Weaning from mechanical ventilation: an open issue

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ABSTRACT

Weaning from mechanical ventilation represents one of the main challenges facing ICU physicians. Difficult weaning affects about 25% of critical patients undergoing mechanical ventilation. Its duration correlates on one hand with pathophysiological aspects of the underlying disease and, on the other hand, with other factors such as the development of neuromyopathy of the critically ill patient, prolonged use of sedative-hypnotic drugs and, most of all, physicians’ reluctance to identify the correct timing of therapeutic steps for weaning and subsequent extubation. The goal of adopting weaning protocols is to overcome problems due to an exclusively clinical opinion. Protocols have to be used together with daily clinical evaluation of the patient and the procedure must be carried out by an ICU team of both medical and nursing staff. Attempts to wean a patient from a ventilator and extubate him should be made through a spontaneous breathing trial (SBT) with T-tube or pressure support ventilation (PSV) with pressure support of 7-8 cmH₂O ± PEEP ≥ 4 cmH₂O. Proper recourse to non invasive mechanical ventilation (NIMV) and an accurate timing for tracheostomy are effective tools which can be used by physicians to facilitate weaning and to improve patient outcomes.

Key words: Weaning - Respiration, artificial - Treatment, outcome.

In 1993, during the Consensus Conference on Mechanical Ventilation, the American College of Chest Physicians defined weaning as the process through which mechanical ventilation is rapidly or gradually interrupted and the patient goes back to spontaneous ventilation because of an improvement or complete resolution of respiratory insufficiency. Two multicenter trials showed that ventilatory support can be rapidly interrupted in about 75% of cases, while in the remaining 25% it must be reduced gradually. The process of deciding to wean is still one of the most complex tasks in everyday work of an intensive care unit (ICU) physician, because of the clinical complexity and its relevance in terms of patient outcomes.

The two phases of weaning

Weaning implies two main events: interruption of mechanical ventilation and extubation. Usually 70-75% of the patients, once the cause of respiratory insufficiency has resolved, will be extubated successfully at the end of the weaning, while the remaining 20-25% of the patients who required intubation and mechanical ventilation for more than 24 h will not be able to breathe without ventilatory support (weaning failure). Weaning is considered successful every time the patient shows good clinical compliance during a trial of spontaneous breathing of 30 to 120 min, without any support or with a minimal level of mechanical assistance (Table I). The need of reintubation
within 24–72 h is defined as extubation failure. The most frequent cause of extubation failure is respiratory insufficiency, and carries a higher mortality rate when related to extra pulmonary disease than pulmonary ones.9 Whatever the cause (Table II),10 the evidence of respiratory distress within 48 h from extubation is quite common; its incidence is between 5% and 25% and varies with the patient population and 24, 48 or 72 h.11-14 Pediatric, medical and multidisciplinary intensive care units have the highest rates of reintubation, often above 10%, while in the absence of comorbidity only 5% of patients who suffer trauma or who are recovering from general or cardiothoracic surgery requires reintubation.15-18

Some factors have been associated with an increased risk of reintubation (Table II):10 the risk of post extubation wheezing and consequent reintubation increases when the difference between inhaled and exhaled tidal volumes with deflated tube cuff is less than 110 mL or when expired volume is 12–16% of the inhaled volume;19-22 the risk of reintubation increases significantly when cough efficiency is reduced (peak expiratory flow < 60 L/min) and when there are increased secretions (>2.5 mL/h in 2 or 3 h before extubation),23, 24 and becomes very high when the described factors are combined with a low level of consciousness (for example, failure to execute simple verbal commands).24 Reintubation is associated with several complications (ventilator associated pneumonia, arrhythmias, atelectasis, myocardial infarction, cerebrovascular disease) and with an increase in mortality especially when preceded by a long period of waiting after extubation.25 The use of weaning protocols and a higher staff to patient ratio, seem to be able to reduce the likelihood of reintubation.6, 26-28

**Weaning duration**

Weaning duration can be very short or it can represent the biggest part of total mechanical ventilation depending on the cause which determined the need of the ventilatory support and on the presence of an imbalance between needed respiratory work and residual neuromuscular capabilities.4, 6, 29 (Table III).4 Neuromyopathy in the critical patient has to be correlated with the cause of respiratory insufficiency and its treatment in the ICU. It may arise as critical illness polyneuropathy (CIP) or as critical illness myopathy (CIM) or as a combination of the two entities. Electromyography in undergoing mechanical ventilation for at least 5–7 days revealed non-specific neuromuscular alterations in 50-100% of cases.30 All perspective studies conducted comparing critical
patients with and without neuromyopathy have shown a longer mechanical ventilation time in patients with CIP and/or CIM.41 (Table IV).42

Decision difficulties regarding timing of mechanical ventilation withdrawal and following extubation are responsible of most delays in the initiation of weaning. Many studies have shown that a significant percentage (about 50%) of patients who underwent self-extubation before or after the beginning of the weaning phase did not need mechanical ventilatory support at all. Another important factor which negatively influences weaning is the use of sedative-hypnotic drugs in continuous infusion. It has been shown that daily withdrawal of sedation made according to protocols reduces the duration of mechanical ventilation, when compared to a withdrawal based on the physician’s own decisions.48 On one hand, the unnecessary prolongation of mechanical ventilation increases the risk of complications (including bronchopulmonary infections, barotrauma, hemodynamic imbalance, tracheal damage and oxygen related lung injury). On the other hand, premature withdrawal of mechanical ventilation may result in reintubation which is associated with an increase in morbidity,49 mortality,49, 50 ICU stay and the possibility that the patient may be later moved to a long-term respiratory assistance ward.25

The demonstration of low efficiency of an exclusively clinical judgement about the most appropriate moment to wean a patient from a ventilator is supported by the evidence of the superiority of a method based on clinical decision and routine weaning protocol together, in terms of a shorter duration of mechanical ventilation, lower incidence of complications and lower costs related to ICU stay.6 Concerning this point, it has been recently shown that the use of a computer-based system of ventilatory assistance and withdrawal is able to reduce weaning duration.52 The system is based on software programmed according to experience of ICU physicians and focuses on managing ventilation with pressure support (PSV) with or without positive end-expiratory pressure (PEEP). It can discriminate clinical data in real time, adjusting mechanical assistance to intubated or tracheostomized patients. This approach is able to reduce gradually the level of mechanical assistance according to a rhythm determined by an automated evaluation of patient clinical compliance and his capability of breathing spontaneously (continuous measurement of respiratory rate, tidal volume and end tidal CO2). The advantage of the system consists in giving the patient assistance that continuously adapts to his real needs, leading to an improvement in patient comfort and interaction with the ventilator.53, 54 Optimizing weaning means...
indeed, on one hand, to reduce to a minimum the
costs of mechanical ventilation, and on the other
hand, moreover, to positively influence patients’
outcomes. The correlation between the duration
of mechanical ventilation and reduced hospital
survival is well known.55, 56

Weaning protocols: are they really needed?

Weaning protocols consist of formulating an
algorithm of planned interventions based on sci-
entific evidence whose application results in the
use of several therapeutic approaches based on
objective clinical parameters that are measurable in
the patient. Daily planning of a protocol normal-
ly consists of a trial of spontaneous non support-
ed breathing (T-tube) or with minimal respirato-
ry support (PSV or CPAP) in the early morning,
with evaluation and collection of data, followed
by a resting period which precedes the possible
beginning of the actual weaning session. The team
is usually formed by a physician, a nurse and a
physical therapist specialized in this field 8, 57 (Table
V) 8, 58 (Table VI). Several studies conducted since
1996 6, 59-62 demonstrated the validity of weaning
protocols in reducing weaning times, and then in
improving patient outcomes. Recent literature
reviews and interpretation of derived data,63-65
uncover several critiques of these protocols. For
example, physicians must adapt scientific evidence
derived protocols to individual patient’s needs.65

Approaches

At this point there are two opposing approa-
ches to the decision to wean: “when to begin” and
“how to proceed”.

a) Conservative approach (full recovery
approach): in this scenario, weaning is begun after
all physiologic parameters altered during the dis-
ease are back to normal. There is considerable indi-
vidual variability in the minimum values consid-
ered to be sufficient for successful weaning to
begin, which proceeds through a gradual reduc-
tion of ventilatory support over the course of hours
or days in order to avoid any sudden modification
of the patient’s clinical condition (the less stressful
approach).58, 66

b) Aggressive approach (less iatrogenic
approach): in this kind of approach weaning con-
sists of withdrawal of ventilatory support and the
patient is observed for spontaneous breathing.
Signs of significant clinical worsening result in

Table IV.— Correlation between duration of mechanical ventilation and critical neuromyopathy.

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Diagnosis</th>
<th>Total duration of MV</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Douglas</td>
<td>Severe</td>
<td>CPK</td>
<td>12.9±6.6</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>ARRD 1992</td>
<td>asthma</td>
<td></td>
<td>3.1±3.1</td>
<td>0.03</td>
</tr>
<tr>
<td>Leijten</td>
<td>MV ≥7 days</td>
<td>ENMG (CIP)</td>
<td>25 (8-109)</td>
<td>0.01</td>
</tr>
<tr>
<td>JAMA 1995</td>
<td>Cardiac Surg</td>
<td>MV ≥7 days</td>
<td>ENMG (CIP)</td>
<td>7±13</td>
</tr>
<tr>
<td>Thiele Eur J</td>
<td>MV ≥5 days</td>
<td>ENMG (CIP)</td>
<td>12.3±5.6</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>CT Sur 1997</td>
<td>Sev. asthma</td>
<td></td>
<td>18.5±5.8</td>
<td>0.002</td>
</tr>
<tr>
<td>Thiele Th C</td>
<td>Sepsis-MOF</td>
<td>ENMG (CIP)</td>
<td>32.3±21.1</td>
<td>0.005</td>
</tr>
<tr>
<td>Sur 2000</td>
<td>Acute stroke</td>
<td>ENMG (CIP)</td>
<td>15 (5.5)</td>
<td>0.001</td>
</tr>
<tr>
<td>Garnacho-M</td>
<td>MV ≥10 days</td>
<td>Clinical</td>
<td>34.8±37.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ICM 2001</td>
<td>MV ≥4 days</td>
<td>ENMG (CIP)</td>
<td>34 (12-99)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Drushky</td>
<td>Sev. sepsis</td>
<td></td>
<td>14 (7-44)</td>
<td>0.006</td>
</tr>
<tr>
<td>De Jonghe</td>
<td>MV ≥7 days</td>
<td>ENMG (CIP)</td>
<td>15.4 (9.2)</td>
<td>0.001</td>
</tr>
<tr>
<td>JAMA 2002</td>
<td>awakened</td>
<td></td>
<td>5.7 (3.9)</td>
<td>0.006</td>
</tr>
<tr>
<td>Garnacho-M</td>
<td>COPD</td>
<td>ENMG</td>
<td>15.4 (9.2)</td>
<td>0.006</td>
</tr>
<tr>
<td>ICM 2001</td>
<td>MV ≥7 days</td>
<td>ENMG (myopathy)</td>
<td>15.4 (9.2)</td>
<td>0.006</td>
</tr>
<tr>
<td>Amaya-Vil.</td>
<td>exac+CCS</td>
<td></td>
<td>5.7 (3.9)</td>
<td>0.006</td>
</tr>
</tbody>
</table>

ENMG: electroneuromyography.
reinstatement of ventilation, but there is great variability in the interpretation of clinical worsening. In this kind of approach, from the moment in which the patient is able to breathe spontaneously, any delay in withdrawing ventilatory support is considered capable of increasing the probability of complications.66, 67

Currently, there is not clear evidence pointing the physician toward one of the approaches over the other, even if it is widely accepted that choosing a fast interruption of sedation and mechanical

TABLE V.—An example of weaning protocol.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The cause of respiratory insufficiency has been resolved or it’s on the point of being resolved, with $\text{SaO}_2 \geq 90%$, $\text{FiO}_2 \leq 0.40$ and $\text{PEEP} \leq 5 \text{cmH}_2\text{O}$.</td>
</tr>
<tr>
<td>2.</td>
<td>Haemodynamic stability (MAP&gt;90 and &lt;160 mmHg; HR&lt;125 and &gt;60 breaths/minute; absence of arrhythmias which would result uncontrollable with ordinary medical treatment).</td>
</tr>
<tr>
<td>3.</td>
<td>Temperature &lt;38°C.</td>
</tr>
<tr>
<td>4.</td>
<td>$\text{Hb} \geq 8 \text{g/dL}$.</td>
</tr>
<tr>
<td>5.</td>
<td>No electrolytes disturbances.</td>
</tr>
<tr>
<td>6.</td>
<td>Patients respond to simple commands and they do not require high doses of sedative drugs.</td>
</tr>
<tr>
<td>7.</td>
<td>Neurological patients with GCS&gt;8, ICP&lt;20 mmHg and CPP&gt;60 mmHg.</td>
</tr>
</tbody>
</table>

If patient’s condition satisfies above criteria a spontaneous breathing trial with T-tube or PSV (pressure support 7 cmH$_2$O; PEEP≤5 cmH$_2$O) is started, with a duration within 30 and 120 min. Following criteria define the failure of the spontaneous breathing trial: $HR \geq 140$ beats/min

1. Respiratory rate >35 breaths/min with clinical signs of intolerance (MAP<90 or >160 mmHg; HR ≥140 beats/min) or increase of 25% in spite of basal value; acute arrhythmias; reduction in consciousness level; severe state of anxiety-agitation.

2. Hypoxemia, with $\text{PaO}_2 <60$ mmHg with oxygen $54$ L/minute.

3. Acidosis, with pH ≤7.30.

In this condition weaning will be continued with a minimal pressure support, letting a respiratory rate within 25 and 30 breaths/minute together with an acceptable clinical tolerance. Pressure support will be reduced as fast as possible according to patient’s clinical tolerance and once the level considered minimum for that condition is reached, if PEEP is ≤5 cmH$_2$O, allowing breathing trial shall be repeated: the latter being tolerated, physicians will consider extubation according to Coplin e Khamiees score (Table VI).

TABLE VI.—Coplin and Khamiees score.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Spontaneous coughing (awake patient) or coughing during suctioning (modified Khamiees):</td>
<td>- 0: no cough - 1: barely audible cough - 2: clearly audible cough - 3: hard cough</td>
</tr>
<tr>
<td>2. Frequency of suctioning (in presence of copious secretions) during the last 4 h (modified Coplin):</td>
<td>- 0: no suctioning - 1: 1 suctioning - 2: 2 suctioning - 3: 3 or more suctioning</td>
</tr>
</tbody>
</table>

Extubation requires a score ≥2

Support aims to reduce the incidence of related side effects, ICU stay and costs of hospitalization.48

Weaning methods

Different ventilatory modes may be used during weaning from mechanical ventilation. The most common ones are: pressure support ventilation (PSV), synchronized intermittent mandatory ventilation (SIMV), continuous positive airway pressure (CPAP) and spontaneous breathing with a T-tube.

a) SIMV. This mode supports patients through a certain number of respiratory efforts per minute, therefore spontaneous breathing alternates with mechanical ones. Mandatory efforts may be flow or pressure limited. There is the possibility of programming a level of pressure support for spontaneous breathing attempts between two forced breaths. The initial respiratory rate is set as half of the one used during controlled ventilation, without modifications of inspiratory flow and tidal volume, and is subsequently reduced gradually by 2-4 breaths/min, according to the patient’s clinical compliance. Extubation is considered when the patient clinically tolerates at least 2 h with a respiratory rate of 4-5 breaths/min. Theoretical advan-
The advantages of this method lie in the wide range of combinations available (total assistance, partial support, no assistance) in order to graduate the transition from a completely assisted ventilation to a spontaneous one. A review of this method revealed that it had a worst performance in terms of weaning duration and probability of success in the range of 14-21 days versus PSV or T-tube.

One of the problems related to SIMV is the additional work of breathing caused by some valve-demand systems and by the resistance in circuits and humidifiers outside the ventilator; another problem seems to be the faulty “breath by breath” synchronization between patient and device, which is responsible for increased respiratory work compared to other ventilatory methods used in weaning (as also evidenced by electromyographic analysis of the diaphragm).

b) PSV. This is a pressure limited and flow cycled mode of ventilation, in which the pressure generated inside the airway is held constant throughout inhalation. When inspiratory flow reaches a certain threshold the cycling from breathing in to breathing out starts. The support pressure is associated with a variable level of PEEP according to the clinical needs of the patient. In this mode the patient becomes the only determinant of respiratory rate, cycling times, inspiratory work and consequently tidal volume, interacting in an active and different manner with the ventilator (trigger) according to compliance characteristics and resistance of the respiratory tract. These characteristics contribute to create a good synchronism between patient and ventilator. PSV reduces imposed respiratory work and consequently the oxygen consumption by respiratory muscles during weaning, with an improvement in the efficiency of spontaneous breathing. This is linked to the pressure support which, besides reducing the amount of respiratory work required to generate sufficient flow, eliminates the additional work related to resistance due to endotracheal tube, inspiratory valve and ventilator circuit. The initial level of pressure support is usually determined by a clinical criterion, considering as optimal a level which allows the patient to breathe comfortably. Experience and available clinical data define as “optimal” a pressure level associated with a respiratory rate of 25 to 30 acts/min. Weaning through PSV is accomplished by progressively reducing support level with 2-4 cmH₂O decrements each time, according to the clinical compliance of the patient. Generally, to consider extubation without intermediate steps (T-tube), a good clinical compliance is required before reaching a support level of ≤ 8 cmH₂O or, with PEEP, ≤ 5 cmH₂O. Examination of the advantages of PSV emphasizes that it has at least the same efficiency as use of the T-tube in terms of duration of weaning and ICU stay, even in the most difficult patients to wean (i.e. COPD).

All trials agree in defining SIMV as the technique with smallest potentials when compared to previous ones.

c) CPAP. This mode applies constant positive pressure at the end of the expiratory phase to promote spontaneous breathing. This technique reduces respiratory work and completely synchronizes respiratory efforts with the ventilator. CPAP is commonly used during weaning because of its pathophysiological rationale, especially in cardiac and COPD patients (although it still lacks scientific evidence proving its superiority above other techniques).

d) Spontaneous breathing through T-tube. This technique offers a possibility of alternating periods of respiratory effort with periods of rest. The T-tube system offers a very low resistance to flow; the absence of valves and of the circuits of the ventilator means no additional respiratory work. The patient’s ability to breathe spontaneously can be assessed by testing T-tube tolerance.

Weaning indexes

Several parameters useful for evaluating weaning potential regarding oxygenation, gas exchange, respiratory work and/or ability, have been studied. The two main features required for a weaning index, beside accuracy of predictive value, are the easy bedside measurement and a high grade of reproducibility. It has been observed that more operators reduce reproducibility of the chosen index. Some parameters are measured on the ventilator (minute volume, MV; maximum inspiratory pressure, MIP or negative inspiratory strength, NIS, occlusion pressure in mouth at 100 ms from the beginning of inspiratory effort, product of compliance, respiratory rate, oxygenation...
WEANING FROM MECHANICAL VENTILATION
CAROLEO

Despite the complexity of various predictive indexes, the f/VT ratio is still a reliable parameter in terms of accuracy and ease of measurement. When an imbalance between respiratory work and muscular capacity exists, a respiratory pattern with small volumes and high respiratory rate, defined as “rapid and shallow breathing”, often results. This respiratory pattern, which can be used as an index of probable weaning failure, is influenced by several factors including anxiety, female gender, insufficient endotracheal tube diameter, presence of sepsis and/or pneumonia, old age, the patient’s position and anamnesis positive for previous pulmonary diseases. Numerous influencing factors and variability of analysis methods used in previous trials (differences in patient populations, predominance of successful weaning, mechanical ventilation duration before weaning start, success or failing criteria, measuring methods and threshold values) are issues which associate f/VT ratio with other indexes in terms of predictive value; on the other hand measuring ease, independence from patient’s effort or collaboration and reasonable predictive value, often makes it the first choice index. Time required for an accurate evaluation of f/VT ratio has been revised several times, yet there are still contradictory opinions regarding its utility. However, it seems reasonable that an evaluation may be considered appropriate when made during first 30 or 60 min from withdrawal or a significant reduction in mechanical ventilation.

In conclusion, according to current evidence, it is clear that a negative evaluation of a weaning index cannot justify on its own the delay of extubation which seems reasonable according to a correctly made clinical judgement. It is most important that physicians know the limits of these parameters so that they can use threshold values adapted to individual patients.

The role of non invasive mechanical ventilation

Prolonged endotracheal intubation and long-standing invasive mechanical ventilation correlate with the development of several complications, which are often responsible for the poor prognosis of patients who are difficult to wean.

It is deducible from these considerations that all therapeutic efforts must be addressed on one hand to avoid intubation and on the other hand, where that may not be possible, to minimize the duration of invasive mechanical ventilation, with special attention to those patients (COPD) whose weaning is generally more difficult. It has been recently shown that in COPD patients who are not able to breathe autonomously, NIMV has the same potential as invasive methods for reducing diaphragmatic work and for improving gas exchange values; it is valid as an alternative to intubation. Besides being useful in preventing the need for intubation and subsequently the setting

### Table VII. Weaning indexes.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Studies, No.</th>
<th>Threshold values</th>
<th>Positive LR range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured on ventilator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V̇E</td>
<td>20</td>
<td>10-15 L/min</td>
<td>0.81-2.37</td>
</tr>
<tr>
<td>NIF</td>
<td>10</td>
<td>-20 -30 cm H₂O</td>
<td>0.23-2.45†</td>
</tr>
<tr>
<td>Pmax</td>
<td>16</td>
<td>-15 -30 cm H₂O</td>
<td>0.98-3.01</td>
</tr>
<tr>
<td>ṖO.1/Pmax</td>
<td>4</td>
<td>0.30</td>
<td>2.14-25.3</td>
</tr>
<tr>
<td>CROP score</td>
<td>2</td>
<td>15</td>
<td>1.05-19.74</td>
</tr>
<tr>
<td>Measured during a brief period of spontaneous breathing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RR</td>
<td>24</td>
<td>30-38 breaths/min</td>
<td>1.00-3.89</td>
</tr>
<tr>
<td>V̇T</td>
<td>18</td>
<td>325-408 mL (4-6 mL/kg)</td>
<td>0.71-3.83</td>
</tr>
<tr>
<td>f/VT ratio</td>
<td>20</td>
<td>60-105/L</td>
<td>0.84-4.67</td>
</tr>
</tbody>
</table>

* V̇E: minute ventilation; NIF: negative inspiratory force; Pmax: maximal inspiratory pressure; ṖO.1: mouth occlusion pressure 0.1 s after the onset of inspiratory effort; RR: respiratory rate; V̇T: tidal volume; f/VT: respiratory rate/tidal volume ratio; CROP: index including compliance, rate, oxygenation, and pressure. †: one study reported an LR of 35.79.
of an invasive mechanical ventilation, NIMV seems able to significantly reduce the duration of complications (nosocomial pneumonia, septic shock etc.) associated with the duration of mechanical ventilation, the duration of ICU stay, and the overall mortality rate of difficult to wean patients. On the other hand, some evidence discourages the use of NIMV in respiratory insufficiency post extubation, except in COPD patients, for whom this hypothesis is yet to be verified.

Balancing evidence in favor of and against the use of NIMV, we can conclude that this method can be applied to prevent intubation of COPD patients and, in cases of cardiac decompensation, and/or to aid weaning in the same groups, while it should be chosen carefully or not chosen at all in other critical patients.

Role of tracheostomy

Tracheostomy is a therapeutic procedure which is commonly considered for patients requiring mechanical ventilation for a long time and/or for patients who show difficulties in weaning, with the goal of reducing resistance and dead space related to endotracheal tube placement and, consequently, respiratory work, while on the other hand allowing better patient management; it also makes it possible enteric nutrition and the removal of the endotracheal tube which represents a continuous and irritating oral-pharyngeal stimulus. On average, tracheostomy is instituted in 10% of ICU patients. The main debate over the timing of tracheostomy seems to point toward its early institution, once the suitability of the clinical context is established; data on precise timing are still insufficient.

Concerning the procedure, percutaneous techniques seem to have taken the place of surgery. The proper technique must be carefully chosen according to the clinical context and operator's experience in order to minimize complications.

Role of rehabilitation

Rehabilitation in intensive care can be defined as the multidisciplinary therapeutic program for patients with chronic respiratory difficulty; it is made according to patient’s characteristics with the goal of optimizing physical performance, chances of autonomy and re-establishment of a normal life. The multidisciplinary character of the intervention is the key point in critical patients; the intervention strategy must involve an intensive care physician and/or a specialist in respiratory diseases as coordinators of a team which should include also a physiatrist, a specialized nurse, a psychologist, a pharmacist, a nutritionist, a welfare worker, and supporting family personnel. This organization makes it possible to plan therapeutic choices which are sensitive to several physiological variables (therapist-driven protocol). The therapeutic approach may, therefore, range from a simple passive mobilization to a regulation of ventilatory parameters and modes for weaning optimization.

Goals of rehabilitation in critical patients who are difficult to wean are set in order to achieve minimal (or no) dependence on the ventilator in the shortest possible time with the best results for the patient's quality of life; this is accomplished through prevention of prolonged immobility and with proper muscle training, especially of those involved in ventilation.

Even if there is a paucity of randomized and controlled studies supporting rehabilitation in ICU, it is widely acknowledged as important to involve the rehabilitation team in the management of patients whose ICU stay is expected to be long.

Conclusions

Every patient who is intubated and assisted with a mechanical ventilator should be examined daily by an ICU physician team to evaluate possibilities of beginning and/or completing weaning, with the aim of minimizing the duration of mechanical ventilation, use of sedative-hypnotic drugs and ICU stay. Attempts to wean patients from the ventilator and therefore to extubate should be made through a spontaneous breathing trial (SBT) with T-tube or PSV (support pressure of 7-8 cmH₂O ± PEEP ≥4 cmH₂O), with a duration ranging from 30 to 120 min. Use of weaning protocols and indexes must represent a valid support for the decisions made after an accurate clinical evaluation, without becoming a
mandatory sequence of therapeutic events. Weaning from mechanical ventilation indeed represents a moment which requires the ICU physician to have constant facility in the whole spectrum of his skills in order to improve overall patients' outcomes.6, 65, 81-83

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