Original Article

Developing a readiness assessment tool for weaning patients under mechanical ventilation

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Abstract

Background: Mechanical ventilation is one of the major supportive interventions in intensive care units. Weaning the patients from mechanical ventilation and its related criteria are of great importance due to the related complications. As there is no comprehensive standard to allocate the time of weaning and due to lack of local research in this field, development of a comprehensive tool to measure patients' readiness for weaning from mechanical ventilation is essential. Therefore, the present study was conducted with an aim to develop a readiness assessment tool for weaning patients from mechanical ventilation.

Materials and Methods: This was a qualitative study with Delphi multi-triangulation design. In the first stage, the related items were extracted from the textbook and through searching the databases. In the second stage, after primary development of the items and based on supervisors' indications, a questionnaire was made and used for assessment through Delphi methods. Twenty individuals, meeting the inclusion criteria, were selected through purposive sampling and their viewpoints concerning acceptability of the items were collected. In the third stage, the items with appropriateness over 70% were selected, and in the fourth stage, the final questionnaire was developed after a session with a panel of experts and supervisors. In the present study, in the first stage, the needed items were collected from various articles and books to provide items extraction. In stages two to four, manual calculation and investigation made by a panel of experts and the research team were adopted.

Results: In the first stage, 100 articles and 51 related books were selected. In the second stage, 87 items were extracted from the articles and books and were sent as semi-open questions of assessment. In the third stage, 28 items with consensus >70% were extracted, and in the fourth stage, 26 items were selected by a panel of experts and the finalized questionnaire with the title "Persian Weaning Tool" (PWT) was developed in three domains: Respiration with 9 items, cardiovascular with 4 items, and other related factors with 13 items.

Conclusions: A three-domain questionnaire is the product of experts' consensus in the present study, which can be used to reduce the length of connection to mechanical ventilation and its complications.

Key words: Iran, mechanical ventilation, nurse, patient, Persian Weaning Tool (PWT), readiness, weaning

Introduction

Mechanical ventilation is one of the major supportive interventions in intensive care.[1] As every phenomenon has hazards, despite its advantages, mechanical ventilation is not free of complications. After an increase occurred in the number of survived patients from progressive respiratory disorders, the complications of mechanical ventilation were revealed and weaning the patients from mechanical ventilation and its related criteria were considered important.[2] It consequently led to the need for a predicting criterion to determine patients' readiness for weaning from mechanical ventilation.[3]

Research shows that 30% of the patients hospitalized in intensive care unit (ICU) need connection to mechanical ventilation. About 80% of these patients do not need a specific process to wean and can be conveniently weaned from mechanical ventilation within a couple of hours or days. In the remaining 20% of the patients, long-term mechanical ventilation leaves the patients with numerous complications[4,5] such as the effects on cardiovascular, respiratory, and musculoskeletal systems, psychological status, hydroelectrolytes and renal condition, digestive system, and infection and incidence of barotraumas.[6-8] Inadequate number of existing hospital beds in the ICUs[9] and their high cost are also among the other problems of patients.[10]

With regard to above-mentioned issues, it is necessary to wean the patients from supportive ventilation as soon

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as they maintain spontaneous respiration. As the failure in weaning leads to an increase in complications and mortality, and prolonged mechanical ventilation time and hospitalization period in the ICU, the necessity to develop a predicator for patients' weaning with an inter-professional approach is revealed.[7] As cooperation in provision of intensive care leads to a safe and efficient care, nowadays, teamwork is of great importance in provision of patients' care with the goal of a comprehensive and cost-effective care.[11]

There have been various criteria already designed such as those of Burns (1971), Morganroth (1984), and Gluckand Corigan scoring system (1996). Tools such as APACHE II and III (acute physiology score + age points + chronic health points) (1991), Frutos-Vivar (to determine the level of re-intubation after extubation) (1991) (to determine the level of re-intubation after extubation), Khami model (to determine extubation outcome) (2001) (to determine extubation outcome), and TISS system (therapeutic intervention scoring system) (2008) are not specified for weaning, but can be efficient to some extent.

Susan Burns (2010) used a scale including respiration, psychological, digestive, cardiovascular, and renal status to assess the outcome of weaning. The results obtained by her showed the success of this scale in detection of the patients ready to start weaning.[12] In the scale of Morganroth, heart rate, patients' psychological and psychomotor status, consumption of sedatives, antibiotics, and vasopressors, body temperature, respiratory secretions and cardiac status, air oxygen percentage, and end-expiratory positive pressure, compliance, minute ventilation, and machine sensitivity (trigger) were used.[13] Gluck and Corigan scoring system includes five subscales of rapid shallow breathing index, ratio of residual volume to tidal volume, static compliance, airway pressure, and CO2 pressure.[14] Based on earlier research, application of each of these scales causes problems that are discussed subsequently.

In Todorova's study, the levels of plasma proteins and albumin were reported as the important non-pulmonary indexes to assess patients' condition and predict their weaning outcome.[15] Yung and Toobin showed that the ratio of respiration rate to tidal volume, despite its simplicity, is more precise for prediction of weaning outcome compared to other conventional criteria,[2] but has not been considered in the above-mentioned scales. Patients' psychological and physiologic conditions should be concurrently considered at the time of weaning.[16] So, it can be concluded that the aforementioned systems lack a comprehensive approach to the patient due to ignoring patients' psychological and physiologic conditions. They also face limitations because of not considering plasma proteins and albumin and the ratio of respiration rate to tidal volume, so many of these tools lack the needed comprehensiveness and have limitations when applied for the patients in Iran.

Some studies were conducted by Gluck (1996), which used few items such as laboratory tests and respiratory criteria to predict weaning time.[14] Another study conducted by Walsh (2004) on prediction of weaning time in patients hospitalized in the ICU just focused on the levels of Na and K, temperature, hemoglobin (Hb), respiratory criteria, existence of cough reflex, pain, and consumption of inotropes.[17] In 2010, Monaco conducted a study on prediction of weaning outcome by just using the criteria of respiration, temperature, and Na and K.[18] In Iran, three studies have been conducted in this field. In 2007, Hosseini showed the efficiency of Apachi II system in prediction of weaning outcome,[6] but in the study of Jalalian, no specific criteria were found to determine the time of weaning process.[19] In 2011, Salmani showed the efficiency of Burn's scale in lowering the length of mechanical ventilation.[20]

With regard to the above-mentioned issues, development of a comprehensive tool to measure patients' readiness for weaning from mechanical ventilation is essential. As various staffs of health providing team cooperate with one another in the weaning process,[11,21-23] development of a tool with an inter-professional approach, especially for the physicians and nurses, was considered.

Materials and Methods

This was a qualitative study with Delphi multi-triangulation design.

In the first stage, the researcher extracted the factors effective on patients' weaning from mechanical ventilation through systematic and manual search. In this stage, items needed for the study were searched in data banks such as Ovid, PubMed, CCTR, Medline, and CINAHL using the key words weaning, patient, ventilation, mechanical, and readiness, as well as combination of words with *AND and OR*. This resulted in selection of 9796 articles and 51 books, related to the subject of the study, up to year 2011. After revision, 100 articles, in which weaning tools were somehow used, were selected and finally, appropriate items were extracted from those selected articles and the existing books, yielding a total of 87 items.

These items, in the form of a designed questionnaire with semi-open questions in eight domains and 87 items with three options of acceptable, not acceptable, and

comments, were sent to 20 experts, selected through purposive sampling, with respect to the courses related to patients' weaning from mechanical ventilation. The option of comments was applied to obtain the experts' suggestions or criticisms about each item. This questionnaire was sent to the experts to collect their viewpoints and suggestions concerning the acceptability of the items in predication of patients' readiness for weaning.

In order to send the questionnaires, firstly, participants' consent concerning attending the study was obtained and recorded through phone calls after giving explanations about the study to them. Then, comprehensive information about the present study, items, the way of their designing and application, accompanied with the questionnaire was prepared and e-mailed to the participants. They were asked to reflect their viewpoints by two options of acceptable and not acceptable and to footnote any suggestions in the related field. In addition, the deadline for the return of questionnaires was also mentioned. After sending the questionnaires, their receipt by the participants was confirmed through a phone call. During the deadline of questionnaires' return, the participants were reminded through phone calls.

In the third stage, 20 returned questionnaires were reviewed by the research team and the items with consensus >70 (28 items) were determined.[24] If needed, the necessary modifications were made based on experts' indications, which resulted in a suggested tool. All imposed changes were made based on experts' viewpoints and suggestions in terms of item modification, item combination, or item deletion.

In the fourth stage, the prepared tool, along with the items obtained in stage three, was reconsidered in a 2-h session with 10 experts including specialists in ICU, nurses with work experience in ICU, and the research team, and after combination of similar items, deletion of some items, and suggesting adding two more items, a total of 26 items remained. Then, face and content validities and scoring system were checked, and finally, after a re-revision by the research team, the related tool was titled as Persian Weaning Tool (PWT).

The study population comprised experienced ICU nurses and specialists of anesthesiology and ICU care. Twenty participants meeting the inclusion criteria were selected through purposive sampling from the study population. Inclusion criteria were: Having knowledge and experience in working with patients under mechanical ventilation, being a physician with specialization such as anesthesiologists and ICU specialists, having the interest to attend the study, having adequate time for cooperating in the study, and nurses with at least 5 years of work experience in the ICU. Out of 20 participants, 11 were nurses, of whom two had MS of ICU, one had PhD of nursing, and the rest had BS of nursing. Out of nine physicians attending the study, four had fellowship in critical care and the rest had specialty in anesthesiology. Data analysis of each stage was conducted at the time of the same stage by the research team. All ethical considerations approved by Isfahan University of Medical Sciences, deputy of research.

Results

As already mentioned, since the failure in weaning leads to an increase of complications and mortality, and prolonged mechanical ventilation time and hospitalization in the ICU, the necessity of development of a criterion that can predict the outcomes of weaning is revealed, and this study was conducted to develop such a tool. In proceeding toward the direction of access to research goals, the PWT was developed as a tool with consensus >70% in three domains of respiration status with 9 items, cardiovascular status with 4 items, and general condition with 13 items.

Each item was scored ranging from score 3 (for patients with appropriate condition regarding the related item), score 2 (for the conditions in which the patients needed care), to score 1 (for the critical conditions in which the patients needed immediate intervention). Option of not applicable was also considered for the items that could not be calculated [Table 1]. Total scores ranged 26-75 and a score of ≥50 showed patients' readiness for weaning (based on the participants' viewpoints in the fourth stage of research). It is hoped that this tool may be used in promotion of weaning process quality.

Discussion

In the present study, 26 items with consensus >70% were selected in development of the tool. Based on participants' viewpoints, although other items are important in assessment of weaning, they are better to be deleted due to prevailing conditions in hospitals such as the lack of necessary facilities and equipments for their calculation or their time-consuming process of calculation. In fact, as the goal of the present study was development of an applicable and useful tool in the ICU wards in Iran with regard to existing conditions and facilities, the items with consensus <70% were deleted.

Most of the suggested items were original except for the item of *malnutrition* which was changed to *nutrition tolerance* according to participants' viewpoints, as they believed based on research, nutrition tolerance is more applicable than malnutrition; therefore, this item was changed to nutrition tolerance.

Table 1: Persian Weaning Tool

Item	Score	Comments
Respiration status		
Secretion quality	Not applicable	
	1	Abundant and thick
	2	Thin and abundant
	3	Rare and thin or none
Arterial pH	Not applicable	ABG not checked
	1	7.50-7.60 or 7.15-7.30
	2	7.31-7.50
Arterial $PaCO_2$	Not applicable	ABG is not checked
	1	25-35 mm Hg
	2	35-64 mm Hg
(RSBI)[1]	Not applicable	The inability to calculate tidal volume
	1	<105
	2	100-105
	3	>100
$PaO2/FiO_2$	Not applicable	
	1	<100 mm Hg
	2	100-300 mm Hg
	3	>300 mm Hg
PEEP/CPAP	Not applicable	
	1	>10
	2	6-10
	3	1-5
Ventilation index	Not applicable	PIP: The inability to calculate
	1	>30
	2	20-30
	3	<20
(SP MV/total MV)[2]	Not applicable	Minute ventilation: The inability to calculate
	1	<50%
	2	50-80%
	3	>80%
Static compliance	Not applicable	Minute ventilation: The inability to calculate
	1	<34
	2	35-49
	3	>50
Cardiovascular status		
Heart rate	Not applicable	
	1	120-150 b/min or 40-60 b/min
	2	90-120 b/min
	3	60-90 b/min
MAP without inotropes = 70-109 mm Hg Blood pressure over the base rate is not 20 mm Hg	Not applicable	
	1	60-80 mm Hg
	2	110-130 mm Hg
	3	80-110 mm Hg

Contd...

Table 1: Persian Weaning Tool

Item	Score	Comments
Cardiovascular status		
Central venous pressure	Not applicable	The patient has not a central venous line
	1	>15 cm H_2O
	2	<15 cm H_2O
Hemoglobin	Not applicable	Chronic anemia
	1	>16 or 8-11 g/dl
	2	13-16 g/dl
	3	11-13 g/dl
General condition		
Pain (subjective information)	Not applicable	
	1	The pain is severe, but manageable
	2	Pain is reduced and tolerable
	3	No pain
Reflexes (cough, gag, and swallow)	Not applicable	
	1	There are two reflexes
	2	There are three reflexes
Bleeding	Not applicable	
	1	Bleeding is minor and can be controlled
	2	Not bleeding
Temperature 8 h before	Not applicable	
	1	39.1-40°C
	2	38.1-39°C
	3	36.5-38°C
Muscle strength and endurance (able to sit on the bed or chair)	Not applicable	Diseases such as myasthenia gravis, quadriplegia, Guillain Barre
	1	The patient cannot sit even with the help of others
	2	The patient needs assistance to sit
	3	The patient is able to sit
Motor response	Not applicable	Quadriplegia, vegetative state
	1	GCS score of 1, the motor response
	2	GCS score of 2, 3, 4, the motor response
	3	GCS score of 5, 6, the motor response
Fear and anxiety (subjective information)	Not applicable	Loss of consciousness
	1	The patient is anxious and restless, and requires medication for control
	2	Patient anxiety can be controlled without medication
	3	The patient appears calm

Contd...

Table 1: Persian Weaning Tool

Item	Score	Comments
General condition		
Sleep and rest (subjective information)	Not applicable	
	1	The patient is drowsy and tired
	2	The patient is a little tired
	3	The patient is wide awak
Nutrition tolerance (in terms of calories)	Not applicable	TPN
	1	Not tolerated
	2	Less than 50% of calories needed to sustain
	3	Calories needed to fully bear (30 Kg/day)
Urine output	Not applicable	
	1	Oliguria or anuria
	2	Pathological polyuria
	3	Normal urine output
Electrolytes (Na, K, Mg, P)	Not applicable	
	1	The patient has severe imbalance of one or more electrolytes
	2	The patient has moderate imbalance of one or more electrolytes
	3	Electrolytes are normal
BUN	Not applicable	
	1	Severe disorder: ≥50
	2	Moderate disorder: 40-69
	3	Mild disorder: 17-39
	4	Normal: ≤16
Cr	Not applicable	
	1	≥1.95 mg/dl
	2	1.5-1.94 mg/dl
	3	≤0.4 mg/dl
	4	0.5-1.4 mg/dl

[1]Rapid Shallow Breathing Index, [2]Spontaneous minute ventilation per total minute ventilation

Finally, it should be noted that through selection of 26 items from 87 suggested items, a tool was developed that was more comprehensive compared to the existing tools, as in its development, all body systems were considered.

Bern used a scale including respiratory, psychological, digestive, renal, and cardiovascular status to study the consequence of weaning among patients with mechanical ventilation. As 88% of the patients, obtaining a score of 50, had successful weaning, this scale proved to be successful in detection of the patients ready to start weaning process.[12]

In the study of Gluck and Corigan (1996), it was proved that there are parameters predicting the consequences of weaning, but they used few items such as laboratory tests and respiration criteria in their study.[14]

Meanwhile, in a study conducted in Iran, no specific criterion was found to determine the time of weaning. Although researchers in the above-mentioned study aimed to determine the effective factors on the time of weaning from mechanical ventilation, at the end of their study, they concluded that there was no significant association between any criterion and weaning.[19] In a study titled "The effect of Burn's weaning assessment tool on the length of mechanical ventilation among the patients hospitalized in ICU of Alzahra hospital in Isfahan, Iran," the effect of this tool on reduction of mechanical ventilation was revealed.[20]

Conclusion

The goals of development of PWT were precise determination of weaning process time and prevention of complications that resulted from delayed or early weaning process and reducing its related costs. This may lead to an increase in quality of the given services and patients' recovery, and eventually, enhances the efficiency of professional services. This tool may be a primary design and it is suggested to be compared with other existing tools in further studies and be evaluated concerning its preciseness.

Finally, it is suggested to develop a separated specific tool for each ICU ward.

Acknowledgments

Many appreciations go to the esteemed Vice Chancellery of Research and Technology in Isfahan University of Medical Sciences for supporting this study financially, and also, the Dean and Research Deputy of School of Nursing and Midwifery. All participants who kindly assisted us in conducting interviews are acknowledged, whose names are as follows:

Ahmad Zareie, MScN; Arezo Hosseiny, BScN; Atabak Najafi, MD, FCCM; Ehsaneh Rezaee, MScN; Jarahzadeh, MD, FCCM; Khadijeh Zeraatkar, MScN; Khosrow Tavakol, MScN; Mahmood Saghaie, MD, FCCM; Marzieh Salimi, MScN; Mehdi Shamali, MScN; Mhdi AhmadineJad, MD, anesthesiologist; Mohamadreza Asghari, PhD, MScN, BScN; Mojtaba Joveni, BScN; Omid Aghadavoudi, MD, anesthesiologist; Saeed Abbasi, MD, FCCM; Shahram Amini, MD, anesthesiologist; Shirin Mehtari, BScN; Sohrab Babayi, BScN; Sohrab Salami, MD, FCCM; Zahra Soboh, BScN.

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How to site: Irajpour A, Khodaee M, Yazdannik A, Abbasi S. Developing a readiness assessment tool for weaning patients under mechanical ventilation. Iranian Journal of Nursing and Midwifery Research 2014;19:273-8.

Source of Support: Isfahan University of Medical Sciences, **Conflict of Interest:** None.