albert, et al., 1999: 3/11.1-3/11.2; Traver, et al., 1991: 165; Veerangkabutr, T., 1998: 243), mechanical ventilation may cause complications such as respiratory infection due to impaired secretion removal, and barotrauma mostly from abnormal increased alveolar pressure and volume (Albert, et al., 1999: 3/11.14–3/11.18; Dettenmeier, 1992: 345-347). Moreover, intubated patients may suffer from inability to communicate, pain, and discomfort caused by endotracheal tubes and endotracheal tube suctioning (Yoosuk, S., et al., 1993:34–36). Therefore, when the underlying pathologic process is significantly reversed, and the patient has adequate pulmonary reserves for independent respiration, weaning from mechanical ventilation should be quickly initiated to avoid complications.

The initiation of weaning should consider the readiness of the pulmonary function in gas exchange and ventilation, fluid and electrolytes balances, and sufficient nutrition because the weaning process requires more oxygenation due to the increased work of breathing. This required oxygen for respiration can be approximately 50 percent of the overall body oxygenation (Albert, et al., 1999: 3/11.10-3/11.12; Boonboorapong, T. & Limpisawas, S., 1998: 268–278). In addition, the patient should have strong respiratory muscles including diaphragm and abdominal muscle for effective diaphragmatic movement and cough reflex (Dettenmeier, 1992: 348–350), leading to adequate oxygenation and also ventilation. If the patient is malnourished, especifically protein deficient, the body will breakdown protein from muscles, causing weakness of body muscles including respiratory muscles and the muscles can be easily fatigue during the weaning process from the increased work of breathing. Finally, the patient will not be able to wean and will need mechanical ventilation again (Dettenmeier, 1992: 348-350; Knebel, 1991: 323).

The review of research about weaning from mechanical ventilation shows that the initiation of weaning requires the following physical assessment: stable cardiovascular system (Kamponsiri, T., 1994: 26; Kiatboonsri, S., 1992: 234; Knebel, 1991: 323; Palwatwichai, A., 1999: 370) to ensure adequate oxygen supply to body tissue during the weaning process (Knebel, 1991: 323–324); good nutrition for respiratory muscle strength and endurance (Dettenmeier, 1992: 348–349; Kamponsiri, T., 1994: 26); balanced electrolytes for effective function of respiratory muscles (Kamponsiri, T., 1994: 27); and normal pulmonary function evaluated from a respiratory rate of lower than 25 breaths per minute and no dyspnea nor use of neck muscles in respiration, indicating adequate strength for independent respiration (Kamponsiri, T., 1994: 25). The patient should also have maximal inspiratory pressure of less than -20 cm H_2O, spontaneous tidal volume of more than 5 millilitres per kilogram of body weight, and vital capacity of more than 10 to 15 millilitres per kilogram of body weight to ensure strength and durability of respiratory muscles (Albert, et al., 1999: 3/11.11; Kamponsiri, T., 1994: 25–26; Kiatboonsri, S., 1992: 234–235). Arterial blood gas should be at a normal level to maintain gas exchange ability either receiving oxygen or elimination of carbon dioxide (Kamponsiri, T., 1994: 26; Kiatboonsri, S., 1992: 235). For psychological preparation, the patient should be informed about the weaning process and how to breathe effectively. Healthcare professionals should encourage patients to talk or discuss their feelings in order to reduce worries, confusion, or frustration during the weaning process (Dettenmeier, 1992: 550; Knebel, 1991: 324-325). If a patient presents physical and psychological readiness before the initiation of weaning, the patient will be able to wean from mechanical ventilation. In other words, the patient will have successful weaning.

Successful weaning is when a patient is able to breath independently from mechanical ventilation for 24 consecutive hours after a weaning process. The review of literature shows several factors affecting successful weaning, including age and length of time receiving mechanical ventilation. It is evident that lung compliance decreases at old age and the respiratory pattern turns to rapid shallow breathing, resulting in higher residual volume and carbon dioxide retention (Williams & Hopper, 1998: 233–234); the weaning, therefore, may not be successful as the ventilation is less effective. The patient receiving long-term mechanical ventilation is at high risk of pulmonary infection (Fagon, et al., 1989: 877–884) because an endotracheal tube compromises protective mechanism of the airway and impairs cough reflex (Turner, et al., 1997: 68–76). Moreover, long term mechanical ventilation requires long-term intubation, which leads to other complications such as tracheal obstruction (Heffner, 1993: 768–771). The complications cause more difficulties in respiration and decrease gas exchange and ventilation capacity; hence, they are barriers to successful weaning. Regarding the mode of mechanical ventilation before weaning, different modes offer different advantages for patients. For example, the pressure support ventilation (PSV) mode reduces the work of breathing (Knebel, et al., 1994: 14–18). Weaning with humidified O_2 via T-piece trial allows a patient to breathe independently without resistance from the mechanical ventilator (Albert, et al., 1999: 3/11, 12), however the patient has to use the respiratory muscles entirely. Each mode has a different spontaneous breathing effort; thus, the selection of an appropriate mode can affect the weaning outcome. Severity of illness is another important factor. A patient who is severely ill or in an unstable condition requires sufficient nutrition and oxygenation for the recovery process. A weaning trial also requires high oxygenation due to the increased work of breathing (Boonboorapong, T. & Limpisawas, S., 1998: 277). Thus, weaning whilst a patient is severely ill is unlikely to succeed. Before the initiation of weaning, a patient should present readiness in general physical condition indicated by vital signs and hematocrit, and readiness in respiratory system demonstrated by ventilatory airflow and respiratory effort (Boonboorapong, T. & Limpisawas, S., 1998: 283), because successful weaning requires adequate pulmonary reserves and effective pulmonary function.

An initial survey of weaning from mechanical ventilation in 10 critically ill patients at the 17^{th} Somdejprasangkaraj Hospital found that weaning trial was initiated after an assessment of vital signs, electrocardiograms and respiration, whereas the results from laboratory examinations such as arterial blood gas, serum electrolytes, hematocrit and serum protein were not taken into consideration. The outcomes of weaning trials, therefore, either succeeded or failed. The factors affecting successful weaning included age (Williams & Hopper, 1998 233–234), length of time receiving mechanical ventilation (Dettenmeier, 1992: 350), mode of mechanical ventilation before weaning (Esteban, et al.,1995: 345–350), severity of illness (Afessa, et al., 1999: 456–461), and readiness for weaning (Kamponsiri, T., 1994: 27). However, there have been no studies about the relationships between these factors and their predictability for successful weaning. Therefore, this research was interested in investigating the effects of these factors on successful weaning. The results of this study can serve as basic information for nursing plans; and, consequently, patients will receive more effective weaning care.

Conceptual Framework

This study was based on the weaning concept developed by Boonboorapong, T. and Limpisawas, S. (1998), which states the following criteria for successful weaning: the underlying pathologic process is significantly reversed; there is adequate pulmonary reserve as indicated by sufficient gas exchange and ventilation; and no contraindications to wean from mechanical ventilation evaluated from the function of body organs, nutrition and complications related to the patient's personal factor and weaning factors.

According to the literature review, factors affecting successful weaning included age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning. This review is in agreement with the weaning concept as discussed below.

Age. It is evident that lung compliance is decrease in elderly people; hence deep inspiration is more difficult. The respiratory pattern in elderly people changes into rapid shallow breathing, resulting in decreased alveolar gas exchange, increased residual volume and more difficulties in expiration because of increased pulmonary resistance (Christiansen & Grzybowski, 1993: 99–100; Thompson, 1996: 7–16). The weaning, then, may not be successful due to the impairment of gas exchange and ventilation.

The length of time receiving mechanical ventilation. Long-term mechanical ventilation increases risks of pulmonary infection. Each additional day of mechanical ventilation raises the risks of pneumonitis by one percent (Fagon, et al., 1989: 877–

884). Pulmonary infection directly affects successful weaning because of impaired pulmonary oxygenation due to inflammation, injuries and edema of the alveolar wall (Williams & Hopper, 1998: 520).

Mode of Mechanical Ventilation before Weaning. Each mode has different advantages. Assist-Control (A/C) is the recommended mode for initiation of mechanical ventilation because it ensures a backup minute ventilation in the absence of respiratory drive and allows synchronization of ventilator cycle with the inspiratory effort (Ingenito & Drazen, 2001: 1527). Pressure support ventilation (PSV) reduces the work of breathing (Knebel, et al., 1994: 14–18). Synchronized intermittent mandatory ventilation (SIMV) gradually strengthens respiratory muscles (Pinyokam, N., 1994: 82); however, SIMV mode may require an increase in work of breathing as the patient initiates respiratory effort against the ventilator resistance. Thus, SIMV may be used with an application of pressure support between mandatory ventilation (Boonboorapong, T. & Limpisawas, S., 1998: 287–288). The T-piece trial with humidifier alternately used with mechanical ventilation allows the patient to entirely use respiratory muscles (Palwatwichai, A., 1999: 369–375). After considering the different advantages between each mode, an appropriate mode should be selected for successful weaning.

Severity of illness. A patient who is severely ill or in an unstable condition needs nutrition and oxygen for physical recovery. The oxygenation, therefore, is not adequate for weaning (Boonboorapong, T. & Limpisawas, S., 1998: 277). Hence, weaning when a patient is still severely ill may not be successful.

Readiness for Weaning. A patient should present readiness in his/her general condition such as vital signs and hematocrit, and readiness in the respiratory system such as ventilatory flow and effort (Burns, 1999: 465–479). These parameters indicate adequate pulmonary reserves for successful weaning.

This study aimed to investigate independent variables, which are age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning, and a dependent variable, which is successful weaning from mechanical ventilation. The study aimed to establish the relationship between variables as shown in Figure 1.

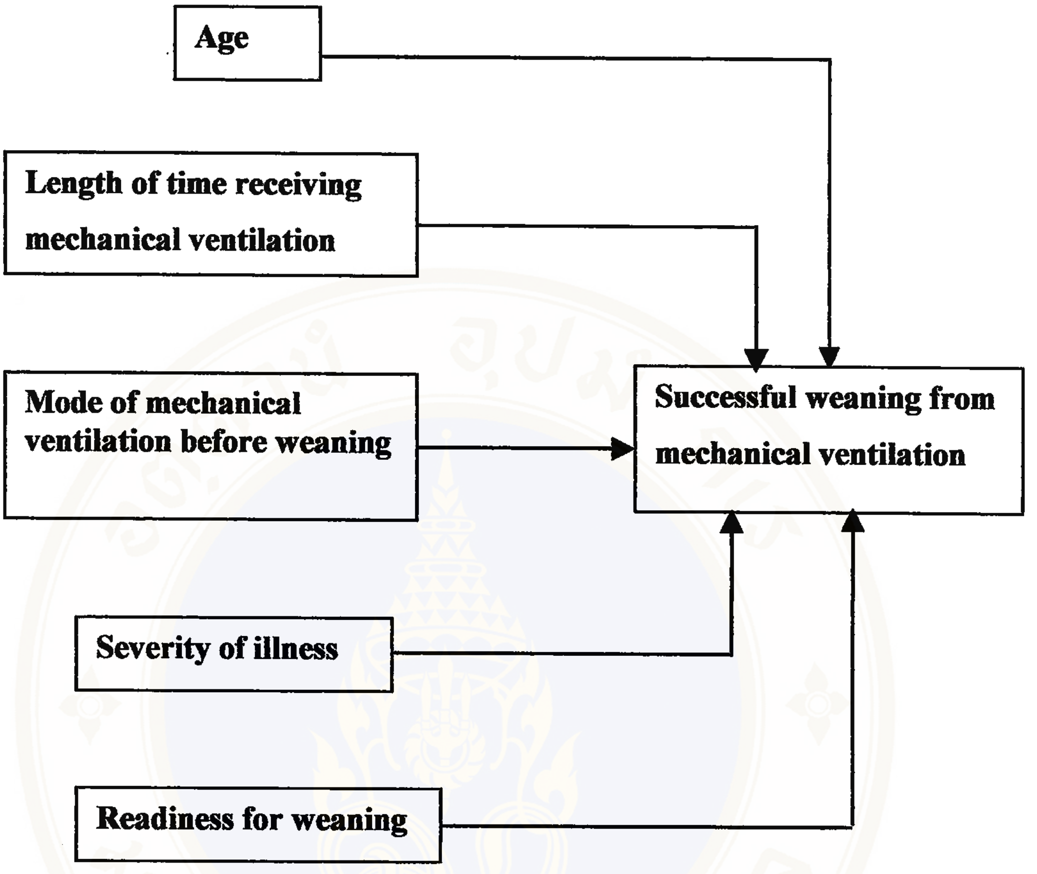

Figure 1 Conceptual framework of the study

Research Questions

1. How are age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning of patients weaning from mechanical ventilation?

2. What are the relationships among age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, readiness for weaning, and successful weaning from mechanical ventilation?

3. Can age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning be used as predicting factors for successful weaning from mechanical ventilation?

Purposes of the Study

1. To describe the age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning of patients weaning from mechanical ventilation.

2. To explore the relationships between age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, readiness for weaning, and successful weaning from mechanical ventilation.

3. To investigate the potency of age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning as predicting factors for successful weaning from mechanical ventilation.

Hypotheses

1. There are statistically significant relationships among age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, readiness for weaning, and successful weaning from mechanical ventilation.

2. Age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning can predict successful weaning from mechanical ventilation.

Scope of the Study

This study was a study of the predictability of age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning which affect successful weaning in patients undergoing mechanical ventilation irrespective of type of ventilator. The patients were admitted to the intensive care units of Chaoprayayomaraj Hospital and the 17th Somdejprasangkaraj Hospital.

Definitions of Terms

The operational definitions of the terms used in this study were as follows:

Age referred to the number of year of age of the patients from the year of birth to the present.

Length of time receiving mechanical ventilation referred to the number of days that a patient had received mechanical ventilation, starting from the first day until the day of weaning initiation. The excess of more than 12 hours were counted as an additional day.

Mode of mechanical ventilation before weaning referred to the mode or techniques used for ventilation either by using a ventilator or independent respiration alternately with mechanical ventilation. Mode of mechanical ventilation before weaning include assist-control (A/C), synchronized intermittent mandatory ventilation (SIMV), pressure support ventilation (PSV), T-piece trial, and other mode that are combinations of several modes.

Severity of illness referred to the physical dysfunction indicated by vital signs, laboratory examinations, acid-base balance, conscious level in every 24-hour period, starting from the reduction of respirator rate until the weaning with T-piece or CPAP, and history of chronic illness. Severity of illness was assessed by an assessment of severity of illness form modified from the Acute Physiology and Chronic Health Evaluation II (APACHE II) developed by Knaus, et al. (1985).

Readiness for weaning referred to the patient's readiness to wean from mechanical ventilation in 24-hour period before an initiation of weaning with T-piece or CPAP. Readiness for weaning consists of readiness of general condition as shown in vital signs, hematocrit, metabolic rate, fluid and electrolyte balance, chest x-ray, nutrition, defecation, rest, body movement, pain and anxiety, and readiness of the respiratory system as shown in gas flow and work of breathing, airway clearance, respiratory muscle strength, and respiratory muscle endurance. Readiness for weaning was assessed by using an assessment of readiness for weaning form modified from the Burn's weaning assessment program developed by Burns (1998).

Successful weaning from mechanical ventilation referred to the ability to breathe independently from mechanical ventilation for 24 consecutive hours after the weaning with T-piece or continuous positive airway pressure (CPAP). The patients might be intubated or extubated.

Expected Outcomes and Benefits

1. To promote the understanding of predicting factors for successful weaning, which is important information for a healthcare team in planning management to promote successful weaning from mechanical ventilation.

2. As a guideline for further study of weaning from mechanical ventilation in other aspects.

CHAPTER II
LITERATURE REVIEW

This study was an examination of predicting factors for successful weaning from mechanical ventilation. The literature and research related to this study were reviewed as follows:

- Successful weaning from mechanical ventilation
- Relationship between age and successful weaning from mechanical ventilation
- Relationship between length of time receiving mechanical ventilation and successful weaning from mechanical ventilation
- Relationship between mode of mechanical ventilation before weaning and successful weaning from mechanical ventilation
- Relationship between severity of illness and successful weaning from mechanical ventilation
- Relationship between readiness for weaning and successful weaning from mechanical ventilation

Successful Weaning from Mechanical Ventilation

Weaning from mechanical ventilation is the discontinuance of mechanical ventilation for a patient's independent respiration (Albert, et al., 1999: 3/11.10; Boonboorapong, T. & Limpisawas, S., 1998: 267). Before the discontinuance of mechanical ventilation, a patient will have a weaning trial with mechanical ventilation set in spontaneous mode or a spontaneous breathing trial via T-piece. If the patient can spontaneously breathe without any abnormal changes in arterial blood gas or pulmonary reserves for two consecutive hours, mechanical ventilation will be discontinued. The patient may be intubated and receives humidified oxygen via an endotracheal tube after the discontinuance of mechanical ventilation, or may be extubated after the discontinuaunce (Boonboorapong, T. & Limpisawas, S., 1998: 267). During a weaning process, successful weaning can be evaluated from the following normal vital signs: respiratory rate range between 10 and 30 breaths per minute, since if the respiratory rate is higher than 30 breaths per minute this indicates an increased work of breathing (Kamponsiri, T., 1994: 25), body temperature ranges from 36 to 38 degree celsius, pulse rate ranges from 60 to 100 beats per minute, and systolic blood pressure range between 90 and 160 mm Hg. The patient should also present sufficient gas exchange and adequate ventilation capacity as follows: tidal volume is higher than 5 millilitres per kilogram of body weight (Kiatboonsri, S., 1992: 234); minute volume should be 5 to 10 litres per minute (Dettenmeier, 1992: 349; Tobin & Alex, 1994: 1186) because a minute volume higher than 10 litres per minute indicates weakness of respiratory muscles and increased work of breathing (Kamponsiri, T., 1994: 26); vital capacity is higher than 10 to 15 millilitres per kilogram of body weight (Dettenmeier, 1992: 349; Tobin & Alex, 1994: 1186); arterial blood gas is within the normal range with pH 7.35 to 7.45, $PaCO_2$ 35 to 45 mm Hg, PaO_2 is equal to or higher than 60 mm Hg when receiving fraction concentration of inspired oxygen (FiO_2) of equal to or lower than 0.4 (Dettenmeier, 1992: 349); and the patient does not have cyanosis. The weaning is successful when the patient does not require mechanical ventilation within 24 hours after a weaning trial (Boonboorapong, T. & Limpisawas, S., 1998: 268). In this study, therefore, successful weaning from mechanical ventilation refers to independent respiration without mechanical ventilation for 24 consecutive hours after the initiation of weaning with T-piece or CPAP; however, the patient may be either intubated or extubated.

T-Piece

T-piece is a weaning technique that allows a patient to breathe through a T-piece joint connected to a corrugated tube. The patient receives highly humidified oxygen at the same FiO_2 as set on the artificial ventilator. After a weaning trial with T-piece technique for 2 hours and there is no contraindication to the discontinuance of mechanical ventilation, as well as no dependancy on an endotracheal tube, the patient may be extubated (Palwatwichai, A., 1999: 369-375).

Continuous Positive Airway Pressure (CPAP)

The CPAP is a weaning technique that requires continuous respiratory effort. The ventilator assists breathing by providing continuous airflow into the respiratory circuit to maintain positive pressure in the tube and trachea during both inspiratory and expiratory phases in order to improve alveolar expansion and maintain functional residual capacity during an expiratory phase. The sustained positive pressure during an expiratory phase will improve hypoxemia; and the positive pressure during an inspiratory phase will decrease the inspiratory work of breathing (Kiatboonsri, S., 1992: 191).

There is no theoretical framework that indicates a particular period of time for the initiation of weaning from mechanical ventilation. Nevertheless, according to the literature review, weaning from mechanical ventilation is mostly initiated when a patient is in a stable condition, the underlying pathologic process is significantly reversed including respiratory muscles are strengthened, pulmonary functions are effective, the nutrition is sufficient, fluid and electrolytes are well balanced, and the patient is psychologically ready (Albert, et al., 1999: 3/11.11; Kiatboonsri, S., 1992: 233-235). This information is in agreement with the conceptual framework developed by Boonboorapong, T. & Limpisawas, S. (1998: 268-278), which this study was based on. According to this framework, the criteria for an initiation of weaning from mechanical ventilation include the following:

1. The underlying pathological process is significantly reversed. This is an essential criterion because major problems leading to mechanical ventilation are dyspnea, impending respiratory failure and respiratory failure, which may lead to oxygenation impairment or apnea. If the underlying problem is not reversed, the body will not be able to adequately exchange gas or ventilate to meet the increased requirements for oxygen and metabolism during the weaning process.

2. A patient has adequate pulmonary reserves. Adequate pulmonary reserves can be determined from adequate gas exchange and no impairment of neuromuscular capacity such as hyperinflation or metabolic alkalosis. The patient should have tidal volume higher than 5 millilitres per kilogram of body weight and a minute volume range from 5 to 10 litres per minute.

3. No contraindications to wean from mechanical ventilation. A patient is not severely ill or does not have any severe complications. There are no other organ system dysfunctions, specifically in the neurological system and cardiovascular system. The patient should have fluid-electrolytes balance and good nutrition.

Thus, successful weaning from mechanical ventilation is based on a healthy physical condition in addition to adequate gas exchange and ventilation capacity.

Relationship between Age and Successful Weaning from Mechanical Ventilation

Age is an important factor for weaning from mechanical ventilation because it is related to pulmonary changes. In old age, the chest wall is more rigid, the respiratory muscle is weaker, and lung expansion decreases; hence forced inspiration is more difficult and the respiratory pattern becomes rapid shallow breathing whilst alveolar gas exchange capacity decreases, residual volume increases, and the expiration is more difficult due to an increase in airway resistance (Christiansen & Grzybowski, 1993: 99-100; Thompson, 1996: 7-16). Moreover, the elderly have decreased cardiac output resulting in less oxygen supply to the tissues (Williams & Hopper, 1998: 234). A weaning trial in an elderly patient, therefore, may fail as the patient is at high risk of hypoxia from hypoventilation, and impairment of oxygen transportation (Krieger, et al., 1989: 858-861). Moreover, elderly patients have less resistance to pulmonary infection due to a decrease in cough effectiveness and a reduction in numbers of cilia in the airways (Christiansen & Grzybowski, 1993: 100-101). The cough and gag reflexes also become less effective; hence they are highly vulnerable to aspiration and respiratory infection (William & Hopper, 1998: 234). Another significant pulmonary change in the elderly that affects successful weaning from mechanical ventilation is decreased tidal volume due to an increase in minute volume, which indicates inadequate pulmonary reserves. Therefore, age is related to successful weaning from mechanical ventilation.

Relationship between Length of Time Receiving Mechanical Ventilation and Successful Weaning from Mechanical Ventilation

The length of time of receiving mechanical ventilation before an initiation of weaning needs to be taken into consideration for successful weaning from mechanical ventilation because it is associated with a patient's psychological and physical readiness. According to a study by Yoosuk, S., et al. (1993: 35-40), patients who were intubated and received mechanical ventilation for longer than five days were suffered significantly more than those receiving mechanical ventilation for 1 to 5 days ($p < 0.05$). Weaning from mechanical ventilation was a factor that significantly increased suffering among intubated patients receiving mechanical ventilation for longer than five days, compared with those receiving mechanical ventilation for 1 to 5 days ($p < 0.01$). Psychological problems may also affect successful weaning because it causes increased respiratory rate, increased work of breathing, and increased oxygen requirement; thus, the weaning may fail (Panpakdee, O., 1993: 221). For successful weaning, a patient should have psychological readiness (Dettenmeier, 1992: 350; Tobin & Alex, 1994: 1177). Regarding the physical aspect, long-term mechanical ventilation may lead to subsequent complications. A study by Artigas, et al. (2001: 304-309) of 103 critically traumatic patients found that the use of mechanical ventilators for longer than 24 hours was a predicting factor for nosocomial pneumonia ($p = 0.0223$). A study by Fagon, et al. (1989: 877-884) investigating the predictability of risk related to pneumonia in patients receiving mechanical ventilation found that the risk of acquired pneumonia increased by 1% for every additional day on mechanical ventilation. Pneumonia affects successful weaning from mechanical ventilation because the lungs cannot exchange gas due to pulmonary inflammation, injuries, and edema of the alveolar wall (Williams & Hopper, 1998: 520). Moreover, long-term mechanical ventilation requires long-term intubation, which may cause tracheal obstruction because the spring-like curvature of translaryngeal endotracheal tubes passing through the upper airway exerts extreme pressure against the mucosa of the posterior endolarynx (Heffner, 1993: 768-771), leading to increased difficulties in breathing and increased respiratory effort. If pulmonary reserves are inadequate, the patient may receive insufficient tidal volume and minute volume, resulting in weaning failure. This is in agreement with a study by Rumbak , et al. (1999: 1092-1095), which reported that 37 patients receiving mechanical ventilation for longer than four weeks who had tracheal obstruction failed weaning trials. They developed dyspnea and increased peak airway pressure during the weaning trials. Thus, the length of time of receiving mechanical ventilation is related to successful weaning.

Relationship between Mode of Mechanical Ventilation before Weaning and Successful Weaning from Mechanical Ventilation

There are several modes of mechanical ventilation. The selection of mode depends on physician's decision, which is always based on a patient's condition. The following standard modes of mechanical ventilation are used for patients.

Assist-Control (A/C)

In assist-control ventilation, every breath is support by a ventilator. A back-up control ventilatory rate is set, but the patient may choose any rate above the set value. The advantages of this mode are security of controlled ventilation with support during every breath and the ability to increase the level of ventilatory support on demand. Otherwise, patients may risk excessive work of breathing due to improper ventilatory settings (St. John, 1998: 54).

Synchronized Intermittent Mandatory Ventilation (SIMV)

The SIMV mode provides patients with intermittent respiratory support from positive pressure. The patients can have self-breaths when the assistance from the ventilator pauses. The ventilator rate is initially set at 8 to 12 breaths per minute, and will be gradually reduced by 2 to 4 breaths per minute at least twice per day to increase the patient's self-respiration. The respiration that exceeds the ventilator rate is the patient's spontaneous breathing. Extubation is considered when the ventilator rate is less than 5 breaths per minute for at least 2 consecutive hours. This mode allows patients to adjust themselves to self-respiration and reduces risks of respiratory muscle fatigue, specifically in a patient receiving long-term mechanical ventilation (Palwatwichai, A., 1999: 369-375). In addition, the use of SIMV in combination with pressure support can reduce the work of breathing as pressure support will offset resistance from the demand valve, circuit tube, and endotracheal tube (Kiatboonsri, S., 1992: 239).

Pressure Support Ventilation (PSV)

The PSV mode requires intact respiratory drive with ventilator support that depends on the preselected pressure support, based on a patient's condition. When the patient initiates respiration, the inspired gas flows in until the preset pressure support is achieved. The pressure will drop to zero during an expiratory phase.

Sometimes pressure support may be set to offset resistance from endotracheal tube and ventilator circuit. The PSV mode allows a patient to determine the respiratory rate, inspiratory time and tidal volume; hence there is no resistance to the ventilator work. This technique also promotes effective utilization of respiratory muscles and requires little work of breathing (Kiatboonsri, S., 1992: 197; Palwatwichai, A., 1999: 369-375).

T-piece trial

This technique is to initiate independent respiration with T-piece for 15-30 minutes and the artificial ventilator is reconnected for an hour, alternately. The trial may start from twice per day. The T-piece period is gradually increased in the following days until the patient can independently breathe for 2 hours, weaning and extubation may be considered. This study followed the latter approach. During a T-piece trial, the patients can fully utilize their respiratory muscles. However, it may not be appropriate for patients who cannot tolerate abrupt discontinuation of mechanical ventilation such as patients with heart failure, because abrupt discontinuation of mechanical ventilation causes the reduction of intrathoracic pressure, resulting in increased pulmonary blood flow which leads to pulmonary congestion (Palwatwichai, A., 1999: 369-375).

It is evident that each mode has different advantages. There are a number of comparative studies on different modes as discussed below.

Brochard, et al. (1994: 846: 869-903) conducted a study on 109 patients who could not wean from mechanical ventilation and had weaning failure after receiving mechanical ventilation for 21 days. Patients were divided into three groups of 35, 43, and 31 patients for weaning trials with a T-piece, SIMV, and PSV, respectively. The results showed that PSV had significantly least failure, compared with the other two techniques ($p < 0.025$). The weaning with PSV also took a significantly shorter time than the other two techniques ($p < 0.05$). Another study by Esteban, et al. (1995: 345-350) conducted on 130 patients who had weaning failure in a 2-hour independent respiration trial. Patients were divided into four groups for four different weaning techniques: IMV, PSV, intermittent trial of spontaneous breathing, and a once-daily trial of spontaneous breathing. The results showed that weaning with a once-daily trial of spontaneous breathing was significantly more successful than weaning with IMV and PSV ($p < 0.006$ and $p < 0.04$, respectively).

Knebel, et al. (1994: 14-18) compared comfortable feeling while breathing with SIMV and PSV techniques in 21 patients receiving mechanical ventilation for at least three days, and was evaluated from dyspnea and anxiety. The findings showed no significant difference in dyspnea and anxiety levels between the patients receiving the two techniques. Russell and Greer (2000: 3645-3648) also examined the comfortable feeling in healthy subjects, comparing between the SIMV and T-piece techniques . They found that the SIMV technique provided more comfortable feeling than the T-piece technique.

Reismann, et al. (2000: 1764-1772) conducted a study of 9 patients with chronic obstructive pulmonary disease who had dynamic hyperinflation and found that the weaning with a T-piece in combination with CPAP significantly induced a deeper and slower respiratory pattern than the weaning with T-piece only ($p < 0.05$). The deep and slow respiration increased the elimination of carbon dioxide; hence patients with severe chronic obstructive pulmonary disease could maintain independent breathing. Vitacca, et al. (2001: 225-230) conducted a study of patients with chronic obstructive pulmonary disease who received mechanical ventilation for longer than 15 days and found that there was an insignificant difference in successful weaning between the PSV and T-piece weaning techniques. Another study of 12 patients with chronic respiratory disorders found that the PSV weaning technique significantly reduced diaphragm energy expenditure per minute, compared with the T-piece technique (Vitacca, et al., 2001: 638-641).

According to the literature review, it is evident that mode of mechanical ventilation before weaning have effects on the respiratory system, cardiovascular system, and psychological condition. Therefore, modes of mechanical ventilation before weaning are related to successful weaning.

Relationship between Severity of Illness and Successful Weaning from Mechanical Ventilation

Severity of illness is an important factor that affects successful weaning because physical illness from an injury, inadequate blood supply, chemical agent contact, or infection causes physical imbalance such as electrolytes imbalance and impairment of body immunity (Huddleston, 1992: 16). The body has more metabolic needs for recovery; hence increased nourishment and oxygen requirements. Therefore, severity of illness has to be taken into consideration for successful weaning. There are several methods of assessment the severity of illness, for example the Simplified Acute Physiological Score (SAPS), the Mortality Prediction Model (MPM), the Acute Physiological and Chronic Health Evaluation (APACHE) (Carson & Bach, 2001: 929). In this study, severity of illness of the patients was assessed by the Acute Physiological and Chronic Health Evaluation II (APACHE II) (Knaus, et al., 1985: 818-829) for both acute physiological and chronic health conditions as detailed below.

1. Physiological assessment. The assessment comprised the following parameters:

1.1 Body temperature. Body temperature is the measurement of body heat, either heat gain or heat loss, as well as the hypothalamus regulates the temperature control. Normal oral temperature is between 36.0 to 37.5 degrees celsius. Rectal temperatures are approximately 0.5 degree celsius higher than oral temperature. Body temperature maybe changed when the body system is disturbed such as having a fever or being injured (Smith, et al., 2000: 212-213). The body requires 10% more oxygen supplies for every one degree celsius rise in body temperature (Wilkins, 1995: 367). Therefore, a body temperature that is higher than normal affects the weaning capacity and may lead to weaning failure if the patient does not have adequate pulmonary reserves and has weak respiratory muscles, as weaning from mechanical ventilation requires a high oxygen supply due to the increased work of breathing.

1.2 Mean arterial pressure. Mean arterial pressure is related to both systolic and diastolic pressure. Systolic pressure, which is normally at 100 to 140 mm Hg, depends on the heart and macrovascular condition. Diastolic pressure, which is normally at 60 to 90 mm Hg, is related to vascular resistance and peripheral vessels (Smith, et al., 2000: 216). The normal range of mean arterial pressure for an assessment of severity of illness is between 70 to 90 mm Hg. Abnormal mean arterial pressure indicates an inefficient circulation system which has an effect on oxygen transportation and leads to hypoxia. Consequently, the patient is not ready for weaning from mechanical ventilation.

1.3 Heart rate. The normal heart rate is between 70 to 110 beats per minute. A higher heart rate than usual is associated with hypoxia, fever, or stress. The heart beats faster to compensate for inadequate oxygen supply to body tissues; for example, patients with heart failure, hemorrhage, or shock (Smith, et al., 2000: 214). Therefore, a patient who has an abnormal heart rate should not initiate a weaning trial because spontaneous breathing requires high oxygen supply; and the patient may subsequently have tissue hypoxia.

1.4 Respiratory rate. The normal respiratory rate is from 12 to 24 breaths per minute (Smith, et al., 2000: 215). The causes of tachypnea include fever, heart failure, pain, pleuritis, anemia, and hyperthyroidism (Chayanon, D., 1996: 174). These conditions should be cured before initiation of weaning from mechanical ventilation, otherwise, the patients will have difficulties in weaning. The oxygen intake and carbon dioxide elimination depends on the patient's respiration; abnormal breathing, therefore, leads to inadequate oxygen supply and carbon dioxide retention.

1.5 Arterial oxygen pressure (PaO_2). PaO_2 indicates the oxygen transportation to the tissues (Smith, et al., 2000: 735). A patient receiving FiO_2 of less than 0.5 should have PaO_2 higher than 70 mm Hg, signaling sufficient oxygen transportation to the body tissues. The alveolar to arterial oxygen pressure difference ($A\text{-}aDO_2$) is an indicator of efficient oxygen transfer from the alveolar to the capillary (St. John, 1998: 11-12). An acceptable value of $A\text{-}aDO_2$ for severity of illness assessment is lower than 200 mm Hg. An $A\text{-}aDO_2$ that is higher than the normal value indicates pulmonary dysfunction; hence it is not an appropriate time for an initiation of weaning because successful weaning needs an adequate gas exchange capacity and pulmonary ventilation.

1.6 Acid–base balance or arterial pH. The normal arterial pH is between 7.33 to 7.49. Changes in the pH that correlate with changes in arterial carbon dioxide pressure indicate primary respiratory abnormalities (Polaski & Tatro, 1996: 494). Abnormal arterial pH should be corrected before an initiation of weaning because acid-base imbalance leads to a reduction of oxygen transportation to the tissues.

1.7 Serum sodium. The level of serum sodium indicates the ratio of amount of sodium ion in the body and body water. Sodium is an essential element to sustain serum osmolarity, which is important for the proper function of body cells, especially neurons. The normal range of serum sodium is 130 to 149 mmol/l. Sodium imbalance, either deficiency or excess, leads to impairment of consciousness and muscle weakness (William & Hopper, 1998: 71). The patient will not be able to wean from mechanical ventilation due to insufficient respiratory strength and ineffective coughing.

1.8 Serum potassium. The level of serum potassium indicates the organ function homeostasis. Potassium is essential in the functioning of smooth muscles, skeletal muscles and cardiac muscles. An abnormally high level of potassium causes fatal arrythmia (Williams & Hopper, 1998: 73). As a result, the patient is not able to wean from mechanical ventilation because the heart contraction is not effective enough to transport oxygen to various parts of the body. Normal serum potassium is between 3.5 and 5.4 mmol/l.

1.9 Serum creatinine. A normal value of serum creatinine assessment is between 0.6 to 1.4 mg/dl. The level of serum creatinine indicates renal excretory function; a high creatinine level signifies problem of the kidney (Beare & Myers, 1994: 1071) or 30 to 50 percent of renal impairment (Intramanee, S., 1998: 57). Additionally, as creatinine is a waste product from the function of skeletal muscles, patients with a high creatinine level should not be weaned from mechanical ventilation as the weaning may lead to more accumulation of creatinine in the body.

1.10 Hematocrit. Oxygen is adequately transported to body tissues when the hemoglobin level is between 10 to 14 gm/dl (Panpakdi, O., 1993: 221) or hematocrit between 30 to 45 percents (Noochprayoon, C., 1996:170). The presence of low hemoglobin and hematocrit suggests the potential for weaning difficulties (Knebel, 1991: 323). Therefore, the hematocrit level of patients for successful weaning from mechanical ventilation should be at a normal level.

1.11 White blood cells. White blood cells eliminate pathological micro-organisms. The normal white blood cell count should be between 3,000 to 14,900 cell/mm^3. The number of white blood cells increases when there is an infection or inflammatory response (Williams& Hopper, 1998: 434). On the other hand, the decrease in numbers of white blood cells signifies lowered body immunity; hence, a person is in critical condition and not likely to have successful weaning from mechanical ventilation.

1.12 Level of consciousness. The consciousness level is evaluated by the Glasgow Coma Scale. Patients ready for weaning from mechanical ventilation should be awake and alert, free of seizure, and able to follow instructions in order to assure a stable ventilatory drive and provide secretion clearance and airway protection. Patients should possess a gag reflex and good cough response (Panpakdee, O., 1993: 221; Scanlan, 1995: 971). An effective cough indicates adequate strength for spontaneous breathing to the extent of successful weaning.

2. Chronic health condition. A chronic health condition is assessed in the patients with a history of vital organ dysfunction, such as severe impairment of liver, heart, renal or respiratory system, including those immuno-compromised like leukemia or lymphoma. The patients will be classified regarding the following conditions:

2.1 Patients receiving emergency surgery. Emergency surgery is an essential procedure for the treatment of a life-threatening condition and the patient is at risk of death if the operation is delayed, for example, patients with severe hemorrhage or patients with ruptured aortic aneurysm (Smith, et al., 2000: 974; Williams & Hopper, 1998: 180). Therefore, these patients may be frustrated after surgery, with inadequate energy reserves for weaning from mechanical ventilation due to both physical and psychological lack of preparation or readiness.

2.2 Patients receiving elective surgery. When the surgery is planned and scheduled beforehand and is not immediately needed, the patient's readiness in both physical and psychological aspects was assessed before the surgery (Smith, et al., 2000; Williams & Hopper, 1998: 180). After the surgery, these patients are likely to completely recover and have successful weaning due to their healthy physical condition.

Referring to the literature review, severity of illness has effects on weaning outcomes. According to the study by Afessa, et al. (1999: 456-461), patients who succeeded in weaning from mechanical ventilation had lower score of severity of illness as assessed by the Acute Physiology and Chronic Health Evaluation II (APACHE II), compared with those who failed the weaning. Therefore, severity of illness is related to successful weaning.

Relationship between Readiness for Weaning and Successful Weaning from Mechanical Ventilation

Successful weaning patients' should have readiness in both general conditions and the respiratory system. The readiness can be assessed as detailed below.

1. **Assessment of general condition**

1.1 Cardiovascular system and hemodynamics is essential for patients weaning from mechanical ventilation because the amount of oxygen transported to body tissues depends on cardiovascular function (Wilkins, 1995: 367-368). Hence, patients weaning from mechanical ventilation should have an efficient hemodynamics. The patient should have a heart rate between 70 to 110 beats per minute and systolic blood pressure between 110 to 160 mm Hg, which signify adequate oxygen transportation capacity.

1.2 Body metabolism. The metabolic rate can be increased from convulsion, fever, and sepsis; consequently, respiratory rate and heart rate rise. For every one degree celsius rise in temperature, oxygen consumption and carbon dioxide production increase by about 10 % (Wilkins, 1995: 367); and the patient requires an increased work of breathing for adequate pulmonary ventilation and gas exchange. Otherwise, patients with hypothermia may exhibit slow and shallow breathing and a reduced pulse rate because hypothermia reduces oxygen consumption and carbon dioxide production (Wilkins, 1995: 367). Therefore, weaning should not be initiated when the body temperature of the patient varies above or below normal.

1.3 Hematocrit level. Hemoglobin is important for oxygen transport to the body tissues. Patients with anemia have decreased oxygen carrying transport. The patients may present weakness and shortness of breathing (Williams & Hopper, 1998: 446). Patients weaning from mechanical ventilation need sufficient strength for spontaneous breathing in order to sustain gas exchange and ventilation capacity. Therefore, the hematocrit level of patients weaning from mechanical ventilation should be at the level that indicates adequate capacity of oxygen transportation to the body tissues. The Burn Weaning Assessment Program states that patients weaning from mechanical ventilation should have a hematocrit level of higher than 25 percent.

1.4 Fluid balance. Patients weaning from mechanical ventilation should have fluid intake and urine output of approximately 1,000 millilitres per day or more

(Rupple & Scanlan, 1995: 296; Scanlan, 1995: 972). The patients should not have excessive fluid intake as the undue fluid intake causes changes in vital signs, such as increased blood pressure, and rapid shallow breathing. Extremely excessive fluid intake causes pulmonary edema, which will restrain pulmonary gas exchange (Scanlan, 1995: 972; Williams & Hopper, 1998: 68). Hence, weaning from mechanical ventilation is difficult for patients with excessive fluid intake due to inefficiency in pulmonary gas exchange and ventilation. On the other hand, the patients should not have body fluid deficiency because the secretion will become sticky and obstruct the airways (Panpakdee, O., 1993: 221), resulting in a disruption of pulmonary ventilation. Hence body fluid imbalance, either excess or deficiency, may lead to weaning failure.

1.5 Nutrition status. Patients should receive nutrition support containing adequate energy and protein for maintaining sufficient muscular mass and contraction power, which are important in effective breathing and coughing. The result of prolonged starvation is a reduction in muscle mass (and strength) with a less marked reduction in visceral protein mass. The muscle weakness is accentuated by deficiencies in electrolytes and trace elements. These factors have significant effects on diaphragmatic function, skeletal muscle function, and even myocardial performance (Webb, et al., Eds., 1999: 383). Patients should receive 1,500-2,000 calories per day to adequately compensate for daily energy loss, consequently, the weaning will be successful. (Dettenmeier, 1992: 349; Scanlan, 1995: 972). The level of serum albumin should be higher than 3 g/dl, since a patient is at risk of infection and fluid accumulation when serum albumin is lower than this level.

1.6 Electrolytes. The level of serum electrolytes have effects on body functions. Essential electrolytes includes serum sodium and serum potassium. Serum sodium is related to body fluid balance (Rupple & Scanlan, 1995: 298). When the level of serum sodium is lower than normal (less than 135 mEq/l), the body either losses both fluid and sodium or free water accumulation, resulting in increased heart rate, decreased blood pressure, and muscle weakness. If a patient has serum sodium of less than 125 mEq/l, the level of consciousness will decline (Polaski & Tatro, 1996: 48-49). On the other hand, when the level of serum sodium is higher than normal (more than 145 mEq/l), the patient may have volume depletion. These conditions affect the weaning as the capacity of pulmonary gas exchange and ventilation decreases, whereas oxygen requirement increases. Serum potassium is involved in the body neurotransmission and the contraction of smooth muscles, skeletal muscles, and cardiac muscles. A lower-than-normal level of serum potassium (less than 3.5 mEq/l) results in slow muscle contraction and muscle weakness, including the respiratory muscles. The patient will have shallow breathing and will present shortness of breath (Polaski & Tatro, 1996: 51-54; Rupple & Scanlan, 1995: 300; Williams & Hopper, 1998: 70-71). A level of serum potassium that is higher than normal (more than 5 mEq/l) causes muscle twitching and spasm at first, followed by muscle weakness (Polaski & Tatro, 1996: 57; Williams & Hopper, 1998: 73). Successful weaning requires adequate breathing activity for maintaining the efficiency of gas exchange and pulmonary ventilation. Therefore, patients weaning from mechanical ventilation require serum electrolytes balance at the following level: serum sodium is 135 to 145 mEq/l, serum potassium is 3.5 to 5.5 mEq/l, serum chloride is 95 to 105 mEq/l, and serum bicarbonate is 20 to 30 mEq/l.

1.7 Pain. The feeling of pain can be observed from physical signs such as increased pulse rate or crying. Psychological symptoms of pain include depression and confusion. Patients suffering from pain such as those who have received an abdominal or thoracic surgery have limitation in lung expansion and cannot cough effectively, leading to inadequate gas exchange (decrease in tidal volume, forced vital capacity, functional residual capacity, and forced expiratory volume) (Webb, et al., Eds., 1999: 540). Therefore, an assessment of pain and pain management should be taken into consideration before an initiation of weaning from mechanical ventilation.

1.8 Rest. Inadequate rest leads to stressful, disturbed, or inactive feeling (Scanlan, 1995: 977). Patients may not be cooperative during weaning from mechanical ventilation and early muscular fatigue leading to unsuccessful weaning.

1.9 Defecation. Diarrhea may cause fluid and electrolytes imbalance. A patient may have volume depletion, resulting in sticky pulmonary secretion that blocks the airways and disrupts ventilation. Constipation, on the other hand, makes the patient feel uncomfortable. These conditions affect the weaning.

1.10 Physical strength. Before an initiation of weaning, a patient should have some movement in bed, e.g. sitting up, in order to gain strength in arms and legs, including the respiratory muscles (Dettenmeier, 1992: 350). Consequently, the patient will be able to effectively breathe and cough, which is essential for successful weaning.

1.11 Chest x-ray. The chest x-ray gives information about the pathological condition in a patient's lungs such as pulmonary edema or pneumonia (Polaski & Tatro, 1996: 498). These conditions reduce the pulmonary gas exchange area and the patient should not be weaned from mechanical ventilation because successful weaning requires effective gas exchange and ventilation.

2. An assessment of the respiratory system

2.1 Gas flow and the work of breathing

2.1.1 Respiratory rate. A respiratory rate higher than 30 breaths per minute indicates increased work of breathing (Kamponsiri, T., 1994: 25). The increase in work of breathing is related to weaning failure. The increased respiratory rate may result from faster respiration in which there is no gas exchange, a reduction of alveolar gas exchange, stress, fever, pain, or anemia (Noochprayoon, C., 1996: 174). The Burn Weaning Assessment Program states that a patient ready for weaning from mechanical ventilation should have a respiratory rate of less than 25 breaths per minute, is present with no dyspnea, and should not use the neck muscle in respiration.

2.1.2 Breath sounds. Abnormal breath sounds include crackles or rales, rhonchi, wheezing, and pleural friction rubs. Crackles indicate the presence of intra-alveolar fluid and airways or atelectasis. Rhonchi is the sound of airflow through major airways plugged by secretion; the sound decreases when the secretion is sucked or coughed out. Wheezing is the sound of air flowing through a narrow path, indicating airway obstruction. Pleural friction rubs is the sound resulting from an inflammation of pleural membrane and pulmonary edema (Chayanon, D., 1996: 186-187; St. John, 1998: 34-35, Williams & Hopper, 1998: 485). The audibility of these sounds indicate pathology of the lungs which affects the capacity of pulmonary gas exchange, resulting in difficulties in weaning from mechanical ventilation.

2.1.3 Pulmonary secretion. A large amount of secretion reduces the pulmonary gas exchange capacity and obstructs the airways. Patients weaning from mechanical ventilation require good ventilation, hence the amount of secretion should be assessed before an initiation of weaning (Knebel, 1991: 323).

2.1.4 Neuromuscular diseases. Neuromuscular diseases such as multiple sclerosis, myasthenia gravis, myotropic lateral sclerosis, or Guillain-Barre syndrome, are diseases of impairment in the transmission of signals between neurons and muscle resulting in progressive muscles weakness (Williams & Hopper, 1998: 1005). In weaning from mechanical ventilation, a patient needs adequate strength for spontaneous breathing and an effective cough; hence it is difficult for patients with the presence of these diseases to achieve successful weaning.

2.1.5 Orotracheal tube. An inappropriate orotracheal caliber may result in weaning failure. An orotracheal tube that is too long or too small in caliber increases airway resistance (Boonboorapong, T. & Limpisawas, S., 1998: 290). The patient may have respiratory muscle fatigue from increased work of breathing due to an attempt to overcome airway resistance; and the weaning will eventually fail.

2.2 Airway clearance. Patent's airways can be evaluated from the effectiveness of coughing to eliminate airway secretion. Patients weaning from mechanical ventilation should be able to cough effectively as the coughing can result in clearer patent airways (Polaski & Tatro, 1996: 515), leading to improved ventilation which has a positive effect on successful weaning.

2.3 Respiratory muscle strength

2.3.1 Maximal inspiratory pressure (MIP or PImax). The normal MIP is -100 cm H_2O. Patients achieving successful weaning from mechanical ventilation should have a MIP lower than -20 cm H_2O (St. John, 1998: 68), indicating capacity for adequate inspiration and adequate respiratory muscle strength.

2.3.2 Maximal expiratory pressure (MEP or PEmax). The Burns Weaning Assessment Program states that a patient ready for weaning from mechanical ventilation should have a MEP higher than 30 cm H_2O, indicating adequate respiratory muscle strength (Burns, 1999: 465-479).

2.4 Respiratory muscle endurance

2.4.1 Spontaneous tidal volume (V_T), volume of a normal respiration. The normal V_T averages between 8 to 10 millilitres per kilogram of body weight. In order to achieve successful weaning, a patient should have V_T of more than 5 millilitres per kilogram of body weight (Scanlan, 1995: 973), indicating adequate capacity for ventilation.

2.4.2 Vital capacity (VC), the forced expiratory volume after a forced inspiration. A capacity of forced expiration reflects an ability to breathe with adequate lung expansion which can prevent atelectasis (Albert, et al., 1999: 3/11.2). For successful weaning, a patient should have VC of more than 10 to 15 millilitres per kilogram of body weight (Scanlan, 1995: 973), indicating adequate capacity of the alveoli in gas exchange.

2.5 Arterial blood gas. The assessment involves blood pH, $PaCO_2$, and PaO_2. The $PaCO_2$ increases when there is carbon dioxide retention due to hypoventilation, which usually results from airway obstruction as in patients with chronic obstructive pulmonary disease. The retention of carbon dioxide causes a reduction of blood pH, leading to acidemia. On the other hand, hyperventilation leads to a reduction in $PaCO_2$ and an increase in blood pH, resulting in alkalemia (Smith, et al., 2000: 735). As a result, it will be difficult for the hemoglobin to transport oxygen to body tissues (Panpakdee, O., 1993: 221). Therefore, patients with abnormal $PaCO_2$ and abnormal pH will have difficulties in achieving successful weaning due to inappropriate ventilation of the body. PaO_2 reflects the reception of oxygen in body tissues (Smith, et al., 2000: 735). Therefore, arterial blood gas represents efficacy in ventilation and body oxygenation. The normal values that indicate successful weaning from mechanical ventilation are: $PaCO_2$ 35 to 45 mm Hg, pH 7.35 to 7.45, and PaO_2 higher than 60 mm Hg, when a patient receives FiO_2 of equal to or lower than 0.4 (Scanlan, 1995: 973; Smith, et al., 2000: 735).

Referring to the literature review, it is evident that when a patient is ready in both general condition and respiratory system, weaning from mechanical ventilation is likely to be successful. Therefore, an assessment of readiness for weaning is related to successful weaning.

Summary

Weaning from mechanical ventilation should be initiated when the underlying pathologic process is significantly reversed, the patient has adequate pulmonary reserves, and body organs effectively function, especially the neurological, cardiovascular and respiratory system. These conditions are represented in terms of various factors. Referring to the literature review, the factors are composed of age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning. These factors are related to successful weaning; this study, therefore, selected them as predicting factors for successful weaning.

CHAPTER III
METHODOLOGY

This study was a descriptive research aiming to examine predicting factors; age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning, for successful weaning from mechanical ventilation.

Population and Sampling

The population in this study was the patients receiving mechanical ventilation who were admitted to the medical intensive care unit, surgical intensive care unit, and medical intermediate care unit at Chaoprayayomaraj Hospital and to the intensive care unit of the 17^{th} Somdejprasangkaraj Hospital. These patients were planned for an initiation of weaning from mechanical ventilation.

The sample in this study was selected by the purposive sampling method, based on the following criteria:

1. older than 15 years with a good level of consciousness.
2. having received mechanical ventilation for longer than six hours.
3. having a weaning trial for the first time in this hospitalization.

The sample size was calculated based on the formula for regression analysis by Thorndike (Thorndike, 1978 cited by Worapongsathorn, T., 1989: 60) as follows:

n	≥	10k + 50
n	=	sample size
k	=	number of independent variables
sample size	≥	10(5) + 50
	≥	100

Therefore, the number of patients in this study was 110 subjects. The proportion of subjects in each hospital was as follows:

The total patients admitted in the intensive care unit of Chaopraya yomaraj Hospital were 822 subjects (2000) and 478 subjects at the 17^{th}

Somdejprasangkaraj Hospital (2000). Therefore, the number of patients collected at Chaoprayayomaraj Hospital was 69 patients and at the 17th Somdejprasangkaraj Hospital 41 patients.

Setting

This study was conducted at Chaoprayayomaraj Hospital and the 17th Somdejprasangkaraj Hospital. Chaoprayayomaraj Hospital is a center for practicing nursing students from Boromrajonani College of Nursing, Suphanburi. The hospital provides treatment for patients with various illnesses. This study was conducted in three critical care units of the hospital; namely medical intensive care unit, surgical intensive care unit, and medical intermediate care unit. The number of patients receiving mechanical ventilation in each unit is higher than 80 percent. At the 17th Somdejprasangkaraj Hospital, the study was conducted in the intensive care unit, of which the admission rate of patients receiving mechanical ventilation is higher than 70 percent. The intensive care units of both hospitals were similar in nurse-patient ratio, environment, and weaning techniques.

Instrumentation

The instruments for data collection consisted of three main parts as follows:

1. Demographic data record. Data collected in this part included gender, age, marital status, education level, occupation, average family income including sufficient income, and cause of illness.

2. Record of factors related to a weaning trial. This part included the following:

2.1 Weaning trial data. This record comprised of the information about length of time receiving mechanical ventilation, time of initiating the weaning, the length of time receiving mechanical ventilation until the initiation of weaning, and mode of mechanical ventilation before weaning.

2.2 Assessment of severity of illness, modified from the Acute Physiology and Chronic Health Evaluation II (APACHE II) which was designed by Knaus, et al. (1985). The assessment aimed to evaluate a patient's illness severity. The score obtained from the assessment is associated with the prediction of the patient's mortality during hospitalization. This assessment is normally utilized in the first 24 hours of a patient's admission to an intensive care unit. The severity score is between 0-70 points, divided into the following aspects: physical assessment 0-59 points, age 0-6 points, and chronic illness 0-5 points. The designers of APACHE II conducted assessment trials with 5,815 critically ill patients in 13 hospitals and found that an increase in the assessment score was significantly contributed to an increase in mortality rate. In this study, APACHE II was adapted for an assessment of severity of illness in every 24-hour period during the weaning trial, starting from the reduction of respirator rate until the weaning with T-piece or CPAP. The assessment was divided into 2 parts: physical and chronic illness assessment but age is excluded because the literature review has pointed out that age is an important factor for successful weaning from mechanical ventilation. Therefore, age was an independent variable for this study. The physical assessment had 12 items comprising body temperature, heart rate, respiratory rate, mean arterial pressure, PaO_2 or $A\text{-}aDO_2$, arterial pH, serum sodium, serum potassium, serum creatinine, hematocrit, white blood cell count, and Glasgow Coma Scale. The total score of this assessment was between 0-59 points. The assessment of chronic illness had one item with a score of 0-5 points based on the patient's history of severe organ dysfunction or immuno-compromised condition prior to the hospitalization including history of no surgery, emergency surgery, or elective surgery, for which the patient was prepared in advance. The total score of the whole assessment form was between 0-64 points; the higher score reflected a higher level of severity of illness.

2.3 Assessment of readiness for weaning, modified from the Burns Weaning Assessment Program which was designed by Burns (1998). This assessment aimed to assess a patient's readiness for weaning from mechanical ventilation. The assessment program utilized in this study was translated into Thai by Sungkhaw, W. (2001); and the Thai version was subsequently translated back into English by Vasanasamasitthi, P.. A panel of 5 experts measured the content accuracy of the assessment program. Then, the reliability test of the assessment form was tested with 10 patients receiving mechanical ventilation using interrater reliability measurement; the test results in the reliability value 0.92. This assessment form contained 26 items, divided into two main parts: an assessment of general condition and respiratory system. The assessment of general condition included cardiovascular and hemodynamic system, body metabolism, hematocrit level, fluid balance, nutrition status, electrolytes, pain, rest, defecation, physical strength, and chest x-ray. The assessment of respiratory system included gas flow and work of breathing, airway clearance, respiratory muscle strength, respiratory muscle endurance, and arterial blood gas. The scoring criteria were: one point for a "yes" answer and no point for the "no" or "no assessment" answer. A total score of 17 points (64 %) or more from the full 26 points was an indication of readiness for weaning. When the researcher collected data, it was found that respiratory muscle strength could not be assessed. Therefore, the researcher consulted experts before excluding this part.

3. Successful weaning record. This part was the record of weaning results after 24 hours. There were two answer choices: 'achieved successful weaning' and 'not achieved successful weaning'. The 'achieved successful weaning' answer meant the patient was able to breathe independently without of mechanical ventilation for 24 hours after an initiation of weaning with T-piece or CPAP irrespective of being intubated or not. The 'not achieved successful weaning' answer meant the patient was unable to breathe independently for 24 hours and was dependent on mechanical ventilation.

Validity and Reliability of the Instruments

Validity

The assessment of severity of illness and readiness for weaning record forms were tested for validity by a panel of 5 experts (See Appendix A) comprising the following:

- Three nurses who specialized in caring for patients receiving mechanical ventilation
- Two anesthetists responsible for patients receiving mechanical ventilation.

The assessment forms were subsequently amended according to the experts' recommendations.

Reliability

The forms for assessment of severity of illness and readiness for weaning were trialed with 10 patients whose characteristics met the purposive criteria of the study. The researcher and the nurse caring for patients who were being weaned from mechanical ventilation utilized the assessment forms with the same group of patients at the same period of time. The results were subsequently calculated for interrater reliability (Luecha, Y., et al., 2000: 123). The trial resulted in the following values:

- Assessment of severity of illness had a reliability value 0.98.
- Assessment of readiness for weaning had a reliability value 0.88.

Data Collection

The data collection was conducted as detailed below:

1. The researcher requested an introduction letter from the Faculty of Graduate Studies, Mahidol University, addressed to the Directors of Chaoprayayomaraj Hospital and the 17th Somdejprasangkaraj Hospital. In addition to introducing the researcher, the letter also explained the objectives of the study and asking for permission for data collection.

2. The researcher introduced herself to the Head of the Nursing Department of the two hospitals, and the Head Nurses of all the study units and informed them about the objectives, the details of the study, and the process of data collection.

3. A schedule of data collection was established as follow:

Hospital	day	Time
Chaoprayayomaraj	Every day	8 am. - 12 am.
The 17th Somdejprasangkaraj	Every day	1 pm. - 4.30 pm.

4. The samples were selected, based on the study's purposive criteria and the study was conducted as follows:

4.1 The researcher surveyed the patients undergoing mechanical ventilation.

4.2 When the researcher found patients undergoing mechanical ventilation had adjustment to reduce the respirator rate, the researcher introduced herself, explained the purpose and benefits of the study, and asked for the patients' participation in the study. They could choose to withdraw from participating in the research at any time, and their participation in this research or not would not affect their medical treatments or nursing care. If the patients agreed to participate in the study, they were informed about personal rights and human rights protection and signed the informed consent form (See Appendix B).

4.3 Data were collected in the following order:

4.3.1 The researcher recorded demographic data and weaning trial data about the time of starting mechanical ventilation. The data were obtained from the patient's medical and nursing records.

4.3.2 After 24 hours of a reduction in the respirator rate, every 24-hours, the researcher collected data on the severity of illness obtained from an assessment of the patient's condition and the treatment record until the initiation of the O_2 T-piece or CPAP weaning.

4.3.3 When a physician decided to start weaning with T-piece or CPAP, the researcher assessed readiness for weaning. Data on time of starting the weaning trial, and mode of mechanical ventilation before weaning were also collected.

4.3.4 The researcher recorded the results of successful weaning after 24 hours of the start of weaning.

5. The complete data collected was subsequently analyzed by statistical methods.

Protection of Human Subjects

As clinical issues in this study were crucial, any identifying names and characteristics of the patients that might affect them will not be revealed. An informed consent for the record was obtained and confidentiality was strictly maintained so as to protect their information. The list of names and written records were destroyed after the data analysis was completed.

Data Analysis

The data were analyzed with the computer program SPSS/FW, as in the following details:

1. Descriptive statistics were utilized for the demographic data and weaning trial data using frequency and percentage.

2. Range, mean, and standard deviation were used for the data elicited with the age, length of time receiving mechanical ventilation, severity of illness, and readiness for weaning were analyzed both overall and for each item.

3. Pearson's product moment correlation coefficient was used with all variables including age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning in relation to the successful weaning.

4. Logistic Regression analysis was used to examine the predicting factors for successful weaning of age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning by setting the significant level at 0.05, based on assumptions of the dependent variable was a dichotomous variable with binomial distribution and no multicollinearity between independent variable.

CHAPTER IV
RESULTS

This study of predicting factors for successful weaning from mechanical ventilation was conducted on 119 patients. Among these, 107 patients achieved successful weaning but the other 12 could not wean from mechanical ventilation. The results of the study are presented in the following order:

1. demographic data of the patients,
2. data about weaning from mechanical ventilation of the patients,
3. relationship among age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, readiness for weaning, and successful weaning from mechanical ventilation,
4. predicting factors for successful weaning from mechanical ventilation.

1. Demographic Data of the Patients

Table 1 Demographic Data of the Patients (n = 119)

Information	Successful Weaning from Mechanical Ventilation					
	Achieved		Not achieved		Total	
	number	percent	number	percent	number	percent
Gender	107	100.00	12	100.00	119	100.00
Male	63	58.88	6	50.00	69	57.98
Female	44	41.12	6	50.00	50	42.02
Marital status	107	100.00	12	100.00	119	100.00
Single	17	15.89	2	16.67	19	15.92
Married	62	57.94	2	16.67	64	53.78
Widowed	28	26.17	8	66.66	36	30.25

Table 1 Demographic Data of the Patients (n = 119) (continued)

Information	Successful Weaning from Mechanical Ventilation					
	Achieved		Not achieved		Total	
	number	percent	number	percent	number	percent
Age (years)	107	100.00	12	100.00	119	100.00
15-19	4	3.73	0	0	4	3.36
20-39	12	11.21	0	0	12	10.08
40-64	43	40.18	4	33.33	47	39.50
65 and over	48	44.68	8	66.67	56	47.06
Total	*Range 17-92, Mean 61.80, S.D. 18.22*					
Achieved	*Range 17-92, Mean 60.70, S.D. 18.32*					
Not achieved	*Range 42-89, Mean 71.58, S.D. 14.50*					
Education level	107	100.00	12	100.00	119	100.00
No formal	28	26.17	5	41.70	33	27.73
Primary	71	66.35	6	50.00	77	64.71
High school	6	5.61	1	8.30	7	5.88
Bachelor degree	2	1.87	0	0	2	1.68
Occupation	107	100.00	12	100.00	119	100.00
Not work	70	65.42	9	75.00	79	66.39
Worker	19	17.16	1	8.33	20	16.81
Agriculture	7	6.54	1	8.33	8	6.72
Merchant	8	7.48	1	8.34	9	7.56
Government	3	2.80	0	0	3	2.52

Table 1 Demographic Data of the Patients (n = 119) (continued)

Information	Successful Weaning from Mechanical Ventilation					
	Achieved		Not achieved		Total	
	number	percent	number	percent	number	Percent
Average family income(bath/month)	107	100.00	12	100.00	119	100.00
None income	6	5.61	1	8.33	7	5.88
< 3,000	12	11.21	1	8.33	13	10.92
3,000-6,000	51	47.67	5	41.67	56	47.06
6,001-12,000	25	23.36	3	25.00	28	23.53
> 12,000	13	12.15	2	1.67	15	12.61
Total	*Range 0-30,000, Mean 6,773.95, S.D. 5684.18*					
Achieved	*Range 0-30,000, Mean 6,683.18, S.D. 5607.37*					
Not achieved	*Range 0-20,000, Mean 7,583.33, S.D. 6542.98*					
Sufficient income	107	100.00	12	100.00	119	100.00
Sufficient	66	61.68	6	50.00	72	60.50
Insufficient	41	38.32	6	50.00	47	39.50
Cause of illness	107	100.00	12	100.00	119	100.00
Respiratory	45	42.06	6	50.00	51	42.86
Cardiovascular	22	20.56	1	8.33	23	19.33
Neurological	16	14.95	1	8.33	17	14.29
Gastrointestinal	11	10.28	2	16.68	13	10.92
Urological	5	4.68	1	8.33	6	5.04
Suicidal attempt	3	2.80	0	0	3	2.52
Sepsis	2	1.87	1	8.33	3	2.52
Others	3	2.80	0	0	3	2.52

Table 1 Demographic Data of the Patients (n = 119) (continued)

Information	Successful Weaning from Mechanical Ventilation					
	Achieved		Not achieved		Total	
	number	percent	number	percent	number	percent
Operation	107	100.00	12	100.00	119	100.00
None operative	95	88.79	9	75.00	104	87.40
Operative	12	11.21	3	25.00	15	12.60
- abdomen	7	58.33	2	66.67	9	60.00
- others	5	41.67	1	33.33	6	40.00

Table 1 demonstrates the higher proportion of males to females in the patients achieved successful weaning; however, the proportion between the two genders was equal in the patients not achieved successful weaning. Data about marital status showed that the majority of the patients achieved successful weaning were married (51.94%), whereas most of those in the other group were divorced or widowed (66.6%). The average age of the patients not achieved successful weaning was 71.58 years, higher than that of those achieved successful weaning (60.70). The highest educational level of the patients was primary education. The patients did not work and had an average family income of between 3,000 to 6,000 baht per month. More than half of the patients achieved successful weaning reported sufficient income (61.68%) but only half of those who could not wean from mechanical ventilation reported the same. Half of the patients in both groups had respiratory disorders as causes of their illness, and only the minority of them had received surgical treatment (11.21% of the patients achieved successful weaning and 25.00% of those not achieved successful weaning).

2. Data about Weaning from Mechanical Ventilation of the Patients

Table 2 Weaning Trial Data from Mechanical Ventilation of the Patients (n= 119)

Information	Successful Weaning from Mechanical Ventilation					
	Achieved		Not achieved		Total	
	number	percent	number	percent	number	percent
Length of time receiving mechanical ventilation	107	100.00	12	100.00	119	100.00
1-3 days	72	67.29	5	41.68	77	64.71
4-6 days	25	23.36	3	25.00	28	23.53
7-9 days	6	5.61	1	8.33	7	5.88
10-12 days	2	1.87	1	8.33	3	2.52
13-15 days	2	1.87	1	8.33	3	2.52
> 15 days	0	0	1	8.33	1	0.84
Mode of mechanical ventilation before weaning	107	100.00	12	100.00	119	100.00
SIMV with pressure support	58	54.20	11	91.67	69	57.98
A/C	30	28.04	0	0	30	25.21
A/C combine T-piece	19	17.76	1	8.33	20	16.81

Table 2 Weaning Trial Data from Mechanical Ventilation of the Patients (n= 119) (continued)

Information	Successful Weaning from Mechanical Ventilation					
	Achieved		Not achieved		Total	
	number	percent	number	percent	number	percent
Severity of illness score	107	100.00	12	100.00	119	100.00
0-10	16	14.95	2	16.67	18	15.13
11-15	50	46.73	8	66.66	58	48.74
16-20	28	26.17	2	16.67	30	25.21
21-25	10	9.35	0	0	10	8.40
> 25	3	2.80	0	0	3	2.52
Readiness for weaning score	107	100.00	12	100.00	119	100.00
0-16	78	72.90	12	100.00	90	75.63
17-24	29	27.10	0	0	29	24.37

Table 2 shows that the majority of the patients, either patients achieved or not achieved successful weaning (67.29% and 41.68%, respectively), received mechanical ventilation for one to three days. More than half of the patients achieved successful weaning received the SIMV with pressure support mode (54.20%). Almost of the patients not achieved successful weaning received the same mode (91.67%). Regarding the severity of illness score, nearly half of the patients achieved successful weaning had the score from 11 to 15 (46.73%); and more than half of those who not achieved successful weaning had a score from 11 to 15 (66.66%). The assessment of readiness for weaning found that the majority of the patients achieved successful weaning had readiness for weaning scores from 0 to 16 (72.90%) but all patients not achieved successful weaning had readiness for weaning scores from 0 to16.

Table 3 Range, Mean, and Standard Deviation of Data about Weaning from Mechanical Ventilation of the Patients

Data	Successful Weaning from Mechanical Ventilation								
	Achieved			Not achieved			Total		
	Range	Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.
Length of time receiving mechanical ventilation	1-14	3.16	2.62	1-17	6.42	5.25	1-17	3.49	3.12
Severity of illness score	5-26	11.57	4.11	7-18	12.68	3.15	5-26	11.68	4.02
Readiness for weaning score	11-20	15.53	1.93	10-16	13.17	1.99	10-20	15.29	2.06

Table 3 shows that the average length of time receiving mechanical ventilation of the patients not achieved successful weaning was 6.42 days (S.D. = 5.25), longer than that of the patients achieved successful weaning, which was 3.16 days (S.D. = 2.62). Nevertheless, the average score of severity of illness of patients in the two groups were similar, as the assessment of severity of illness form showed the average score of the patients achieved and not achieved successful weaning at 11.57 (S.D. = 4.11) and 12.68 (S.D. = 3.15), respectively. The average readiness for weaning score of patients achieved successful weaning was, however, higher than the average readiness for weaning score of those not achieved successful weaning. The assessment of readiness for weaning found that the average score of total patients was 15.29 (S.D. = 2.06).

3. Relationship among Age, Length of Time Receiving Mechanical Ventilation, Mode of Mechanical Ventilation before Weaning, Severity of Illness, Readiness for Weaning, and Successful Weaning from Mechanical Ventilation

Table 4 Pearson's Product Moment Correlation between Variables (n = 119)

Variable	1	2	3	4	5	6	7	8
1. Age	—	-0.006	0.120	-0.083	-0.061	-0.016	-0.123	-0.181*
2. Length of time receiving mechanical ventilation			0.054	-0.229*	0.197*	-0.049	-0.291**	-0.316**
3. Mode of mechanical ventilation before weaning[a]				-0.685	-0.519**	-0.076	0.083	-0.234*
4. Mode of mechanical ventilation before weaning[b]					-0.267**	0.100	0.064	0.199*
5. Mode of mechanical ventilation before weaning[c]						-0.017	-0.185*	0.076
6. Severity of illness							-0.059	-0.083
7. Readiness for weaning								0.347**
8. Successful weaning from mechanical ventilation								—

[a] 1 = SIMV with pressure support, 0 = others [b] 1 = A/C, 0 = others

[c] 1= A/C+short T-piece, 0 = others

[d] 1 = achieved successful weaning, 0 = not achieved successful weaning

*$p < 0.05$, ** $p < 0.01$

Table 4 reveals that age, length of time receiving mechanical ventilation, and the SIMV with pressure support mode had a negative relationship with successful weaning from mechanical ventilation at a statistically significant level ($r = -0.181$, $p < 0.05$; $r = -0.316$, $p < 0.01$; $r = -0.234$, $p < 0.05$, respectively). On the other hand, the mode of mechanical ventilation before weaning with A/C mode, and readiness for weaning had a positive relationship with successful weaning from mechanical ventilation at a statistically significant level ($r = 0.199$, $p < 0.05$; $r = 0.347$, $p < 0.01$, respectively).

5. Predicting Factors for Successful Weaning from Mechanical Ventilation

Table 5 Logistic Regression (n = 119)

variable	B	S.E.	Wald	df	Sig	Exp (B)
Age	-0.0620	0.0379	2.6776	1	0.1018	0.9399
Length of time receiving mechanical ventilation	-0.2720	0.1064	6.5397	1	0.0105*	0.7619
Mode of mechanical ventilation before weaning			2.0623	2	0.3566	
Mode 1[a]	-1.7057	1.2004	2.0188	1	0.1554	0.1817
Mode 2[b]	7.2179	42.5375	0.0288	1	0.8653	1363.00
Severity of illness	-0.1531	0.1125	1.8531	1	0.1734	0.8581
Readiness for weaning	0.6896	0.2419	8.1256	1	0.0044*	1.993
Constant	0.8833	4.6702	0.0358	1	0.8500	
Nagelkerke-R^2		0.543				

[a] SIMV with pressure support [b] A/C * $p < 0.05$

Table 5 indicates that more than half of the variations (54.30%) could be explained by the logistic equation. The variables that can be used as predicting factors for successful weaning are length of time receiving mechanical ventilation and readiness for weaning.

$$\text{Probability}_{\text{(achieved successful weaning)}} = \frac{1}{1 + e^{-W}}$$

when

W = 0.8833 - 0.0620 (age) - 0.2720 (length of time receiving mechanical ventilation) - 1.7057 (SIMV with pressure support) + 7.2179 (A/C) - 0.1513 (severity of illness) + 0.6896 (readiness for weaning)

CHAPTER V
DISCUSSION

This research was a study of the predicting factors for successful weaning from mechanical ventilation. The results are discussed in four main parts according to objectives of the study as follows:

1. Demographic data of patients weaning from mechanical ventilation
2. Data concerning age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning of patients weaning from mechanical ventilation
3. Correlation of successful weaning from mechanical ventilation with age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning
4. Predicting factors for successful weaning from mechanical ventilation

1. Demographic data of patients weaning from mechanical ventilation

The total number of patients in this study of weaning from mechanical ventilation was 119. The majority of these patients were male (57.98%); the male-female ratio was 7:5. This is consistent with a study conducted by Sungkhaw, W. (2001), which found that 62.50 percent of patients weaning from mechanical ventilation were male. Another study conducted by Goodnough-hanneman (1994: 4-11) found the higher proportion of males among patients weaning from mechanical ventilation after undergoing heart surgery as 79.01 percent of the patients were male. More than half of the sample in this study were married (53.78%), most of them were educated at primary level (64.70%) and did not work (66.38%). The average family income was 6,773.95 bahts per month, which was sufficient for the family expense. These data agree to the nature of Thai society, in which the past educational law stated compulsory education at primary level. The causes of illness were mostly respiratory diseases (42.85%). This result is in accordance with previous studies on weaning from mechanical ventilation (Afessa, et al., 1999: 456-461; Rumbak, et al., 1999: 1092-1095), which found respiratory diseases, especially COPD and pneumonia, in most patients. These two diseases induce impairments in gas exchange and pulmonary ventilation, which are major causes of the requirement for mechanical ventilation (Albert, et al., 1999: 3/11.1). Another study conducted by Kelly & Matthay (1993: 1818-1824), which found that a total of 51 percent of the ICU attending physicians evaluations listed pulmonary failure as the major factor necessitating prolonged mechanical ventilation. Impaired oxygenation requiring a high fraction of inspired oxygen was the most common factor necessitating continued ventilation in the pulmonary group in approximately 50 percent of the evaluations.

2. Data concerning age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning of patients weaning from mechanical ventilation

Age

Data show that the average age of the patients was 61.80 years; and approximately half of the patients were older than 65 years (47.05%). This result is consistent with previous studies (Krieger, et al., 1989: 858-861; Vitacca, et al., 2001; 225-230), which found most patients older than 65 years. Moreover, the survey study (Groegar, et al., 1993: 279-291 cited by Thompson, 1996: 7-16) found that half of the patients admitted into critical care units were older than 65 years. The patients in this study were admitted into the critical care units with respiratory failure and required mechanical ventilation. The average age of the patients achieved successful weaning was lower than those not achieved successful weaning (60.70 and 71.58 years, respectively). This result is consistent with previous studies of Vitacca, et al. (2001: 225-230), which found the average age of the patients achieved successful weaning was lower than those not achieved successful weaning (71.00 and 74.00 years, respectively). Moreover, these data are consistent with data from a study of weaning from mechanical ventilation in patients underwent open heart surgery, which found that the average age of patients achieved successfully weaning from mechanical ventilation was 61 years whereas the average of patients not achieved successful weaning was 66 years (Groegar, et al., 1993: 279-291 cited by Thompson, 1996: 7-16). Therefore, it is evident that most patients failed weaning trials from mechanical ventilation are older than who succeeded it.

Length of time receiving mechanical ventilation

Data show that the majority of the patients (64.70%) received mechanical ventilation for 1 to 3 days; the average length of time receiving mechanical ventilation was 3.49 days (Table 3), which could be considered as short term (Burns, 1998: 87-99). This result was different from the result of retrospective study on patients receiving care from the intensive care unit of Department of Internal Medicine, Nakornping Hospital, which found that the average duration of patients receiving mechanical ventilation was 7.10 days (Pothirat, C., Ed., 2002: 15). The average length of time receiving mechanical ventilation of the 107 patients achieved successful weaning in this study was shorter than the average length of time in the group not achieved successful weaning (3.16 and 6.42 days, respectively). This result is consistent with a study in patients older than 70 years (Krieger, et al., 1989: 858-861), which found average length of time receiving mechanical ventilation in the patients achieved successful weaning was 2.58 days whereas patients not achieved successful weaning had received mechanical ventilation for averagely 6.12 days.

Mode of mechanical ventilation before weaning

This study found that more than half of the patients received SIMV with pressure support mode of mechanical ventilation before weaning (57.98%). This result is in accordance with a study conducted by Sungkhaw, W. (2001) in which 59.40 percent of the patients received SIMV with pressure support before weaning from mechanical ventilation. The reason that most patients received SIMV with pressure support more than other modes may be due to the adjustable feature of volume-cycle mechanical respirators, which are mostly utilized in the study site of this research. This result is consistent with data concerning the application of mechanical ventilation at Lampang Central Hospital and Sawanpracharak Hospital, which demonstrate that SIMV with pressure support is a popular mode applied to patients receiving volume-cycle artificial respirators (Pothirat, C., Ed., 2002: 5-9).

Severity of illness

The severity of illness scores of the sample in this study ranged from 5 to 26 with an average score of 11.68. Considering the scores of the patients achieved successful weaning (mean = 11.57) in comparison with those not achieved successful weaning (mean = 12.68), nearly half of the patients achieved successful weaning (46.73%) had the scores ranging from 11 to 15 points whereas most patients who could not achieve successful weaning (83.34%) had severity score between 16-20 points. These results demonstrated higher severity of illness among the patients not achieved successful weaning, compared with those achieved successful weaning. This result is in accordance with the results of a study led by Afessa, et al. (1999: 456-461) and a study led by Vitacca, et al. (2001: 225-230), which found that the average score of severity of illness of patients not achieved successful weaning is higher than those achieved successful weaning from mechanical ventilation (16.90 and 11.30; 18.00 and 16.00, respectively). The result is also consistent with item scores of severity of illness assessment; for example, the heart rate of patients achieved successful weaning were in normal range, varying from 70 to 109 beats per minute whereas the heart rate of patients not achieved successful weaning ranged from 110-139 beats per minutes, which are higher than normal heart rate according to APACHE II scoring (Knaus, et al., 1985: 818-829). The heart rate higher than normal indicates higher level of severity of illness and inappropriate condition for weaning from mechanical ventilation (Boonboorapong , T. & Limpisawas, S., 1998: 268-278), as it is recommended that an indication of readiness for weaning is heart rate lower than 120 beats per minute (Knebel, 1991: 321-331). Similarly, the data of severity of illness score concerning respiratory rate demonstrate normal respiratory rate in the patients achieved successful weaning, ranging from 12 to 24 breaths per minute; respiratory rates of the patients not achieved successful weaning, on the other hand, ranged from 25 to 34 breaths per minute, which are higher than normal according to the APACHE II scoring (Knaus, et al., 1985: 818-829). The high respiratory rate indicates that the patient has inappropriate respiratory mechanics, requires high cardiac output and oxygen consumption, and is not ready to wean from mechanical ventilation as for successful weaning a patient needs to have respiratory rate lower than 30 breaths per minute, which indicates sufficient body tissue oxygenation (Knebel, 1991: 321-331).

Readiness for weaning

The study found average score of readiness for weaning at 15.29. The readiness for weaning scores of most patients achieved successful weaning ranged from 0 to 16 (72.90%) with the average score of 15.53. For all patients not achieved successful weaning, the readiness for weaning scores ranged from 0 to 16 with the average score 13.17. Considering each aspect of readiness for weaning, it was found that the patients achieved successful weaning had higher average scores in aspect of general condition and respiratory system, compared with the patients not achieved successful weaning. Patients achieved successful weaning had higher average scores, compared with those not achieved successful weaning, in the following items of readiness for weaning assessment (See Appendix D): item 1 – stable condition of cardiovascular system as assessed from heart rate 70 to 110 beats per minutes and systolic blood pressure 110 to 160 mm Hg; item 2 – no presence of factors influencing metabolism rate such as having fever or septicemia; item 12 - no expression or complaints of fear or anxiety; item 17 – no flatulence or abdominal fluid retention; and item 20 – respiratory tidal volume higher than 5 millilitres per kilogram of body weight. These data indicated that patients achieved successful weaning were more ready to wean than those not achieved successful weaning, which is in accordance with related literature previously reviewed (Dettenmeier, 1992: 350; Kamponsiri, T., 1994: 25; Knebel, 1991:321-331; Tobin & Alex, 1994: 1177).

3. Correlation of successful weaning from mechanical with age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning

This study found correlation of successful weaning from mechanical ventilation with length of time receiving mechanical ventilation and readiness for weaning at statistically significant level $p < 0.01$. Age and mode of mechanical ventilation before weaning with A/C, as well as SIMV with pressure support, mode of mechanical ventilation was found correlated with successful weaning from mechanical ventilation at statistically significant level $p < 0.05$. These findings are discussed in details below.

Length of time receiving mechanical ventilation

The length of time that patients had received mechanical ventilation had negative correlation with successful weaning from mechanical ventilation at statistically significant level ($r = -0.316$, $p < 0.01$). This finding supports hypothesis 1 of this study, as it demonstrates that short-term mechanical ventilation contributes to success in weaning from mechanical ventilation. This finding is consistent with the data, which shows that the average length of time receiving mechanical ventilation of the patients achieved successful weaning was 3.16 days whereas that of the patients not achieved successful weaning was 6.42 days. The length of time receiving mechanical ventilation associates with complications that have effects on successful weaning. The review of related literature found that physiological and psychological problems occurring in patients receiving mechanical ventilation would affect the weaning from mechanical ventilation. It was found that patients receiving mechanical ventilation for longer than five days were more suffered than those receiving the mechanical ventilation for 1 to 5 days at a statistically significant level (Yoosuk, S., et al., 1993: 35-40). The suffered feeling contributes to inappropriateness for weaning from mechanical ventilation as patients should be psychologically ready before the initiation of weaning (Dettenmeier, 1992: 350). Moreover, every one extensive day in the length of time receiving mechanical ventilation increases risk of pneumonia by one percent (Fagon, et al., 1989: 877-884) and patients are at risk of having tracheal obstruction (Heffner, 1993: 768-771). These conditions interfere pulmonary gas exchange, resulting in unsuccessful weaning. This is supported by a study led by Rumbak, et al. (1999: 1092-1095), which found that patients receiving mechanical ventilation for longer than four weeks had tracheal obstruction, resulting in failed weaning. Thus, length of time receiving mechanical ventilation has negative relationship with successful weaning from mechanical ventilation. In addition, the results of this study also demonstrated negative correlation between the length of time receiving mechanical ventilation and readiness for weaning as it is found that patients receiving mechanical ventilation for a shorter period of time achieved successful weaning more than those receiving mechanical ventilation for a longer time.

Readiness for weaning

This study found positive relationship between readiness for weaning and successful weaning from mechanical ventilation ($r = 0.347$, $p < 0.01$), hence supporting hypothesis 1. The results show that patients who were ready to wean could achieve successful weaning. This finding is consistent with data concerning readiness for weaning of the patients which had average score of readiness for weaning at 15.29. Referring to Burns, et al. (2000: 2259-2267), the average score of readiness for weaning higher than 16 (64%) indicates that the patient is likely to achieve successful weaning. The results of this study show that patients achieved successful weaning had higher readiness for weaning scores than those not achieved successful weaning (mean = 15.53 and 13.17, respectively). Referring to item scores of readiness for weaning assessment, positive correlation was found between the following items and successful weaning: Item 1 – stable function of cardiovascular system as indicated with heart rate 70 to 110 beats per minute and systolic blood pressure 110 to 160 mm Hg ($r = 0.229$, $p < 0.05$), which is essential in patients weaning from mechanical ventilation as tissue oxygenation depends on cardiac function in pumping blood to various parts of the body (Wilkins, 1995: 367-368); thus efficient cardiac function induces sufficient tissue oxygenation for the increased oxygen requirement during the process of weaning (Boonboorapong, T. & Limpisawas, S., 1998: 268-278). Therefore, readiness for weaning in this aspect can lead to successful weaning. Item 2 – no presence of factors influencing metabolic rate of the body such as infection or septicemia ($r = 0.209$, $p < 0.05$) also relates to successful weaning because the changes in metabolic rate contribute to increased heart rate and increased respiratory rate. In addition, every one degree celsius increase in body temperature induces 10 percent increase in oxygen consumption and carbon dioxide production of the body (Wilkins, 1995: 367). Therefore, the absence of these conditions contributes to successful weaning. Item 13 – the respiratory rate was lower than 25 rates per minute and no presence of dyspnea or breathing with neck muscles ($r = 0.208$, $p < 0.05$) also presented positive relationship with successful weaning. The respiratory rate higher than 30 breaths per minute indicates increased work of breathing (Kamponsiri, T., 1994: 25), reflecting that the body is not ready to wean from mechanical ventilation hence the weaning may be unsuccessful. Item 20 - spontaneous tidal volume higher than 5 millilitres per kilogram of body weight had significant relationship with successful weaning ($r = 0.357$, $p < 0.01$) as it indicates durability of respiratory muscles; therefore readiness in this aspect can result in successful weaning. For psychological readiness, it was found that most patients had sufficient incomes (60.50%) and did not have work responsibilities as they did not work (66.38%). These data imply no serious financial problem which affect on psychological readiness. Therefore, readiness for weaning correlate with successful weaning from mechanical ventilation as stated in the literature previously reviewed (Kiatbonsri, S., 1992: 234; Knebel, 1991; 321-334; Scanlan, 1995: 973).

Age

This study found negative correlation between age and successful weaning from mechanical ventilation at statistically significant level ($r = -0.181$, $p < 0.05$) as stated in hypothesis 1. The results indicated that successful weaning is less likely to occur at older age. The average age of patients not achieved successful weaning in this study was 71.58 years. At old age, a person's lung compliance decreases, resulting in difficult forced breathing. The breathing pattern turns to rapid shallow breathing leading to decreased capacity of gas exchange and higher residual volume (Christiansen & Grzybowski, 1993: 99-100). Older patients, therefore, are at higher risk of hypoxia due to hypoventilation and the limitation of oxygenation (Krieger, et al., 1989: 858-861). Moreover, older patients also have decreased cardiac output due to the reduction in efficiency of myocardial contraction, resulting in decreased oxygenation in various body tissues (Williams &Hopper, 1998: 234). These condition contributes to weaning failure in people at old age. Therefore, age has negative relationship with successful weaning.

Mode of mechanical ventilation before weaning

The SIMV with pressure support mode has negative relationship with successful weaning from mechanical ventilation at statistically significant level ($r = -0.234$, $p < 0.05$). This finding supports hypothesis 1, which states that there is a relationship between mode of mechanical ventilation before weaning and successful weaning from mechanical ventilation. The rationale for not achieved successful weaning in patients receiving SIMV with pressure support techniques may lie in the gradual reduction of the machine respiratory rate in addition to comfortable feeling from pressure support during the patient's spontaneous breathing. This mode is usually applied to patients receiving mechanical ventilation for a long time (Palwatwichai, A., 1999: 369-375). This finding is consistent with the data which show that patients achieved and not achieved successful weaning from mechanical ventilation received SIMV with pressure support mode (54.20 % and 91.61 %, respectively). The results of this study demonstrated positive correlation of A/C mode with successful weaning from mechanical ventilation, indicating that the patients receiving A/C mode was likely to achieve successful weaning. Data concerning mode of mechanical ventilation before weaning show that 28.04 percent of the patients achieved successful weaning received A/C mode whereas none of the patients not achieved successful weaning received these mode. Moreover, this study also found negative correlation of A/C mode with length of time receiving mechanical ventilation ($r = -0.229$, $p < 0.05$), indicating that the patients receiving A/C had shorter length of time in receiving mechanical ventilation, which is also related to successful weaning from mechanical ventilation as previously mentioned. As the A/C mode is full-support ventilation (St. John, 1998: 54), physicians' decision to initiate weaning with these mode, in stead of gradual reduction of respiratory rate, might be based on the patients' condition which demonstrates abilities to have spontaneous breathing. Thus these patients were able to successfully wean from mechanical ventilation.

4. Predicting factors for successful weaning from mechanical ventilation

An analysis with logistic regression equation found that predicting factors for successful weaning from mechanical ventilation in a weaning model were length of time receiving mechanical ventilation and readiness for weaning with the predictive value 0.543. Hence, the length of time receiving mechanical ventilation and readiness for weaning can predict successful weaning from mechanical ventilation by 54.30 percent. This finding partially supports hypothesis 2 of this study and is discussed in details below.

The length of time receiving mechanical ventilation is an indicator of underlying causes of the patient's requirement for mechanical ventilation. When the patient has sufficient pulmonary reserves, weaning will be initiated (Boonboorapong, T. & Limpisawas, S., 1998: 268–278) because long-term mechanical ventilation may induce disuse atrophy of muscles, which may finally lead to weaning failure ((Boonboorapong, T. & Limpisawas, S., 1998: 268–278) but this study did not found that patients had disused atrophy of muscles because the average length of time receiving mechanical ventilation was 3.49 days, which could be considered as short term (Burns, 1998: 87-99). This is supported by the result of this study that shows correlation between the length of time receiving mechanical ventilation and successful weaning from mechanical ventilation at statistically significant level 0.01.

Readiness for weaning reflects physiological and psychological readiness of patients (Knebel, 1991: 321-331), which is essential in weaning from mechanical ventilation. The readiness for weaning includes the readiness in general condition as reflected in vital signs, hematocrit, body metabolic, fluid and electrolytes balance, chest x-ray, nutrition, defecation, rest, body movement, pain and anxiety, and the readiness of respiratory system presenting in gas flow and work of breathing, airway clearance, respiratory muscle strength, and respiratory muscle endurance. Therefore, readiness for weaning indicates sufficient gas exchange and pulmonary ventilation. This study found correlation between readiness for weaning and successful weaning from mechanical ventilation at statistically significant level 0.01 and also found internal relationship between readiness for weaning and the length of time receiving mechanical ventilation at statistically significant level 0.05. Thus length of time receiving mechanical ventilation and readiness for weaning could be used as predicting factors for successful weaning from mechanical ventilation.

The following logistic regression equation could be used to predict probability (Vanichbancha, K., 2001: 58-86) of successful weaning from mechanical ventilation:

$$\text{Probability}_{\text{(achieved successful weaning)}} = \frac{1}{1 + e^{-w}}$$

when

W = 0.8833 - 0.0620 (age) - 0.2720 (length of time receiving mechanical ventilation) - 1.7057 (SIMV with pressure support) + 7.2179 (A/C) - 0.1513 (severity of illness) + 0.6896 (readiness for weaning)

Conclusion

The results of predicting factors for successful weaning from mechanical ventilation in this study indicate that age, mode of mechanical ventilation before weaning, and severity of illness are not predictive for successful weaning from mechanical ventilation. Nevertheless, length of time receiving mechanical ventilation and readiness for weaning may be applied to explain the variation of logistic regression analysis for the prediction of successful weaning from mechanical ventilation by 54.30 percent whereas other variables in this study can not explain the other 45.70 percent of the results, which may be affected by other factors not included in this study. Therefore, the length of time receiving mechanical ventilation and readiness for weaning could reflect possibility of successful weaning and should be taken into consideration before the initiation of weaning to increase the chance of successful weaning from mechanical ventilation.

CHAPTER VI
CONCLUSION

Summary of the Study

This study was a prospective descriptive research aiming to examine predicting factors; age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning as related to successful weaning from mechanical ventilation and to investigate the potency of age, length of time receiving mechanical ventilation, mode of mechanical ventilation before weaning, severity of illness, and readiness for weaning as predicting factors for successful weaning from mechanical ventilation. This study was based on the weaning concept developed by Boonboorapong, T. & Limpisawas, S. (1998). The samples were patient older than 15 years with a good level of consciousness, received mechanical ventilation longer than six hours, and initiated weaning from mechanical ventilation by physician order. The total samples were 119 patients admitted to medical intensive care unit, medical intermediate care unit, and surgical intensive care unit at Chaoprayayomaraj Hospital and in the intensive care unit of the 17th Somdejprasangkaraj Hospital between February 2002 to July 2002. Research instruments were included demographic data record, record of factors related to a weaning trial (weaning trial data, assessment of severity of illness, and assessment of readiness for weaning), and successful weaning record. Furthermore, an assessment of severity of illness had interrater reliability value 0.98 and an assessment of readiness for weaning had interrater reliability value 0.88. The data were analyzed with the computer program SPSS/FW and presented on frequency, percent, range, mean, standard deviation, Pearson's product moment correlation coefficient, and logistic regression.

The higher proportion of males to females in the patients achieved successful weaning (7:5); however, the proportion between the two genders was equal in the patients not achieved successful weaning. Data about marital status showed that the majority of the patients achieved successful weaning were married (51.94%), whereas most of those in the other group were divorced or widowed (66.6%). The average age of the patients not achieved successful weaning was 71.58 years, higher than that of those achieved successful weaning (60.70 years). The highest educational level of the patients was primary level. The patients did not work and had an average family income of between 3,000 to 6,000 baht per month. More than half of the patients achieved successful weaning reported sufficient income (61.68%) but only half of those who could not wean from mechanical ventilation reported the same. Half of the patients in both groups had respiratory disorders as causes of their illness, and only the minority of them had received surgical treatment (11.21% of the patients achieved successful weaning and 25.00% of those not achieved successful weaning).

The majority of the patients, either patients achieved or not achieved successful weaning (67.29% and 41.68%, respectively), received mechanical ventilation for one to three days. More than half of the patients achieved successful weaning received the SIMV with pressure support mode (54.20%). Almost of the patients not achieved successful weaning received the same mode (91.67%). Regarding the severity of illness score, nearly half of the patients achieved successful weaning had the score from 11 to 15 (46.73%); and more than half of those who not achieved successful weaning had a score from 11 and 15 (66.66%). The assessment of readiness for weaning found that the patients achieved successful weaning had readiness for weaning scores from 0 to16 (72.90%) but all patients not achieved successful weaning had readiness for weaning score from 0 to16.

The average length of time receiving mechanical ventilation of the patients not achieved successful weaning was 6.42 days (S.D. = 5.25), longer than that of the patients achieved successful weaning, which was 3.16 days (S.D. = 2.62). Nevertheless, the average score of severity of illness of patients in the two groups were similar, as the assessment of severity of illness form showed the average score of the patients achieved and not achieved successful weaning at 11.57 (S.D. = 4.11) and 12.68 (S.D. = 3.15), respectively. The average readiness for weaning score of patients achieved successful weaning was, however, higher than the average readiness for weaning score of those not achieved successful weaning. The assessment of readiness for weaning found that the average score of the total patients was 15.29 (S.D. = 2.06).

The reveals that age, length of time receiving mechanical ventilation, and the SIMV with pressure support mode had a negative relationship with successful weaning from mechanical ventilation at a statistically significant level ($r = -1.81$, $p < 0.05$; $r = -0.316$, $p < 0.01$; $r = -0.234$, $p < 0.05$, respectively). On the other hand, the mode of mechanical ventilation before weaning with assist-control mode and readiness for weaning had a positive relationship with successful weaning from mechanical ventilation at a statistically significant level ($r = 0.199$, $p < 0.05$; $r = 0.347$, $p < 0.01$, respectively). More than half of the variations (54.30%) could be explained by the logistic equation. The variables that can be used as predicting factors for successful weaning are length of time receiving mechanical ventilation and readiness for weaning.

$$\text{Probability}_{\text{(achieved successful weaning)}} = \frac{1}{1 + e^{-W}}$$

when

W = 0.8833 - 0.0620 (age) - 0.2720 (length of time receiving mechanical ventilation) - 1.7057 (SIMV with pressure support) + 7.2179 (A/C) - 0.1513 (severity of illness) + 0.6896 (readiness for weaning)

Implications and Recommendations

The implications and recommendations of the study of predicting factors for successful weaning from mechanical ventilation, are as follows:

Implication and Application of Research Finding

1. The length of time receiving mechanical ventilation was an important factor for successful weaning from mechanical ventilation; therefore, patients should receive close care from nurses both physiologically and psychologically to resolve problems that may cause a patient to become dependent on mechanical ventilation. Patients who can breath unassisted have a decreased risk of complications such as pneumonia, trachea obstruction, and psychological problems that can interfere with weaning from mechanical ventilation.

2. Readiness for weaning was one factor that contributed to successful weaning from mechanical ventilation. Therefore, nurses should properly prepare patients to be weaned. Before weaning, nurses should check the general condition of the patient, monitor vital signs and assess hematocrit, body metabolism, fluid and electrolyte balance, chest x-ray, nutrition status, defecation, rest, physical strength, pain, anxiety or fear. The patients' respiratory system should be checked through assessment of gas flow and the work of breathing, airway clearance, and respiratory muscle endurance. Furthermore, nurses should prepare the patients psychologically by teaching the patients how to breathe in order to decrease the patients' anxiety over being taken of mechanical ventilation.

3. Age and mode of mechanical ventilation before weaning with SIMV with pressure support had a negative relationship with successful weaning from mechanical ventilation. Therefore, elderly patients or patients who received SIMV with pressure support mode should be gradually weaned from mechanical ventilation, in order for weaning to be successful. Conversely, mode of mechanical ventilation before weaning with A/C mode had a positive relationship with successful weaning from mechanical ventilation. Therefore, nurses and health care teams should consider wean patients from mechanical ventilation when the underlying pathologic process is significantly reversed.

Recommendation for Further Research

1. From the results of the study, it was found that readiness for weaning could predict successful weaning from mechanical ventilation. The readiness of weaning consist of 26 items. Therefore, the study should have comparative study in each item between patients achieved successful weaning and patients did not achieve successful weaning so the result can be used to help nurses and health professional better prepare patients for more successful weaning.

2. Only the patients with good level of consciousness were selected this study, therefore there should be studies on predicting factors for successful weaning from mechanical ventilation on unconscious patients using the same variables as this study, for further understanding about the factors that can predict successful weaning from mechanical ventilation in patients with impaired consciousness or neurologic patients.

3. Future study should study the same factors as this study on patients requiring ventilator support via tracheotomy tube.

4. Part of the instruments used in this study that are assessment of readiness for weaning, which is a standard instrument used in other countries, may not be responsive to the setting the researcher chose for data collection. Therefore, nurses and health care team should try to develop an assessment of readiness for weaning which is more responsive to Thailand.

5. For the future studies the same factors should be used on sample size of 150 or above and the sample size should be calculated from the relative risks based on the formula for logistic regression analysis, leading to more credibility of the results.

Limitation

1. The sample size in this study could not by calculated based on the formula for logistic regression analysis due to weaning from mechanical ventilation is associated with various factors that are both physiological and psychological. No factors could predict successful weaning or failure weaning, moreover, there has not been any study on the relationships and the predictability of these factors. There is also no literature regarding the relative risks for successful weaning from mechanical ventilation leading to calculated sample size.

2. The readiness for weaning score from this study may be inaccurate for patients because the scoring criteria was one point for a "yes" answer and no points for both the "no" and "no assessment", so that patients who had no points from "no assessment" may actually have readiness for weaning in those areas. The setting in which the researcher collected data was limited. There was a lack of laboratory information regarding electrolytes, hematocrit, and arterial blood gas.

3. The results of the study regarding mode of mechanical ventilation before weaning was incomplete because the mode of mechanical ventilation before weaning with A/C had not been used on patients not achieved successful weaning in this study.

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APPENDIX A

List of Experts

1. Associate Professor Khun-Ying Puttipannee Vorrakitpokatorn
   Department of Anaesthesiolgy
   Faculty of Medicine, Siriraj Hospital, Mahidol University
2. Assistant Professor Patiparn Toomtong
   Department of Anaesthesiolgy
   Faculty of Medicine, Siriraj Hospital, Mahidol University
3. Miss Suporn Lilitthum
   Head nurse of Post-operative Intensive Care Unit
   Faculty of Medicine, Siriraj Hospital, Mahidol University
4. Miss Daranee Intajuk
   Registered nurse of Cardiology Intensive Care Unit
   Faculty of Medicine, Siriraj Hospital, Mahidol University
5. Miss Nipawan Siriprasert
   Nurse Manager
   Phyathai 3 Hospital

APPENDIX B

Information Consent Form

คำชี้แจงการพิทักษ์สิทธิ์สำหรับผู้เข้าร่วมวิจัย

สวัสดีค่ะ ดิฉันนางสาวพนาภรณ์ รัตนปนัดดา เป็นนักศึกษาปริญญาโท สาขาการพยาบาลผู้ใหญ่ คณะพยาบาลศาสตร์ มหาวิทยาลัยมหิดล กำลังศึกษาวิจัยเรื่องปัจจัยทำนายความสำเร็จในการหย่าเครื่องช่วยหายใจ โดยผลที่ได้จะเป็นข้อมูลพื้นฐานให้ทีมสุขภาพใช้ในการวางแผนช่วยเหลือเพื่อส่งเสริมให้ผู้ป่วยประสบความสำเร็จในการหย่าเครื่องช่วยหายใจ ซึ่งคุณเป็นบุคคลหนึ่งที่จะช่วยให้ข้อมูลที่เป็นประโยชน์ต่อการศึกษาครั้งนี้ ถ้าคุณยินดีจะเข้าร่วมวิจัยดิฉันจะขอรบกวนคุณในการตอบคำถามเกี่ยวกับข้อมูลส่วนตัวประมาณ 10 นาที และขออนุญาตในการจดบันทึกข้อมูลเกี่ยวกับการรักษาพยาบาลของคุณจากแฟ้มประวัติ และบันทึกทางการพยาบาล โดยข้อมูลที่ได้จากคุณทั้งหมดจะเป็นความลับ และไม่มีการเปิดเผยชื่อของคุณให้ผู้อื่นทราบ แต่จะนำข้อมูลที่ได้ไปวิเคราะห์ในภาพรวม และนำผลการวิจัยมาใช้ประโยชน์ในการปรับปรุงการดูแลในผู้ป่วยที่หย่าเครื่องช่วยหายใจให้มีคุณภาพยิ่งขึ้น

หากคุณมีข้อสงสัยประการใดเกี่ยวกับการวิจัยครั้งนี้ ดิฉันยินดีจะตอบคำถามให้คุณเข้าใจ คุณมีสิทธิที่จะตอบรับหรือปฏิเสธการเข้าร่วมในการวิจัยครั้งนี้ได้อย่างเสรี และไม่ว่าคุณจะเข้าร่วมในการวิจัยครั้งนี้หรือไม่ก็ตาม คุณยังคงได้รับการดูแลจากเจ้าหน้าที่ของโรงพยาบาลเป็นอย่างดี ดิฉันขอขอบคุณที่คุณสละเวลาให้สัมภาษณ์ในครั้งนี้

พนาภรณ์ รัตนปนัดดา

เบอร์โทรศัพท์ที่ติดต่อได้ : 09-9263184

....

สำหรับผู้เข้าร่วมวิจัย

ข้าพเจ้าได้รับทราบรายละเอียดของการวิจัยดังที่อธิบายไว้ข้างต้นแล้ว มีความเข้าใจและยินดีให้ความร่วมมือในการวิจัย ลงชื่อ.................................

( )

วันที่................................

APPENDIX C

Instruments

เครื่องมือในการเก็บรวบรวมข้อมูล
"ปัจจัยทำนายความสำเร็จในการหย่าเครื่องช่วยหายใจ"

ส่วนที่ 1 **แบบบันทึกข้อมูลพื้นฐานของผู้ป่วย**

<u>คำชี้แจง</u> โปรดทำเครื่องหมาย ✓ หรือเติมข้อความตามความเป็นจริง

1. เพศ..................
2. อายุ...............ปี
3. สถานภาพสมรส.......................................
4. การศึกษาสูงสุด.......................................
5. อาชีพ..
6. รายได้เฉลี่ยของครอบครัวต่อเดือน..................บาท
7. ความเพียงพอของรายได้ ☐ ไม่เพียงพอ ☐ เพียงพอ
8. การวินิจฉัยโรค.......................................

ส่วนที่ 2 แบบบันทึกปัจจัยที่เกี่ยวกับการหย่าเครื่องช่วยหายใจ

ตอนที่ 1 แบบบันทึกเกี่ยวกับการหย่าเครื่องช่วยหายใจ

คำชี้แจง โปรดทำเครื่องหมาย ✓ หรือเติมข้อความตามความเป็นจริงลงในช่องว่าง

1. เวลาที่เริ่มใช้เครื่องช่วยหายใจ.........................น. วันที่..........................
2. เวลาที่เริ่มลดการช่วยหายใจ............................น. วันที่..........................
3. เวลาที่เริ่มการหย่าเครื่องช่วยหายใจ...................น. วันที่..........................
4. รวมระยะเวลาที่ใช้เครื่องช่วยหายใจจนถึงก่อนเริ่มการหย่าเครื่องช่วยหายใจ จำนวน..............ชั่วโมง
5. วิธีการช่วยหายใจก่อนการหย่าเครื่องช่วยหายใจ

☐ ผู้ป่วยได้รับการช่วยหายใจจากเครื่องเป็นช่วง ๆ ด้วยแรงดันบวก ร่วมกับหายใจเองขณะที่เครื่องเว้นระยะการช่วยหายใจ (SIMV)

☐ ผู้ป่วยได้รับการช่วยหายใจจากเครื่องเป็นช่วง ๆ ร่วมกับการหายใจเองขณะที่เครื่องเว้นระยะการช่วยหายใจ โดยได้รับแรงดันเสริมขณะที่หายใจเอง (SIMV+PSV)

☐ ผู้ป่วยได้รับแรงเสริมปริมาณหนึ่งในขณะที่หายใจเอง (PSV)

☐ วิธีอื่น ๆ ระบุ...

ตอนที่ 2 แบบวัดความรุนแรงของการเจ็บป่วย

ความรุนแรงของการเจ็บป่วยด้านร่างกาย

<u>คำชี้แจง</u> โปรดเติมข้อความในช่องว่างให้สมบูรณ์ ด้วยข้อมูลในช่วงเวลา 24 ชั่วโมง นับตั้งแต่เริ่มลดการช่วยหายใจไปจนถึงเมื่อเริ่มต้นหย่าเครื่องช่วยหายใจ ถ้าข้อใดไม่มีข้อมูลในช่วงเวลาดังกล่าวให้เติม "ไม่มีข้อมูล" ลงในช่องว่าง แต่ถ้าระยะเวลาตั้งแต่เริ่มลดการใช้เครื่องช่วยหายใจจนถึงเริ่มหย่าเครื่องช่วยหายใจไม่ถึง 24 ชั่วโมง ให้ใช้ข้อมูลในช่วง 24 ชั่วโมงก่อนเริ่มหย่าเครื่องช่วยหายใจ

	วันที่		วันที่		วันที่	
ข้อมูล	ค่าสูงสุด	ค่าต่ำสุด	ค่าสูงสุด	ค่าต่ำสุด	ค่าสูงสุด	ค่าต่ำสุด
อุณหภูมิกาย °ซ						
....						
....						
Glasgow coma score						

ความรุนแรงของการเจ็บป่วยด้านภาวะสุขภาพเรื้อรัง

<u>คำชี้แจง</u> แบบวัดส่วนนี้เป็นการประเมินการมีประวัติการทำงานผิดปกติของอวัยวะอย่างรุนแรง หรือ มีภูมิคุ้มกันบกพร่อง (immuno-compromised) เกิดขึ้นก่อนที่ผู้ป่วยจะเข้ารับการรักษาในโรงพยาบาลตามเกณฑ์ ดังต่อไปนี้

1. ตับ : การส่งตรวจชิ้นเนื้อพบตับแข็ง และ portal hypertention เคยมี เลือด..

....

....

5. ภูมิคุ้มกันบกพร่อง (Immuno-compromised) : ผู้ป่วยได้รับการรักษาที่เสี่ยง...

....

....

ตอนที่ 3 แบบประเมินความพร้อมก่อนการหย่าเครื่องช่วยหายใจ

คำชี้แจง ข้อความข้างล่างต่อไปนี้เป็นการประเมินความพร้อมของผู้ป่วย ด้วยข้อมูลล่าสุดในช่วง 24 ชั่วโมง ก่อนเริ่มหย่าเครื่องช่วยหายใจ โปรดทำเครื่องหมาย ✓ ลงในช่องว่างด้านขวาของข้อความตามความเป็นจริง

เกณฑ์การประเมิน	ใช่	ไม่ใช่	ไม่ได้ประเมิน
การประเมินสภาพทั่วไป			
1. การทำงานของระบบไหลเวียนโลหิตคงที่ โดยมีอัตราการเต้นของหัวใจ 70-110 ครั้งต่อนาที			
....			
....			
การประเมินระบบทางเดินหายใจ			
การไหลของก๊าซและแรงที่ใช้ในการหายใจ			
....			
....			
การทำให้ทางเดินหายใจโล่ง			
....			
....			
ความทนทานของกล้ามเนื้อที่ใช้ในการหายใจ			
....			
....			
ค่าความดันก๊าซในเลือดแดง			
....			
....			
26. ค่าความดันในเลือดแดงมากกว่า 60 มิลลิเมตรปรอท..............			
....			

APPENDIX D

More Results

ตารางที่ 1 ค่าเฉลี่ย และส่วนเบี่ยงเบนมาตรฐาน ของความรุนแรงของการเจ็บป่วยในช่วง 24 ชั่วโมงก่อนหย่าเครื่องช่วยหายใจรายข้อ ในกลุ่มตัวอย่างที่หย่าเครื่องช่วยหายใจสำเร็จและไม่สำเร็จ

ข้อมูล	การหย่าเครื่องช่วยหายใจ							
	สำเร็จ				ไม่สำเร็จ			
	ค่าสูงสุด		ค่าต่ำสุด		ค่าสูงสุด		ค่าต่ำสุด	
	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.
อัตราการเต้นของหัวใจ (ครั้ง/นาที)	109.73	19.48	77.82	15.57	114.58	31.25	82.58	24.65
อัตราการหายใจ (ครั้ง/นาที)	25.53	5.21	15.44	2.93	29.17	8.43	15.25	3.74

ตารางที่ 2 ค่าเฉลี่ย และส่วนเบี่ยงเบนมาตรฐาน ของคะแนนความพร้อมในการหย่าเครื่องช่วยหายใจรายข้อ

ข้อมูล	การหย่าเครื่องช่วยหายใจ					
	สำเร็จ		ไม่สำเร็จ		ทั้งหมด	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
การประเมินสภาพทั่วไป	**8.24**	**1.50**	**6.83**	**1.85**	**8.10**	**1.59**
1. การทำงานของระบบไหลเวียนโลหิตคงที่ อัตราการเต้นของหัวใจ 70-110 ครั้งต่อนาที ความดันซีสโตลิค 110-160 มิลลิเมตรปรอท	0.76	0.43	0.42	0.51	0.72	0.45
2. ไม่มีปัจจัยที่ทำให้เกิดการเพิ่มขึ้น หรือการลดลงของอัตราการเผาผลาญในร่างกาย	0.90	0.31	0.67	0.49	0.87	0.33
12. ผู้ป่วยไม่บ่น/แสดงอาการวิตกกังวล	0.62	0.49	0.33	0.49	0.59	0.49
การประเมินระบบทางเดินหายใจ	**7.35**	**1.01**	**6.42**	**1.00**	**7.25**	**1.04**
17. ไม่มีภาวะท้องอืดหรือน้ำในช่องท้อง	0.94	0.23	0.67	0.49	0.92	0.28
20. ปริมาตรอากาศในการหายใจเข้าหรือออกปกติ 1 ครั้งมากกว่า 5 มิลลิลิตรต่อกิโลกรัมของน้ำหนักตัวผู้ป่วย	0.87	0.34	0.42	0.51	0.82	038

ตารางที่ 3 ความสัมพันธ์รายข้อของความพร้อมในการหย่าเครื่องช่วยหายใจกับความสำเร็จในการหย่าเครื่องช่วยหายใจ

ข้อ	r	p-value
การประเมินสภาพทั่วไป		
1. การทำงานของระบบไหลเวียนโลหิตคงที่โดยมีอัตราการเต้นของหัวใจ70-110 ครั้งต่อนาที ความดันซีสโตลิค 110-160 มิลลิเมตรปรอท	0.229	0.012
2. ไม่มีปัจจัยที่ทำให้เกิดการเพิ่มขึ้นหรือการลดลงของอัตราการเผาผลาญในร่างกาย	0.209	0.022
การประเมินระบบทางเดินหายใจ		
13. อัตราการหายใจน้อยกว่า 25 ครั้งต่อนาที ไม่มีอาการหายใจลำบาก ไม่ใช้กล้ามเนื้อที่คอช่วยในการหายใจ	0.208	0.023
20. ปริมาตรอากาศในการหายใจเข้าหรือออกปกติ 1 ครั้ง มากกว่า 5 มิลลิลิตรต่อกิโลกรัมของน้ำหนักตัวผู้ป่วย	0.357	0.000

APPENDIX E

Permission Letter for Using the Instrument

วันที่ : Mon, 24 Dec 2001 09:55:00 -0500

ผู้ส่ง : William Kraus <wak4b@cms.mail.virginia.edu> [ADD]

หัวเรื่อง : Re: Asking for permission to use the instument

ถึง : panaporn ratana <panaporn.r@chaiyo.com>

You do not need formal permission- please use it and good luck

---

> Dear Sir,
> I am a second-year Graduate student in the Masters degree program
of the Faculty of Nursing, Mahidol University, Bangkok,Thailand. I am
conducting a thesis entitled " Predicting factor for successful weaning
from mechanical ventilation".
> As I were reviewing necessary articles for my topic; I found the
article " APACHE II : A severity of disease classification system" as
published in Vol.13, No.10, 1985 of Critical Care Medicine to be very
informative and important my thesis.
> So, could you please give me some advice if I can possibly
inquire for a permission from you to use APACHE II in my thesis. I am
looking forward to hearing from you soon.
> Yours
sincerely
> Panaporn
rattanapanadda
> student nurse in master degree
program
> Mahidol university,
Thailand
> Email:
panaporn.r@chaiyo.com
>

William A. Kraus M.D.
Evelyn Troup Hobson Professor and Chair
Department of Health Evaluation Sciences
University of Virginia School of Medicine
Box 600717 Charlottesville, Va. 22908
1-804-924-8430 Fax 1-804-924-8437

วันที่ : Thu, 29 Nov 2001 15:49:52 -0500 (Eastern)

ผู้ส่ง : "Suzanne M. Burns" <smb4h@cms.mail.virginia.edu> [ADD]

หัวเรื่อง : Re: asking for permission to use the instrument

ถึง : panapom ratana <panapom.r@chaiyo.com>

Dear Panapom,

You have my permission to use the BWAP assessment worksheet for your research. I wish you well and good luck. I'll look forward to hearing how your project goes.

Sincerely, Suzi Burns

On 29 Nov 2001 04:11:40 -0000 panapom ratana <panapom.r@chaiyo.com> wrote:

> Dear Sir,
> I am a second-year Graduate student
> in the Master degree program of the Faculty of Nursing,
> Mahidol University, Bangkok, Thailand. I am conducting the
> thesis entitled "Predicting factor for successful weaning from
> mechanical ventilation". As I were
> reviewing necessary articles for my topic; I found the
> article " The long-term mechanically ventilated patient :
> An outcomes management approach" as published in
> Vol.10,No.1of Critical Care Nursing Clinics of North
> America to be very informative and important for my thesis.
> So, could you please give me some advice if I can possibly
> inquire for a permission from you to use the Burns Wean
> Assessment Program in my thesis. Please tell me for your
> decision by email to panapom.r@chaiyo.com
>
> Yours sincerely
> Panapom Rattanapanadda
> Student nurse in master degree program
> Faculty of Nursing, Mahidol university, Thailand
> ____________________
> ""
> http://mail.chaiyo.com/

Suzanne M. Burns RN, MSN, RRT, ACNP, CCRN, FAAN
Associate Professor of Nursing, Acute and Specialty Care
Clinican 5, Medicine/MICU
Project Coordinator, Medical Management
McLeod Hall School of Nursing
University of Virginia Health System
Charlottesville, Va 22903-3395
Voice mail: (434) 924-2259
FAX: (434) 982-1809
e-mail: smb4h@virginia.edu

BIOGRAPHY

NAME	Miss Panaporn Rattanapanadda
DATE OF BIRTH	26 April 1975
PLACE OF BIRTH	Suphanburi, Thailand
INSTITUTION ATTENED	Boromarajonani College of Nursing, Ratchaburi, 1992-1996:
	Diploma in Nursing Science Equivalent to Bachelor of Science in Nursing
	Sukhothai thammathirat University, 1996-1998:
	Bachelor of Public Health (Public Health Administration)
	Mahidol University, 2000-2003:
	Master of Nursing Science (Adult Nursing)
POSITION & OFFICE	1996 – Present, Division of Nursing, The 17th Somdejprasangkaraj Hospital, Thailand
	Position: Registered Nurse