Respiratory Medicine (2005) 99, 1096–1104

ELSEVIER

respiratoryMEDICINE

Early physiotherapy in the respiratory intensive care unit

Enrico Clini[a], Nicolino Ambrosino[b,*]

[a]*Fondazione Villa Pineta, Pavullo, Italy*
[b]*Dipartimento Cardio Toracico, via Paradisa 2-Cisanello, 56124 Pisa, Italy*

Received 6 December 2004

KEYWORDS
Respiratory insufficiency;
Weaning;
Physical therapy;
Muscle training

Summary Physiotherapy is an integral part of the management of patients in respiratory intensive care units (RICUs). The most important aim in this area is to enhance the overall patient's functional capacity and to restore his/her respiratory and physical independence, thus decreasing the risks of bed rest associated complications. This article is a review of evidence-based effectiveness of weaning practices and physiotherapy treatment for patients with respiratory insufficiency in a RICU. Literature searches were performed using general and specialty databases with appropriate keywords.

The evidence for applying a weaning process and physiotherapy techniques in these patients has been described according to their individual rationale and efficacy.

The growing number of patients treated in RICUs all over the world makes this non pharmacological approach both welcome and interesting. However, to date, there are only strong recommendations concerning the evidence-based strategies to speed weaning. Early physiotherapy may be effective in ICU: however, most techniques (postures, limb exercise and percussion/vibration in particular) need to be further studied in a large population. Evidence supporting physiotherapy intervention is limited as there are no studies examining the specific effects of interventions on long-term outcome.

Introduction

The general aims of any physiotherapy program in the critical areas is to apply advanced, cost-effective therapeutic modalities to decrease the patient's dependency on the ventilator, to improve residual function, to prevent the need for new hospitalisations and to improve the patient's quality of life.[1] In other words, the aim of this programme is to enhance the overall patient's functional capacity and to restore his/her respiratory and physical independence, thus decreasing

*Corresponding author. Tel.: +39 50996786.
E-mail address: n.ambrosino@ao-pisa.toscana.it (N. Ambrosino).

0954-6111/$ - see front matter
doi:10.1016/j.rmed.2005.02.024

the risks of bed-rest associated complications.[1] Physiotherapy treatment when started early helps prevent weaning delay, limited mobility and total dependence on the ventilator.[2] Therefore, weaning process and physiotherapy are two major and related interventions to speed up the patient's recovery. As a matter of fact, both strategies are typically applied in the late phase of the critically ill patients, just following the acute phase during which he/she is confined in bed and, due to sedatives, may not be collaborative.

In hospitals of the most developed countries, physiotherapy represents an integral part of the management of patients with respiratory insufficiency, who may be mechanically ventilated and are cared for in a respiratory intensive care units (RICUs). In these areas patients have usually overcome the acute phase and, therefore, may be actively treated.

In a recent European survey[3] important variations in the number, role and profile of respiratory physiotherapist in critical care areas has been recorded. The role of physiotherapists in these areas varies considerably among different countries, depending on factors such staffing levels, training, and expertise.[4,5]

The aim of this article is to review the evidence supporting the rationale and clinical effectiveness of specific physiotherapy interventions and the use of weaning protocols for patients in a RICU.

Search strategy

Literature searches were performed using the databases MEDLINE and CINAHL (Cumulative Index to Nursing and Allied Health Literature) with appropriate subject headings and keywords, including intensive care, rehabilitation, weaning, physical therapy, chest physiotherapy, breathing exercises, and muscle (re)training. To ensure that the major relevant articles were reviewed, the reference lists of the extracted articles were reviewed to identify other potentially relevant articles.

Weaning

The most common reason for an intensive care unit (ICU) admission is an episode of respiratory failure, either due to an exacerbation of chronic obstructive pulmonary disease (COPD), or an acute medical or surgical event, superimposed on some other underlying chronic lung disease. About 80% of patients admitted to ICU and mechanically ventilated resume spontaneous breathing quite easily after a few days of ventilation.[6] Endotracheal intubation, long-term complications after intubation, the use of continuous sedation and malnutrition are associated with prolonged mechanical ventilation.[6]

The 20% of patients who cannot be weaned within a few days are concentrated in specific populations. Increased age and cardiorespiratory or neuromuscular co-morbidities make the discontinuation from mechanical ventilation particularly difficult.[6] The weaning success rate differs among studies depending on the case mix, COPD patients being the most difficult to separate from the ventilator.[7]

Weaning from mechanical ventilation, therefore, becomes an obstacle in these patients,[6] because: (1) the underlying disease contributes to immobility and deconditioning prior to the current episode of respiratory failure; (2) substantial airflow obstruction requires treatment with systemic corticosteroids or neuromuscular blocking agents that further leads to immobility and disuse atrophy; (3) malnutrition exists due to the underlying disease compounded by the new disease process, and (4) the presence of gas exchange abnormalities. RICUs are dedicated hospital areas where health professionals may properly and specifically care for these population of patients, thus increasing their chance to be weaned from mechanical ventilation.[8]

Therapist driven protocols

Several studies have been performed to assess the best ventilatory technique to speed up the weaning process. A recent review article[9] concluded that, since there are few rigorous randomized trials,[7,10] more work is required in this area. Currently, pressure support ventilation (PSV) and T-piece are the most common methods of weaning.

More recent papers have highlighted the concept of using standardized protocols to wean the patient from mechanical ventilation.[11–13] Therapist-driven protocols (TDPs) are a consensus of medical knowledge and opinion that is summarised into a care plan or algorithm with changes in therapy directed by changes in objectively measurable patient's variables.[6] The daily plan of a TDP consists of recording functional activities: initial evaluation will include assessment of the patient and ventilator status and patient-ventilator synchrony. This evaluation is usually performed routinely every day and at each ventilator setting change.

Despite conflicting results exist regarding the application of a fixed protocol-based strategy to discontinue mechanical ventilation,[11–14] the use of TDPs has proven to be effective when applied to the weaning process in the critical care area. Saura et al.[13] prospectively studied 51 patients weaned by a fixed protocol and compared them with 50 retrospective controls. The implementation of the protocol decreased the duration of mechanical ventilation and ICU stay by increasing the number of safe direct extubations. Similar results were found by Ely et al.[11] who demonstrated that the daily screening of the respiratory function of ventilated patients followed by trials of spontaneous breathing can reduce the length of ventilation, the cost of intensive cares and complications.

Taking the specific activity of a RICU into account, several trials have been reported regarding difficult weaning.[15] Overall, the clinical experience in RICU seems to confirm good results regarding success rate (about 60%) in difficult to wean patients when a protocol-based strategy is going to be implemented.[8,16] Recently, it has been shown that spontaneous breathing trials and decreasing levels of inspiratory pressure support are equally effective in tracheostomised and in difficult to wean COPD patients[17] cared for in a RICU. However, whatever method of weaning is used, it is important to stress the point that the technique employed in this process is probably less important than the confidence and familiarity with the protocol adopted, or the underlying pathologies.[15]

Physiotherapy

Table 1 shows the list of the most applied interventions applied in RICUs.

Table 1 Physiotherapy techniques applied to patients in RICU.

Activity	Technique
Mobilisation	Postures Passive and active limb exercise Continuous rotational therapy (CRT)
Chest physiotherapy	Manual hyperinflation (MH) Percussion/vibration
Muscle retraining	Respiratory muscle training Peripheral muscle training Electrical stimulation (ES)

Mobilisation

Postures

Positioning describes the use of body position as a specific treatment technique.[1] Positioning is used with the aim to improve of ventilation/perfusion (V′/Q′) matching, lung volumes and mucociliary clearance, to reduce the work of breathing (WOB) and the work of the heart.[18] Specific examples of positioning to be used in the ICU setting include upright positioning to improve lung volumes and decrease the WOB in patients who are being weaned from mechanical ventilation; prone positioning to improve V′/Q′ matching, redistribute oedema, and increase functional residual capacity for patients with ARDS; side lying with the affected lung uppermost to improve V′/Q′ matching for patients with unilateral lung disease.

Prone positioning has been shown to result in short-term improvements in oxygenation for 57–92% of patients with severe acute respiratory failure or ARDS.[19,20] Improvements in lung function have also been documented for patients with unilateral lung disease when they are positioned in side lying with the affected lung uppermost.[21]

Chatte et al.,[22] investigating 32 patients receiving mechanical ventilation due to severe acute respiratory failure not caused by left ventricular heart failure or atelectasis, have found that the mean PaO_2/FiO_2 ratio significantly increased from supine to the prone position. Ibanez et al.[23] studied 10 patients who were receiving mechanical ventilation because of acute respiratory failure for a unilateral disease; they found that the oxygenation index significantly increased when patients were positioned in side lying with the affected lung uppermost. However, it is not known whether these improvements in pulmonary function result in faster recovery or improved outcome for patients with these conditions. An additional consideration regarding the use of positioning is its effect on gastroesophageal reflux and the subsequent potential pulmonary aspiration and nosocomial pneumonia. The supine position (compared with the 45° head-up position), and the length of time in the supine position, have been found as potential risk factors for the pulmonary aspiration of gastric contents in patients receiving mechanical ventilation.[24] Indeed, the semirecumbent position (45° head up) is able to essentially prevent pulmonary aspiration[25] while decreasing (but not preventing) gastroesophageal reflux for patients with a nasogastric tube inserted. The new evidence supporting the prone positioning describes its predictive capacity for 28-day mortality associated with its effect on $PaCO_2$.[26]

Limb exercises

These techniques may be used for patients in the critical area (especially for those receiving mechanical ventilation) and include active exercises.[1] The patient is assisted through actively moving or turning in bed, getting out of bed via mechanical lifting machines, standing, transfers from bed to chair, and walking. The reported physiologic rationale for mobilisation is that it may optimize oxygen transport by enhancing, for example, alveolar ventilation and V'/Q' matching, and it represents a gravitational stimulus to maintain or restore normal fluid distribution in the body and to reduce the effects of immobility.[18]

Limb exercises (passive, active assisted, or active resisted) may be performed with critical care patients with the aim of maintaining joint range of motion, but also of improving soft-tissue length, muscle strength and function, and of decreasing the risk of thromboembolism.[27] Passive limb movements have only been shown to result in significant increases in metabolic and hemodynamic variables for critically ill patients, with approximately 15% increase in oxygen consumption.[28] However, results on the ability of limb exercises to maintain joint range of motion and/or to improve muscle strength and function are also lacking.

Overall, the body of evidence in this field only refers to non randomised studies. Moreover, although there is unequivocal evidence that prolonged bed rest results in deconditioning, there are no published study, in critical care patients receiving mechanical ventilation, investigating the effect of mobilisation on the pulmonary function, the weaning process, or the length of stay.

Continuous rotational therapy

Continuous rotational therapy (CRT) refers to the use of specialized beds that continuously and slowly turn a patient along the longitudinal axis, up to an angle of 60° onto each side, with preset degree and speed of rotation.[29] The rationale for the use of CRT is that it will prevent dependent airway closure and atelectasis, pooling and stagnation of pulmonary secretions, and subsequent infection that may result from prolonged immobility.[30]

In one of the largest studies investigating the use of CRT in the management of critically ill patients, De Boisblanc et al.[31] studied 120 patients with sepsis or COPD admitted to a medical ICU, 80% of them receiving mechanical ventilation. Patients were randomly allocated to a group nursed on conventional or periodically oscillating beds for 5 consecutive days. A significantly lower incidence of pneumonia was seen in the group that was nursed on the oscillating beds compared with those patients nursed conventionally (9% versus 22%, respectively), especially in the subgroup of patients with sepsis.

Similar significant reductions in the incidence of lower respiratory tract infection, pneumonia, and atelectasis were also found by other authors[32–34] for patients treated with CRT compared with conventional beds or normal positioning, which is still the most widely used method and it might be the most relevant for those patients typically admitted to RICUs. Additionally, Fink et al.[33] found, for survivors, a significantly lower duration of endotracheal intubation and length of stay in hospital for patients nursed on the oscillating beds. In a crude cost-benefit analysis, authors themselves [33] also noted that average costs per day of care in the ICU were not significantly different for patients treated with CRT or with conventional beds. It has been noted, however, that CRT may not be well tolerated by some patients, who may become agitated during treatment.[31,33] The combination of multiple techniques involving mobilisation may results in the best clinical outcomes for patients admitted to a intensive care area.[35]

Chest physiotherapy

Chest physiotherapy is one of the most frequently performed interventions in the intensive care areas.[1] There are many physiological reasons that a patient in ICU may benefit from physiotherapy treatment.[1] These include mucociliary disfunction, altered lung volumes when patients are mechanically ventilated, increased pulmonary shunt, the effects of neuromuscular weakness on respiratory flows, increased risk of nosocomial pneumonia. So far, chest physiotherapy has been recognised as an important aspect to achieve successful weaning from the ventilator.[1] Indeed, lack or reduction of the cough reflex in a intubated patient may be associated with retention of bronchial secretions and the risk of pulmonary infection. Several physiotherapy techniques are used to facilitate an adequate bronchial drainage in these patients, mainly depending on the patient's compliance and staff expertise.[36,37] The use of devices (e.g. PEP mask, flow and volume spirometers) to increase the clearance of bronchial secretions are generally not considered in the early phase of treatment, as these techniques require substantial co-operation from the patient. The effectiveness of these devices has not been included in the present review.

Manual hyperinflation (MH)

It is important to distinguish between MH and manual hyperoxygenation, the latter being the delivery of high levels of oxygen, using a manual resuscitator bag, but with no attempt to increase the tidal volume. Manual hyperoxygenation is usually performed before and between suction passes, with the specific intention of preventing suction-induced hypoxaemia. MH technique involves disconnecting the patient from the ventilator and inflating the lungs with a large tidal volume via a manual resuscitator bag.[38] MH is used with the aim of preventing pulmonary collapse, re-expanding collapsed alveoli, improving oxygenation and lung compliance, and increasing movement of pulmonary secretions toward the central airways.[39] The actual application of this technique by both physiotherapists and nursing staff, in terms of the volume delivered, airway pressure, amount of positive end-expiratory pressure applied, flow rates, and FiO_2, may be quite variable.[39]

However, the difficulties with MH surround the definition of the technique, how it is performed and the different resuscitation circuits that are used rather than machine hyperinflation. Only one study[40] has compared manual and ventilator hyperinflation: authors have found the techniques to be equally effective at clearing pulmonary secretions and, as in other study,[41] improving static pulmonary compliance. Other authors have demonstrated that MH may prevent atelectasis and reexpand atelectasis,[42,43] increase secretion clearance,[38] and reduce the incidence of nosocomial pneumonia in mechanically ventilated patients.[35]

Percussion and vibration

Percussions may be performed manually (using cupped hands) by clapping the chest wall over the affected area of the lung. Vibrations may be applied manually or via mechanical devices by vibrating, shaking, or compressing the chest wall during the expiratory phase.[36] These techniques are believed to increase clearance of airway secretions by the transmission of an energy wave through the chest wall.[36]

The effectiveness of percussion in enhancing sputum clearance has been poorly studied in stable, nonintubated patients with chronic pulmonary disease. Only Gallon[44] has demonstrated an increase in airway clearance in patients who produced more than 20 g of sputum. The addition of vibrations to a combined treatment of chest physiotherapy did not significantly improve arterial blood gases and lung compliance.[45] Regarding the effectiveness of these techniques in ICU patients, Ntoumenopoulos et al.[35] demonstrated a direct relationship between physiotherapy treatment and the reduction in the incidence of ventilator-associated pneumonia by 31%.

Muscle retraining

The most important aim of training muscle even in the more compromised patients is to enhance their functional capacity and to decrease the risks associated with the intensive care and the bed rest.[2] The earlier the training programme in a ventilated patient is started, the greater its effect is, limiting as much as possible the late consequences (limited mobility, or even worse, total dependency on the ventilator).[5]

Respiratory muscle

As with other skeletal muscles, the ventilatory pump may also be profoundly altered by the effects of bed-rest and of the disease itself and any co-morbid conditions. Indeed the "abuse" of controlled mechanical ventilation in the ICU may lead to the development of selective and rapid diaphragmatic atrophy, as shown in a laboratory study.[46] Respiratory muscle weakness and, in particular, the imbalance between the muscle strength and load upon the respiratory system is one of the major determinants of weaning failure.

Nevertheless, the rationale of respiratory muscle training in the ICU is controversial. To date, no physiopathological information is available to support the specific use of respiratory muscles training in critical care patients; only data on community and spontaneously breathing chronic respiratory patients exist.

COPD patients are not likely to benefit much from this specific treatment. It has been shown that the impaired contractile effect of the diaphragm in these patients is due to the altered geometric shape of the diaphragm dome rather than to the muscle atrophy. The diaphragm of patients with COPD is as good as that of normal subjects in generating pressure at comparable lung volumes,[47] showing an adaptive change toward the slow-twitch characteristics of the muscle fibers[48] thus increasing resistance to fatigue. A recent meta-analysis conducted by Lotters et al.[49] concludes that Inspiratory Muscle Training (IMT) is an important component of pulmonary rehabilitation in severely impaired COPD patients in the community. An interesting potential role of IMT may be its use in preventing steroid-induced myopathy. In a randomised-controlled trial, Weiner et al.[50] have showed, that the inotropic and endurance capacity of inspiratory muscles were spared from the damage due to 2 weeks' administration of corticosteroids only in the group of patients undergoing specific training.

Neuromuscular patients are also likely to benefit from respiratory muscle training [51–53] while in the community; however, no specific trial exists regarding the application of this technique while in the critically ill condition.

Finally, respiratory muscles training has been associated with favourable weaning outcome in a series of ICU ventilatory-dependent COPD patients.[54–59]

Peripheral muscle

The physiological changes caused by inactivity involve skeletal muscle, cardiovascular and respiratory function, body and blood composition, and the central nervous and endocrine systems. During a period of inactivity muscle mass declines and the potential efficiency of a muscle to perform aerobic exercise declines. Loss of strength was found to be greatest during the first week of immobilization, declining by as much as 40% in muscle strength after the first week.[60] Skeletal muscles are composed of two major types of fiber. Type I fibers are mainly involved in aerobic activity, while type II fibers have a lower capacity for this activity. Deconditioning causes a distinct transformation of subtypes of type II fibers: type IIa fibers convert to type IIb fibers,[61] the former having a higher aerobic capacity. Selective atrophy is dependent upon the location and the function of the specific muscle. For example, the antigravity muscles of the calf and back appear to lose strength with bed rest at an accelerated rate compared to muscles involved with grip strength.[60]

The cardiovascular response to exercise is also altered.[62] In particular, in bed-ridden patients, the ability of the system to adjust to changing posture (moving from the supine to the sitting position) is severely impaired.[63] Immobility also leads to clinically significant bone demineralisation, together with protein wastage and a decrease in total body water and sodium.[64] Deterioration of central nervous system function results in a decreased capacity to maintain the standing position and (subsequently) to walk; the performance of intellectual function tests may also be impaired, and disorientation may occur.[65]

Critical illness polyneuropathy and myopathy are common in ICU.[66,67] These syndromes are specific to the critically ill population, distinct from changes associated with bed rest: their occurrence also significantly correlates with the ability to wean a patients from a ventilator.[68]

One of the rehabilitative end points in critical care areas might be defined as a return of a muscle strength that allows basic daily life-activities (e.g. washing, dressing, cooking, etc.) and the ability to walk independently. Anedoctically and based on several experiences, the patients may undergo sessions aimed at passively and actively training the lower and upper extremities, such as lifting light weights or pushing against a resistance. Any patient able to walk at one point in time can start directly with progressive walking retraining, aided by a rolling walker or by the therapist, if needed. When a patient cannot be weaned from the ventilator, a portable respirator can eventually be used to decrease the WOB during walking. The only study specifically related to peripheral muscle retraining in COPD patients recovering from an acute episode of hypercapnic respiratory failure and admitted in a RICU is that by Nava.[69] In that controlled trial[69] a step-by-step retraining program has been associated with a more significant improvement in the patient's exercise capacity and symptoms score as compared to controls.

Electrical stimulation (ES)

Neuromuscular electrical stimulation (ES) is used by physical therapists to improve muscle performance. This type of stimulation is characterised by a low-volt stimulation targeted to stimulate motor nerves to cause a muscle contraction. So far, ES has been used to increase healthy muscles performance.[70] However, application of this technique has been consistently associated with increased mass, strength, and endurance of both normally sports injured [71] as well as of abnormally innervated muscles in a range of pathological conditions.[72,73] ES delays the wasting of muscle mass during denervation/immobilisation and optimises recovery of muscle strength during rehabilitation.[74,75] Low-frequency electrical stimulation has been shown to induce an increase in the muscular oxidative capacities and could represent another form of mild physical training.[76]

Despite these facts may be not relevant in the critically ill population, the obtained results in a injured or weak muscle might support the use of ES also in different conditions. Indeed, passive training of specific locomotor muscle groups by means of ES might be better tolerated than whole body exercise in patients with severe deconditioning. It was hypothesised that this novel strategy would be particularly effective in improving functional impairment and the consequent disability that characterises patients with end stage COPD. Small

Table 2 Efficacy of rehabilitation techniques applied in RICU.

Activity	Modality/technique	Level of evidence
Weaning process	TDPs	A
Mobilisation	Postures	C
	Limb exercises	D
	CRT	B–C
Chest physiotherapy	MH	B–C
	Percussion/vibration	C
Muscle retraining	Respiratory muscle	C
	Peripheral muscle	B–C
	ES	B

A–D levels are referred to the Sackett's rules of evidence.
TDP, therapist-driven protocol; CRT, continuous rotational therapy; MH, manual hyperinflation; ES, electrical stimulation.

controlled studies of this technique (applied to the lower limb muscles) in severe COPD patients have been recently reported [77,78] suggesting overall feasibility and improvement in muscle function and exercise tolerance. One of these studies [77] indicates that ES may be used even during periods of exacerbations, a condition associated with loss of muscle strength and mass.[79]

Interestingly, ES has been applied in bed-bound COPD patients receiving mechanical ventilation with marked peripheral muscle hypotonia and atrophy, resulting in significantly improved muscle strength and respiratory rate and decreased the number of days needed to transfer the patients from bed to chair.[80]

The major advantage of this technique over conventional exercise training is considered to be the lack of ventilatory stress during passive muscular activity, reflecting the reduced muscle mass involved. However, optimal forms of stimulation settings and morphological studies correlating improvements in exercise tolerance with muscular changes after ES compared with conventional exercise training are yet to be determined.[81]

Conclusions

Rehabilitation in the RICUs aims to enhance the overall patient's functional capacity and to restore his/her respiratory and physical independence, particularly for those patients still presenting ventilatory dependence upon admission.

The earlier rehabilitation can begin, the greater the potential to reverse the effects of immobility and prolonged bed rest. These programs are important due to the increasing number of patients being treated in ICUs across the world. Table 2 reviews the level of efficacy for individual treatments used in RICUs.

From a scientific point of view, it seems rather difficult to perform outcome studies concerning physiotherapy in ICU. Indeed, the population admitted vary considerably (for example patients who are critically ill in the general ICUs are often interchanged with patients suffering from COPD who may or may not be under ventilatory treatment) and the combination of activities, applied at the same time, may interfere making difference to the individual patient's outcome in the critical care area.

To date only strong recommendations can be made regarding weaning strategies. Evidence supporting physiotherapy treatments is limited due to the lack of long term outcome studies. Despite most techniques (postures, limb exercise and percussion/vibration in particular) need to be further studied on a large population, early physiotherapy may be effective in ICU.

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