Intensive Care Med
DOI 10.1007/s00134-008-1026-7

ESICM STATEMENT

R. Gosselink
J. Bott
M. Johnson
E. Dean
S. Nava
M. Norrenberg
B. Schönhofer
K. Stiller
H. van de Leur
J. L. Vincent

Physiotherapy for adult patients with critical illness: recommendations of the European Respiratory Society and European Society of Intensive Care Medicine Task Force on Physiotherapy for Critically Ill Patients

Received: 27 March 2007
Accepted: 3 January 2008

Electronic supplementary material
The online version of this article (doi:10.1007/s00134-008-1026-7) contains supplementary material, which is available to authorized users.

Abstract The Task Force reviewed and discussed the available literature on the effectiveness of physiotherapy for acute and chronic critically ill adult patients. Evidence from randomized controlled trials or meta-analyses was limited and most of the recommendations were level C (evidence from uncontrolled or nonrandomized trials, or from observational studies) and D (expert opinion). However, the following evidence-based targets for physiotherapy were identified: deconditioning, impaired airway clearance, atelectasis, intubation avoidance, and weaning failure. Discrepancies and lack of data on the efficacy of physiotherapy in clinical trials support the need to identify guidelines for physiotherapy assessments, in particular to identify patient characteristics that enable treatments to be prescribed and modified on an individual basis. There is a need to standardize pathways for clinical decision-making and education, to define the professional profile of physiotherapists, and increase the awareness of the benefits of prevention and treatment of immobility and deconditioning for critically ill adult patients.

Introduction

Critical illness can last from hours to months, depending on the underlying pathophysiology and response to treatment. It carries high morbidity and mortality rates, and the associated care is a major determinant of healthcare costs. The evolution of intensive care medicine and integrated team management has greatly improved the survival of critically ill patients [26, 69]. In view of the high costs associated with ICU, every attempt should continue to be made to prevent complications and appropriately treat the primary underlying pathophysiology to minimize length of stay in ICU. There are common complications particularly associated with a prolonged ICU stay, including deconditioning, muscle weakness, dyspnea, depression and anxiety, and reduced health-related quality of life [17, 41, 70]. Chronic critical illness is associated with prolonged immobility and intensive care unit (ICU) stay [29] and accounts for 5–10% of ICU stays, a proportion that appears to be increasing [13]. Because of these detrimental sequelae of long-term bed rest, there is a need for rehabilitation throughout the critical illness [16, 38, 66, 73, 114] and thereafter [49], to address these effects. The amount of rehabilitation performed in ICUs is often inadequate [20] and, as a rule, is better organized in weaning centers [66, 73].

Physiotherapy in the management of patients with critical illness

Physiotherapists are involved in the management of patients with acute, subacute and chronic respiratory conditions and in the prevention and treatment of the sequelae of immobility and recumbency [47, 77]. Their role varies across units, hospitals, and countries [77], with respect to patient referral, roles, treatment goals and selection of interventions [47, 77]. Due to a lack of substantive evidence, an earlier review could not draw firm conclusions on the effectiveness of physiotherapy for critically ill patients [98]. The purpose of this document is to critically review the evidence currently available for the use of physiotherapy in the *adult* critically ill patient and to make recommendations for assessment and monitoring and best practice in three relevant clinical areas:

- Deconditioning and related complications
- Respiratory conditions (retained airway secretions, atelectasis, pneumonia, acute lung injury, inhalation injury, postoperative pulmonary complications, chest trauma, intubation avoidance and weaning failure)
- Emotional problems and communication

The Task Force members met twice face to face and agreed on the identified areas and the working procedures (see details in ESM). Details of the effectiveness of physiotherapy in specific pulmonary conditions, implications for staffing and suggestions for future research are discussed in the ESM.

Conditions and physiotherapy interventions

Assessment and monitoring

Physiotherapy assessment of critically ill patients is less driven by medical diagnosis, instead focusing on deficiencies at a physiological and functional level [39]. This leads to identification of problems and the prescription of one or more interventions. Physiotherapists should be able to prioritize, and identify aims and parameters of treatments, ensuring that these are both therapeutic and safe by appropriate monitoring of vital functions [22, 100]. Accurate and valid assessment of respiratory conditions, and of deconditioning and related problems, is of paramount importance for physiotherapists. While these areas should be assessed with previously validated measures, such measures are often not available or applicable in an ICU setting (e.g., outcomes for functional performance such as the Functional Independence Measure, the Berg Balance scale and SF-36 may be inapplicable for acutely ill ICU patients yet be successfully used to monitor the progress of patients in long-term weaning facilities) [16]. In addition, physiotherapists can contribute to the patient's overall well-being by providing emotional support and enhancing communication. Fig. 1 outlines the etiology of respiratory insufficiency and failure (see also ESM), and may serve as a framework for the respiratory assessment and treatment. Assessment of muscle and neurological function is difficult in the ICU [81], but physiotherapists can reveal undetected injuries [92]. Detailed descriptions of assessment are given elsewhere [100].

Recommendations:

- Assessment prior to treatment should determine the underlying problem amenable to physiotherapy and which, if any, intervention(s) are appropriate (level D).
- Appropriate monitoring of vital functions should be used and acted upon to help ensure that physiotherapy interventions are both therapeutic and safe (level D).

Physical deconditioning and related complications

Due to the nature of critical illness and the modalities used to manage it, prolonged bed rest, with well-known adverse physiologic effects, seems to be the rule in the ICU (see ESM for details). Rehabilitation has the potential to restore lost function but is traditionally not started until after ICU discharge. Critically ill patients are often viewed as 'too sick' to tolerate physical activity in the early phase of their illness and their immobilization is frequently 'inevitably' prolonged. This will enhance deconditioning and might further complicate the clinical course [21]. Early mobilization was shown 30 years ago to reduce the time to wean from mechanical ventilation and is the basis for functional recovery [103, 104]. Recently more attention has been given to (early) physical activity as a safe and feasible intervention after the initial cardio-respiratory and neurological stabilization [6, 71]. In the ICU setting, the prescription of exercise is mostly based on clinical condition and response to treatment. Reducing the active muscle mass (or even passive motion or electrical muscle stimulation), the duration of the exercise and/or the number of repetitions will result in lower metabolic demands. Patients with hemodynamic instability, or those on high FiO_2 and high levels of ventilatory support, are not candidates for aggressive mobilization. The risk of moving a critically ill patient should be weighed against the risks entailed by immobility and recumbency [50, 108]. No adverse effects of physical activity on the inflammatory status of critically ill patients have been demonstrated [109]. Fig. 2 outlines the steps involved in safe mobilization of critically ill patients [100]. In the following paragraphs several specific treatment modalities will be discussed.

Positioning can be used to increase gravitational stress and associated fluid shifts, through head tilt and other positions that approximate the upright position. The upright position increases lung volumes and gas exchange [15], stimulates autonomic activity, and can reduce cardiac stress from compression [57]. *Mobilization* has been part of the physiotherapy

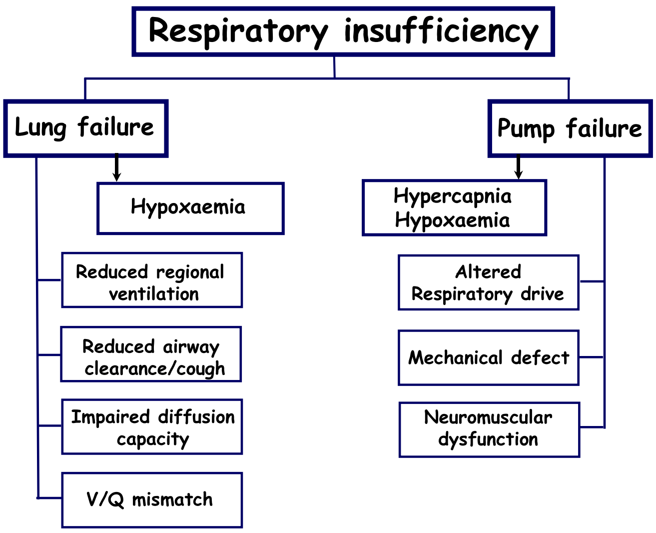


Fig. 1 Model of respiratory insufficiency (adapted from [90])

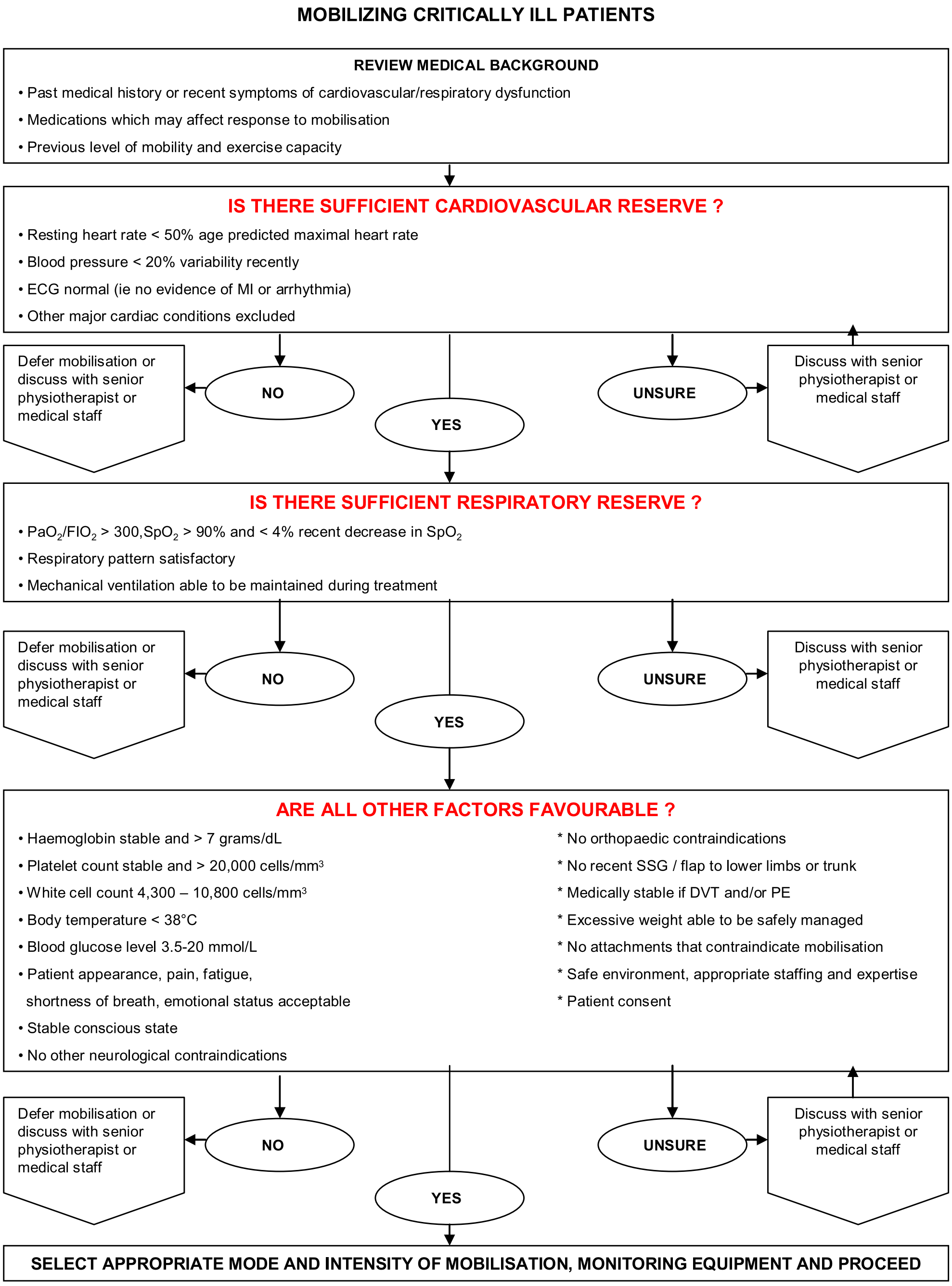


Fig. 2 Overview of safety issues before mobilizing critically ill patients. (Reproduced from: Stiller K, Phillips A (2003) Safety aspects of mobilising acutely ill inpatients. Physiother Theory Pract 19(4):239–257; with permission of Taylor & Francis Group, LLC, http://www.taylorandfrancis.com [100])

management of acutely ill patients for several decades [23]. Mobilization refers to physical activity sufficient to elicit acute physiological effects that enhance ventilation, central and peripheral perfusion, circulation, muscle metabolism and alertness and are countermeasures for venous stasis and deep vein thrombosis [79]. Strategies – in approximate order of intensity – include passive and active turning and moving in bed, active-assisted and active exercise, use of cycling pedals in bed, sitting over the edge of the bed, standing, stepping in place, transferring from the bed or chair, chair exercises and walking. These activities are safe and feasible in the early phase of ICU admission [6]. Walking and standing aids (e.g., modified walking frames, tilt tables) are safe and feasible to facilitate the mobilization of critically ill patients [15, 112, 113]. In patients with spinal cord injury abdominal belts improve vital capacity [34] and increase the exercise ability. Non-invasive ventilation during mobilization may improve exercise tolerance for non-intubated patients, similar to that demonstrated in patients with severe COPD [106].

Aerobic training and muscle strengthening, in addition to routine mobilization, improved walking distance more than mobilization alone in ventilated patients with chronic critical illness [73]. A recent randomized controlled trial (RCT) showed that a 6-week upper and lower limb training program improved limb muscle strength, increased ventilator-free time and improved functional outcomes in patients requiring long-term mechanical ventilation compared to a control group [16]. These results are in line with a retrospective analysis of patients on long-term mechanical ventilation who participated in whole-body training and respiratory muscle training [66]. In patients recently weaned from mechanical ventilation, the addition of upper-limb exercise enhanced the effects of chest physiotherapy on exercise endurance and dyspnea [82]. Recent technological developments have resulted in equipment for active or passive leg cycling during bed rest. This allows early application of leg cycling in critically ill patients, potentially improving functional status [11].

Low-resistance multiple repetitions of *resistive muscle training* can augment muscle mass, force generation and oxidative enzymes. This in turn can improve O_2 extraction and efficiency of muscle O_2 kinetics. Applying these physiological responses to the ICU scenario, ICU patients should be given sets of repetitions (3 sets of 8–10 repetitions at 50–70% of 1 repetition maximum, RM) [52] to perform daily within their tolerance, commensurate with their goals. In patients unable to perform voluntary muscle contractions, *neuromuscular electrical stimulation* (NMES) has been used to prevent disuse muscle atrophy. In patients with lower limb fractures and cast immobilization for 6 weeks, daily NMES for at least 1 h reduced the decrease in cross-sectional area of the quadriceps and enhanced normal muscle protein synthesis [33]. In ICU patients, NMES of the quadriceps, in addition to active limb mobilization, enhanced muscle strength and hastened independent transfer from bed to chair [114].

Passive stretching or range-of-motion exercise may have a particularly important role in the management of patients who are unable to move spontaneously. Passive movement has been shown to enhance ventilation in neurological patients in high-dependency units [14]. Evidence for using continuous dynamic stretching is based on the observation, in other patient groups, that continuous passive motion (CPM) prevents contractures and promotes function [91]. CPM has been assessed in patients with critical illness subjected to prolonged inactivity [38]. Three hours of CPM per day reduced fiber atrophy and protein loss, compared with passive stretching for 5 min twice daily [38].

For patients who cannot be actively mobilized and are at high risk for soft tissue contracture (e.g., following severe burns or trauma, and in some neurological conditions), *splinting* may be indicated. In burns patients, fixing the position of joints has been shown to reduce muscle and skin contraction [55]. The ideal duration of the intervention is unknown. Many facilities use a '2 h on, 2 h off' schedule, but this is not supported by data [85]. In patients with neurological dysfunction, splinting may reduce muscle tone [42].

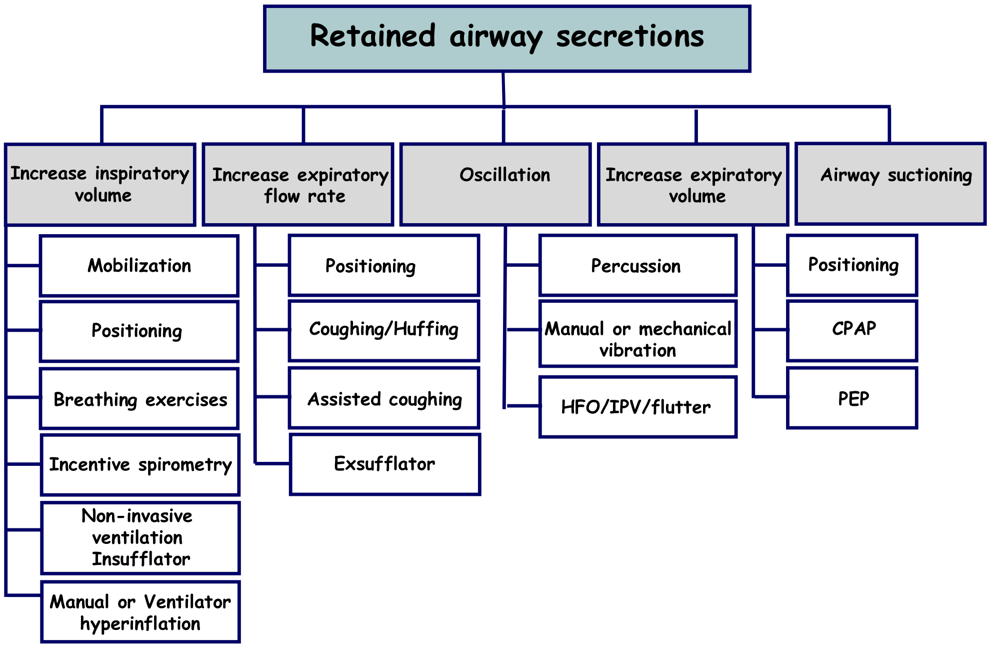
Recommendations:

- Active or passive mobilization and muscle training should be instituted early (level C).
- Positioning, splinting, passive mobilization and muscle stretching should be used to preserve joint mobility and skeletal muscle length in patients unable to move spontaneously (level C).
- NMES may be instituted, where equipment is available, in patients who are unable to move spontaneously and at high risk of musculo-skeletal dysfunction (level C).
- Techniques, such as positioning, passive movement and transfers, should be administered jointly with the nursing staff (level D).
- The physiotherapist should be responsible for implementing mobilization plans and exercise prescription, and make recommendations for progression of these in conjunction with other team members (level D).

Respiratory conditions

Respiratory dysfunction is one of the most common causes of critical illness necessitating ICU admission. Failure of either of the two primary components of the respiratory system (i.e., the gas-exchange membrane and the ventilatory pump.. [90] (Fig. 2; see ESM, Table S2), can result in a need for mechanical ventilation to maintain adequate gas exchange and to assume some, if not all, of the work of breathing. The aims of physiotherapy in respiratory dysfunction are to improve global and/or regional ventilation and lung compliance, to reduce airway resistance and the work of breathing, and to clear airway secretions. Body positioning and mobilization are potent options for treatment that may optimize oxygenation by improving ventilation, V/Q matching, using gravity dependency to augment alveolar recruitment, and lung perfusion. Evidence for interventions used to clear retained airway secretions will be discussed generally. The ESM describes the evidence for interventions in specific pathophysiological problems and diagnoses, i.e. atelectasis, pneumonia, acute lung injury, acute respiratory distress syndrome, inhalation injury, postoperative pulmonary complications and chest trauma.

Fig. 3 Pathways and treatment modalities for increasing airway clearance (*PEP*, positive expiratory pressure; *CPAP*, continuous positive airway pressure; *HFO*, high-frequency oscillation; *IPV*, intrapulmonary percussive ventilation; *NIV*, non-invasive ventilation; *IPPB*, intermittent positive pressure breathing)



Retained airway secretions

As different mechanisms can be responsible for reducing airway clearance, it is important firstly to identify the problem and then to select the intervention(s) that may be appropriate (Fig. 3).

Non-intubated patient: Interventions aimed at *increasing inspiratory volume* (see Fig. 3) affect lung expansion, regional ventilation, airway resistance and pulmonary compliance. Interventions aimed at *increasing expiratory flow* include *forced expirations (both active and passive)*. Actively, these can be with an open glottis (a huff), or with a closed glottis (a cough). *Manually assisted cough*, using thoracic or abdominal compression, may be indicated for patients with expiratory muscle weakness or fatigue (e.g., neuromuscular conditions) [96]. All forced expiratory techniques rely on an adequate inspiratory volume and may need to be accompanied by interventions to increase inspiratory volume, if reduced inspiratory volume is contributing to an ineffective cough. The *mechanical in-exsufflator* can be used to deliver an inspiratory pressure followed by a high negative expiratory force, via a mouthpiece or facemask. This increases tidal volume and augments expiratory flow and thus is indicated when the patient is unable to clear secretions. Although not widely used, it has been successfully applied in the management of non-intubated patients with retained secretions secondary to respiratory muscle weakness (e.g., muscular dystrophy) [35]. *Airway suctioning* is, dependent on local agreements, practiced by doctors, nurses and physiotherapists and is used solely to clear central secretions that are considered a primary problem when other techniques are ineffective. Detailed descriptions of airway suctioning techniques and the risks associated with these techniques are given elsewhere [4].

Recommendations for the non-intubated patient:

- Interventions for increasing inspiratory volume should be used if reduced inspiratory volume is contributing to ineffective forced expiration (level B).
- Interventions for increasing expiratory flow should be used to assist airway clearance if reduced expiratory force is contributing to ineffective forced expiration (level B).
- Manually assisted cough techniques and/or in-exsufflation should be applied in the management of non-intubated patients with retained secretions secondary to respiratory muscle weakness (level B).
- Oro-nasal suctioning should be used only when other methods fail to clear secretions (level D).
- Nasal suctioning should be used with extreme caution in patients with anticoagulation, bony or soft tissue injuries or after recent surgery of the upper airways (level D).

Intubated and ventilated patients: *Body positioning* and *mobilization* may optimize airway secretion clearance and oxygenation by improving ventilation, alveolar recruitment and V/Q matching. *Manual hyperinflation* (MHI) or ventilator hyperinflation, positive end-expiratory pressure (PEEP) ventilation and *airway suctioning* may assist in secretion clearance [7]. The aims of *MHI* are to prevent pulmonary atelectasis, re-expand collapsed alveoli, improve oxygenation, improve lung compliance, and facilitate movement of airway secretions towards the central airways [43, 68]. The head-down position may enhance the effects of MHI on sputum volume and compliance [8]. MHI involves a slow deep inspiration with manual resuscitator bag, an inspiratory hold, and then a quick release of the bag to enhance expiratory flow and mimic a forced expiration. MHI can precipitate marked hemodynamic changes associated with a decreased cardiac output, which result from large fluctuations in intra-thoracic pressure [95]. As with other forms of ventilatory assistance, damage to the lung can occur if inflation is forced or PEEP is lost during the technique. A pressure of 40 cmH_2O has been recommended as an upper limit [84]. Similarly, there is a risk of hypo- as well as hyperventilation. MHI can also increase intracranial pressure (ICP) and mean arterial pressure, which has implications for patients with brain injury. These increases are usually limited, however, such that cerebral perfusion pressure remains stable [78]. *Airway suctioning* may have detrimental side effects [110] although reassurance, sedation, and pre-oxygenation of the patient may minimize these effects [61]. Suction can be performed via an *in-line closed suctioning system* or an *open system*. The in-line system does not appear to decrease the incidence of ventilator-associated pneumonia (VAP) [25, 59] or the duration of mechanical ventilation, length of ICU stay or mortality [59], but it does increase costs. Closed suctioning may be less effective than open suctioning for secretion clearance during pressure-support ventilation [58]. The routine *instillation of normal saline* during airway suctioning has potential adverse effects on oxygen saturation and cardiovascular stability, and variable results in terms of increasing sputum yield [1, 9]. *Chest wall compression* prior to endotracheal suctioning did not improve airway secretion removal, oxygenation, or ventilation after endotracheal suctioning in an *unselected* population of mechanically ventilated patients [105].

Recommendations for the intubated patient:

- Body positioning and mobilization can be used to enhance airway secretion clearance (level C).
- Manual or ventilator hyperinflation and suctioning are indicated for airway secretion clearance (level B).
- MHI should be used judiciously in patients at risk of barotrauma and volutrauma or who are hemodynamically unstable (level B).
- Care must be taken to ensure that over- or under-ventilation does not occur with MHI (level B).
- Airway pressures must be maintained within safe limits (e.g., by incorporating a pressure manometer into the MHI circuit) (level D).
- Reassurance, sedation, and pre-oxygenation should be used to minimize detrimental effects of airway suctioning (level D).
- Open system suctioning can be used for most ventilated patients (level B).
- Neither suctioning nor instillation of normal saline should be performed *routinely* (level C).

Respiratory insufficiency – intubation avoidance

Complications of endotracheal intubation and mechanical ventilation are common, and weaning from mechanical ventilation can be challenging, so where appropriate and possible, physiotherapy is aimed at avoiding intubation. Of paramount importance is whether the respiratory failure is due to lung failure, pump failure, or both (Fig. 2; see ESM Table S2), as the problems and strategies will vary accordingly. Imbalance between respiratory muscle (pump) workload and muscle (pump) capacity can result in respiratory insufficiency (Fig. 4) and is a major cause of need for ventilatory support. Physiotherapy may help decrease ventilatory load, e.g., by reducing atelectasis [62, 99] or removing airway secretions [60, 99]. Conditions contributing to the need for ventilatory support or weaning failure are described in the ESM (Table S3).

Problems related to the work of breathing and efficiency of ventilation, along with progressive debility, are the primary focuses of physiotherapy in the management of respiratory insufficiency and the avoidance of

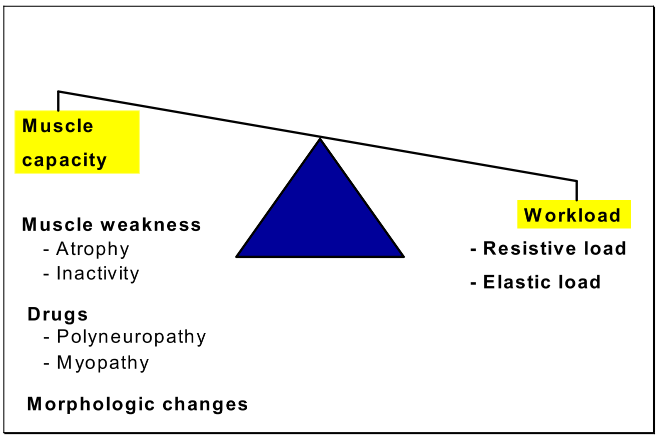


Fig. 4 Factors contributing to respiratory insufficiency, failure and ventilator dependence

intubation. *Positioning* can reduce the work of breathing and improve the efficiency of ventilation. Improvements have been documented (see ESM) for patients with unilateral lung disease when they are positioned on their side with the affected lung uppermost [45]. For those with, or at risk of, reduced FRC, supported upright sitting, with the help of pillows if necessary, may be beneficial [46]. In lung failure, *CPAP* has produced favorable outcomes in adults with ARDS [36] and in patients with *Pneumocystis carinii* pneumonia [37], and may prevent re-intubation [24]. NIV has been used for postoperative support [2] and for COPD patients with CAP [18], as well as in some patients with acute lung injury [89], to avoid intubation When pump dysfunction is present, *NIV* can reduce breathlessness [10], reduce rates of intubation [83], reduce mortality from exacerbations of COPD [83], and is cost effective [80]. Both CPAP and NIV can reduce the need for intubation in acute cardiogenic pulmonary edema [67].

Recommendations:

- Body positioning should be used to optimize ventilatory pump mechanics in patients with respiratory insufficiency (level C).
- CPAP and NIV should be considered for the management of acute cardiogenic pulmonary edema (level A).
- NIV should be used as the first line of treatment in pump failure due to exacerbations of COPD, providing immediate intubation is not warranted (level A).
- NIV may be used in selected patients with pump failure due to acute respiratory complications from musculo-skeletal chest wall dysfunction or neuromuscular weakness (level A).
- NIV/CPAP can be used in selected patients with type 1 acute respiratory failure, e.g., inhalation injury, trauma and some pneumonias (level C).

Weaning failure

Only a small proportion of patients fail to wean from mechanical ventilation, but they require a disproportionate amount of resources. *Therapist-driven protocol (TDP)* was shown to reduce the duration of mechanical ventilation and ICU cost [27, 51]. However, a recent study showed that protocol-directed weaning may be unnecessary in an ICU with generous physician staffing and structured rounds [54]. A *spontaneous breathing trial (SBT)* can be used to assess readiness for extubation with the performance of serial measurements, such as tidal volume, respiratory rate, maximal inspiratory airway pressure, and the rapid shallow breathing index [63, 111]. Early detection of worsening clinical signs such as distress, airway obstruction and paradoxical chest wall motion ensures that serious problems are prevented. Airway patency and protection (i.e., an effective cough mechanism) should be assessed prior to commencement of weaning. *Peak cough flow* is a useful parameter to predict successful weaning in patients with neuromuscular disease or spinal cord injury when extubation is anticipated [5]. An "*airway care score*" has been developed based on the quality of the patient's cough during airway suctioning, the absence of 'excessive' secretions and the frequency of airway suctioning [12, 27].

NIV can facilitate weaning [74] and reduce ICU costs [102], and physiotherapists can play a major role in its application [53, 77]. NIV is effective in preventing post-extubation failure in patients at risk [75, 97]. Respiratory muscle weakness is often observed in patients with weaning failure [56]. Since inactivity ('ventilator-induced diaphragm dysfunction', VDI) is suggested as an important cause of respiratory muscle failure [31], and intermittent loading of the respiratory muscles has been shown to attenuate respiratory muscle deconditioning [32], *inspiratory muscle training* might be beneficial in patients with weaning failure. Uncontrolled trials [3, 64] and one RCT [65] observed an improvement in inspiratory muscle function and a reduction in duration of mechanical ventilation and weaning time with intermittent inspiratory muscle training. Finally, *biofeedback* to display the breathing pattern has been shown to enhance weaning [44]. *Voice and touch* may be used to augment weaning success either by stimulation to improve ventilatory drive or by reducing anxiety [40]. Environmental influences, such as ambulating with a portable ventilator, have been shown to benefit attitudes and outlooks in long-term ventilator-dependent patients [28].

Recommendations:

- Therapist-driven weaning protocols and SBTs can be implemented dependent on physician staffing in the ICU (level A).
- Therapist-driven protocols for weaning should be adhered to if in existence (level A).
- In patients with respiratory muscle weakness and weaning failure respiratory muscle training should be considered (level C).
- NIV may be used as a weaning strategy in a selected population of hypercapnic patients (level A).
- Patients at risk of post-extubation ventilatory failure should be identified and considered for NIV (level B).
- During the early post-extubation phase, assisted coughing maneuvers or nasal endotracheal suctioning should be performed as necessary (level C).
- Physiotherapists can assist in patient management post-decannulation (level D).

Emotional problems and communication

Critically ill patients may experience feelings of anxiety, alienation and panic, particularly if nursed in an ICU or high-dependency unit [76, 101]. Those on mechanical ventilation may experience additional distress from the endotracheal tube [30]. These emotions may lead to post-traumatic stress disorder in some patients after discharge [48]. Anxiety also adversely affects recovery if not assessed and treated [72]. Promoting a restful environment conducive to relaxation and sleep is a daily challenge in critical care [87]. Physiotherapists can make a valuable contribution to the psychological well-being and education of the critically ill patient [94]. *Relaxation interventions* can reduce anxiety and panic, promote sleep, and, in turn, reduce the severity of pain and dyspnea. *Body positioning and repositioning* are useful means of achieving relaxation and reduce symptoms. Breathlessness can respond favorably to positioning [93]. *Therapeutic touch* has been reported to promote relaxation and comfort in critically ill patients, which in turn may enhance sleep [86]. Physiotherapists, by virtue of their hands-on treatment provided to ICU patients, have an opportunity to provide such therapeutic touch. *Massage* may be useful in enhancing relaxation and reducing anxiety and pain in acute and critical care [88]. *Communication* is central to patient satisfaction and physical and emotional well-being [94]. The development of post-traumatic stress disorder has been associated with the inability to communicate effectively. Informed consent is a means of empowering the patient when highly vulnerable [19]. *Education* is designed to help the patient understand their condition and care and appreciate their own role in pain control, e.g., patient-controlled analgesia, wound support during movement or airway clearance, and strategies such as body positioning for comfort [107].

Recommendations:

- Physiotherapists should ensure treatment sessions address discomfort and anxiety as well as physiological problems (level D).
- Physiotherapists should ensure patient education is included in treatment sessions (level D).
- Physiotherapists can consider massage as an intervention for anxiety management and sleep promotion (level C).
- Physiotherapists should include appropriate use of therapeutic touch in all treatments they provide (level D).

Summary

Physiotherapists are members of the interdisciplinary healthcare team for the management of critically ill patients. For the purpose of this review, several important areas for physiotherapy in critical illness were identified: physical deconditioning, neuromuscular and musculoskeletal complications; prevention and treatment of respiratory conditions; and emotional problems and communication. The following problems were identified as evidence-based targets for physiotherapy: deconditioning, muscle weakness, joint stiffness, retained airway secretions, atelectasis and avoidance of intubation and weaning failure. Appropriately prescribed physiotherapy may improve outcomes and reduce the risks associated with intensive care, as well as minimize costs.

The lack of systematic reviews and RCTs to support or reject physiotherapy interventions was recognized by the Task Force, as most recommendations were level C and D. However, evidence-based medicine in the ICU is not restricted to RCTs and meta-analyses. Other forms of evidence, including expert opinion and physiologic evidence, are also valid in terms of providing a basis for practice and identifying areas where further research is needed to strengthen and advance this evidence base.

Discrepancies regarding the efficacy of physiotherapy in clinical trials support the need to identify indications for interventions based on an individual's needs, rather than being condition dependent, and to establish sound principles for the prescription of specific interventions to achieve the desired outcome. However, there is a need to standardize pathways for clinical decision-making and education, and define the professional profile of ICU physiotherapists in more detail. Patients in the ICU have multiple problems that change rapidly in response to the course of illness and to medical management. Rather than standardized treatment approaches for various conditions, the goal is to extract principles of practice that can guide the physiotherapist's assessment, evaluation and prescription of interventions and their frequent modification for each patient in the ICU.

References

1. Ackerman MH, Mick DJ (1998) Instillation of normal saline before suctioning in patients with pulmonary infections: a prospective randomized controlled trial. Am J Crit Care 7:261–266
2. Aguilo R, Togores B, Salvador P, Rubi M, Barbe F, Agust A (1997) Noninvasive ventilatory support after lung resectional surgery. Chest 112:117–121
3. Aldrich TK, Karpel JP, Uhrlass RM, Sparapani MA, Eramo D, Ferranti R (1989) Weaning from mechanical ventilation: adjunctive use of inspiratory muscle resistive training. Crit Care Med 17:143–147
4. Anonymous (1992) AARC clinical practice guideline. Nasotracheal suctioning. American Association for Respiratory Care (update 2004). Respir Care 37:1176–1179
5. Bach JR, Saporito LR (1996) Criteria for extubation and tracheostomy tube removal for patients with ventilatory failure. A different approach to weaning. Chest 110:1566–1571
6. Bailey P, Thomsen GE, Spuhler VJ, Blair R, Jewkes J, Bezdjian L, Veale K, Rodriquez L, Hopkins RO (2007) Early activity is feasible and safe in respiratory failure patients. Crit Care Med 35:139–145
7. Berney S, Denehy L (2002) A comparison of the effects of manual and ventilator hyperinflation on static lung compliance and sputum production in intubated and ventilated intensive care patients. Physiother Res Int 7:100–108
8. Berney S, Denehy L, Pretto J (2004) Head-down tilt and manual hyperinflation enhance sputum clearance in patients who are intubated and ventilated. Aust J Physiother 50:9–14
9. Blackwood B (1999) Normal saline instillation with endotracheal suctioning: primum non nocere (first do no harm). J Adv Nurs 29:928–934
10. Bott J, Carroll MP, Conway JH, Keilty SE, Ward EM, Brown AM, Paul EA, Elliot MW, Godfrey RC, Wedzicha JA, Moxham J (1993) Randomised controlled trial of nasal ventilation in acute ventilatory failure due to chronic obstructive airways disease. Lancet 341:1555–1557
11. Burtin C, Clerckx B, Robbeets C, Gall S, Pillen R, Leclercq H, Caluwé K, Lommers B, Wilmer A, Troosters T, Ferdinande P, Gosselink R (2006) Effectiveness of early exercise in critically ill patients: preliminary results. Intensive Care Med 32:109
12. Capdevila XJ, Perrigault PF, Perey PJ, Roustan JP, d'Athis F (1995) Occlusion pressure and its ratio to maximum inspiratory pressure are useful predictors for successful extubation following T-piece weaning trial. Chest 108:482–489
13. Carson SS, Bach PB (2002) The epidemiology and costs of chronic critical illness. Crit Care Clin 18:461–476
14. Chang A, Paratz J, Rollston J (2002) Ventilatory effects of neurophysiological facilitation and passive movement in patients with neurological injury. Aust J Physiother 48:305–310
15. Chang AT, Boots R, Hodges PW, Paratz J (2004) Standing with assistance of a tilt table in intensive care: a survey of Australian physiotherapy practice. Aust J Physiother 50:51–54
16. Chiang LL, Wang LY, Wu CP, Wu HD, Wu YT (2006) Effects of physical training on functional status in patients with prolonged mechanical ventilation. Phys Ther 86:1271–1281
17. Combes A, Costa MA, Trouillet JL, Baudot J, Mokhtari M, Gibert C, Chastre J (2003) Morbidity, mortality, and quality-of-life outcomes of patients requiring > or = 14 days of mechanical ventilation. Crit Care Med 31:1373–1381
18. Confalonieri M, Potena A, Carbone G, Porta RD, Tolley EA, Umberto MG (1999) Acute respiratory failure in patients with severe community-acquired pneumonia. A prospective randomized evaluation of noninvasive ventilation. Am J Respir Crit Care Med 160:1585–1591
19. Copnell B, Fergusson D (1995) Endotracheal suctioning: time-worn ritual or timely intervention? Am J Crit Care 4:100–105
20. Corrado A, Roussos C, Ambrosino N, Confalonieri M, Cuvelier A, Elliott M, Ferrer M, Gorini M, Gurkan O, Muir JF, Quareni L, Robert D, Rodenstein D, Rossi A, Schoenhofer B, Simonds AK, Strom K, Torres A, Zakynthinos S (2002) Respiratory intermediate care units: a European survey. Eur Respir J 20:1343–1350
21. De Jonghe B, Bastuji-Garin S, Sharshar T, Outin H, Brochard L (2004) Does ICU-acquired paresis lengthen weaning from mechanical ventilation? Intensive Care Med 30:1117–1121
22. Dean E (1997) Oxygen transport deficits in systemic disease and implications for physical therapy. Phys Ther 77:187–202
23. Dean E, Ross J (1992) Discordance between cardiopulmonary physiology and physical therapy. Toward a rational basis for practice. Chest 101:1694–1698
24. Dehaven CB Jr., Hurst JM, Branson RD (1985) Postextubation hypoxemia treated with a continuous positive airway pressure mask. Crit Care Med 13:46–48
25. Dodek P, Keenan S, Cook D, Heyland D, Jacka M, Hand L, Muscedere J, Foster D, Mehta N, Hall R, Brun-Buisson C (2004) Evidence-based clinical practice guideline for the prevention of ventilator-associated pneumonia. Ann Intern Med 141:305–313
26. Eisner MD, Thompson T, Hudson LD, Luce JM, Hayden D, Schoenfeld D, Matthay MA (2001) Efficacy of low tidal volume ventilation in patients with different clinical risk factors for acute lung injury and the acute respiratory distress syndrome. Am J Respir Crit Care Med 164:231–236
27. Ely EW, Baker AM, Dunagan DP, Burke HL, Smith AC, Kelly PT, Johnson MM, Browder RW, Bowton DL, Haponik EF (1996) Effect on the duration of mechanical ventilation of identifying patients capable of breathing spontaneously. N Engl J Med 335:1864–1869
28. Esteban A, Alia I, Ibanez J, Benito S, Tobin MJ (1994) Modes of mechanical ventilation and weaning. A national survey of Spanish hospitals. The Spanish Lung Failure Collaborative Group. Chest 106:1188–1193
29. Fletcher SN, Kennedy DD, Ghosh IR, Misra VP, Kiff K, Coakley JH, Hinds CJ (2003) Persistent neuromuscular and neurophysiologic abnormalities in long-term survivors of prolonged critical illness. Crit Care Med 31:1012–1016
30. Fontaine DK (1994) Nonpharmacologic management of patient distress during mechanical ventilation. Crit Care Clin 10:695–708
31. Gayan-Ramirez G, Decramer M (2002) Effects of mechanical ventilation on diaphragm function and biology. Eur Respir J 20:1579–1586
32. Gayan-Ramirez G, Testelmans D, Maes K, Racz GZ, Cadot P, Zador E, Wuytack F, Decramer M (2005) Intermittent spontaneous breathing protects the rat diaphragm from mechanical ventilation effects. Crit Care Med 33:2804–2809
33. Gibson JNA, Smith K, Rennie MJ (1988) Prevention of disuse muscle atrophy by means of electrical stimulation: maintenance of protein synthesis. Lancet 2(8614):767–769
34. Goldman JM, Rose LS, Williams SJ, Silver JR, Denison DM (1986) Effect of abdominal binders on breathing in tetraplegic patients. Thorax 41:940–945

35. Gomez-Merino E, Sancho J, Marin J, Servera E, Blasco ML, Belda FJ, Castro C, Bach JR (2002) Mechanical insufflation-exsufflation: pressure, volume, and flow relationships and the adequacy of the manufacturer's guidelines. Am J Phys Med Rehabil 81:579–583
36. Greenbaum DM, Millen JE, Eross B, Snyder JV, Grenvik A, Safar P (1976) Continuous positive airway pressure without tracheal intubation in spontaneously breathing patients. Chest 69:615–620
37. Gregg RW, Friedman BC, Williams JF, McGrath BJ, Zimmerman JE (1990) Continuous positive airway pressure by face mask in *Pneumocystis carinii* pneumonia. Crit Care Med 18:21–24
38. Griffiths RD, Palmer A, Helliwell T, Maclennan P, Macmillan RR (1995) Effect of passive stretching on the wasting of muscle in the critically ill. Nutrition 11:428–432
39. Grill E, Quittan M, Huber EO, Boldt C, Stucki G (2005) Identification of relevant ICF categories by health professionals in the acute hospital. Disabil Rehabil 27:437–445
40. Hall JB, Wood LD (1987) Liberation of the patient from mechanical ventilation. JAMA 257:1621–1628
41. Herridge MS, Cheung AM, Tansey CM, Matte-Martyn A, Diaz-Granados N, Al Saidi F, Cooper AB, Guest CB, Mazer CD, Mehta S, Stewart TE, Barr A, Cook D, Slutsky AS (2003) One-year outcomes in survivors of the acute respiratory distress syndrome. N Engl J Med 348:683–693
42. Hinderer SR, Dixon K (2001) Physiologic and clinical monitoring of spastic hypertonia. Phys Med Rehabil Clin N Am 12:733–746
43. Hodgson C, Ntoumenopoulos G, Dawson H, Paratz J (2007) The Mapleson C circuit clears more secretions than the Laerdal circuit during manual hyperinflation in mechanically-ventilated patients: a randomised cross-over trial. Aust J Physiother 53:33–38
44. Holliday JE, Hyers TM (1990) The reduction of weaning time from mechanical ventilation using tidal volume and relaxation biofeedback. Am Rev Respir Dis 141:1214–1220
45. Ibanez J, Raurich JM, Abizanda R, Claramonte R, Ibanez P, Bergada J (1981) The effect of lateral positions on gas exchange in patients with unilateral lung disease during mechanical ventilation. Intensive Care Med 7:231–234
46. Jenkins SC, Soutar SA, Moxham J (1988) The effects of posture on lung volumes in normal subjects and in patients pre- and post-coronary artery surgery. Physiotherapy 74:492–496
47. Jones AYM, Hutchinson RC, Oh TE (1992) Chest physiotherapy practice in intensive care units in Australia, the UK and Hong Kong. Physiother Theory Pract 8:39–47
48. Jones C, Macmillan RR, Griffiths RD (1994) Providing psychological support for patients after critical illness. Clin Intensive Care 5:176–179
49. Jones C, Skirrow P, Griffiths RD, Humphris GH, Ingleby S, Eddleston J, Waldmann C, Gager M (2003) Rehabilitation after critical illness: a randomized, controlled trial. Crit Care Med 31:2456–2461
50. King J, Crowe J (1998) Mobilization practices in Canadian critical care units. Physiother Can 50:206–211
51. Kollef MH, Shapiro SD, Silver P, St.John RE, Prentice D, Sauer S, Ahrens TS, Shannon W, Baker-Clinkscale D (1997) A randomized, controled trial of protocol-directed versus physician-directed weaning from mechanical ventilation. Crit Care Med 25:567–574
52. Kraemer WJ, Adams K, Cafarelli E, Dudley GA, Dooly C, Feigenbaum MS, Fleck SJ, Franklin B, Fry AC, Hoffman JR, Newton RU, Potteiger J, Stone MH, Ratamess NA, Triplett-McBride T (2002) American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. Med Sci Sports Exerc 34:364–380
53. Kramer N, Meyer TJ, Meharg J, Cece RD, Hill NS (1995) Randomized, prospective trial of noninvasive positive pressure ventilation in acute respiratory failure. Am J Respir Crit Care Med 151:1799–1806
54. Krishnan JA, Moore D, Robeson C, Rand CS, Fessler HE (2004) A prospective, controlled trial of a protocol-based strategy to discontinue mechanical ventilation. Am J Respir Crit Care Med 169:673–678
55. Kwan MW, Ha KW (2002) Splinting programme for patients with burnt hand. Hand Surg 7:231–241
56. Laghi F, Cattapan SE, Jubran A, Parthasarathy S, Warshawsky P, Choi YS, Tobin MJ (2003) Is weaning failure caused by low-frequency fatigue of the diaphragm? Am J Respir Crit Care Med 167:120–127
57. Langou RA, Wolfson S, Olson EG, Cohen LS (1977) Effects of orthostatic postural changes on myocardial oxygen demands. Am J Cardiol 39:418–421
58. Lindgren S, Almgren B, Hogman M, Lethvall S, Houltz E, Lundin S, Stenqvist O (2004) Effectiveness and side effects of closed and open suctioning: an experimental evaluation. Intensive Care Med 30:1630–1637
59. Lorente L, Lecuona M, Martin MM, Garcia C, Mora ML, Sierra A (2005) Ventilator-associated pneumonia using a closed versus an open tracheal suction system. Crit Care Med 33:115–119
60. Mackenzie CF, Shin B (1985) Cardiorespiratory function before and after chest physiotherapy in mechanically ventilated patients with post-traumatic respiratory failure. Crit Care Med 13:483–486
61. Mancinelli-Van Atta J, Beck SL (1992) Preventing hypoxemia and hemodynamic compromise related to endotracheal suctioning. Am J Crit Care 1:62–79
62. Marini JJ, Pierson DJ, Hudson LD (1979) Acute lobar atelectasis: a prospective comparison of fiberoptic bronchoscopy and respiratory therapy. Am Rev Respir Dis 119:971–978
63. Marini JJ, Smith TC, Lamb V (1986) Estimation of inspiratory muscle strength in mechanically ventilated patients: the measurement of maximal inspiratory pressure. J Crit Care 1:32–38
64. Martin AD, Davenport PD, Franceschi AC, Harman E (2002) Use of inspiratory muscle strength training to facilitate ventilator weaning: a series of 10 consecutive patients. Chest 122:192–196
65. Martin D, Davenport PW, Gonzalez-Rothi J, Baz M, Banner J, Caruso L, Layon J, Gabrielli A (2006) Inspiratory muscle strength training improves outcome in failure to wean patients. p 369s
66. Martin UJ, Hincapie L, Nimchuk M, Gaughan J, Criner GJ (2005) Impact of whole-body rehabilitation in patients receiving chronic mechanical ventilation. Crit Care Med 33:2259–2265
67. Masip J, Roque M, Sanchez B, Fernandez R, Subirana M, Exposito JA (2005) Noninvasive ventilation in acute cardiogenic pulmonary edema: systematic review and meta-analysis. JAMA 294:3124–3130
68. Maxwell L, Ellis E (1998) Secretion clearance by manual hyperinflation: possible mechanisms. Physiother Theory Pract 14:189–197
69. Milberg JA, Davis DR, Steinberg KP, Hudson LD (1995) Improved survival of patients with acute respiratory distress syndrome (ARDS): 1983–1993. JAMA 273:306–309
70. Montuclard L, Garrouste-Org, Timsit JF, Misset B, De Jonghe B, Carlet J (2000) Outcome, functional autonomy, and quality of life of elderly patients with a long-term intensive care unit stay. Crit Care Med 28:3389–3395
71. Morris PE (2007) Early mobility of the ICU patient. Crit Care Clin 23:1–116

72. Moser DK, Chung ML, McKinley S, Riegel B, An K, Cherrington CC, Blakely W, Biddle M, Frazier SK, Garvin BJ (2003) Critical care nursing practice regarding patient anxiety assessment and management. Intensive Crit Care Nurs 19:276–288
73. Nava S (1998) Rehabilitation of patients admitted to a respiratory intensive care unit. Arch Phys Med Rehabil 79:849–854
74. Nava S, Ambrosino N, Clini E, Prato M, Orlando G, Vitacca M, Brigada P, Fracchia C, Rubini F (1998) Noninvasive mechanical ventilation in the weaning of patients with respiratory failure due to chronic obstructive pulmonary disease. A randomized, controlled trial. Ann Intern Med 128:721–728
75. Nava S, Gregoretti C, Fanfulla F, Squadrone E, Grassi M, Carlucci A, Beltrame F, Navalesi P (2005) Noninvasive ventilation to prevent respiratory failure after extubation in high-risk patients. Crit Care Med 33:2465–2470
76. Nelson BJ, Weinert CR, Bury CL, Marinelli WA, Gross CR (2000) Intensive care unit drug use and subsequent quality of life in acute lung injury patients. Crit Care Med 28:3626–3630
77. Norrenberg M, Vincent JL (2000) A profile of European intensive care unit physiotherapists. European Society of Intensive Care Medicine. Intensive Care Med 26:988–994
78. Paratz J, Burns Y (1993) The effect of respiratory physiotherapy on intracranial pressure, mean arterial pressure, cerebral perfusion pressure and end tidal carbon dioxide in ventilated neurosurgical patients. Physiother Theory Pract 9:3–11
79. Partsch H (2002) Bed rest versus ambulation in the initial treatment of patients with proximal deep vein thrombosis. Curr Opin Pulm Med 8:389–393
80. Plant PK, Owen JL, Parrott S, Elliott MW (2003) Cost effectiveness of ward based non-invasive ventilation for acute exacerbations of chronic obstructive pulmonary disease: economic analysis of randomised controlled trial. BMJ 326:956
81. Polkey MI, Moxham J (2001) Clinical aspects of respiratory muscle dysfunction in the critically ill. Chest 119:926–939
82. Porta R, Vitacca M, Gile LS, Clini E, Bianchi L, Zanotti E, Ambrosino N (2005) Supported arm training in patients recently weaned from mechanical ventilation. Chest 128:2511–2520
83. Ram FS, Lightowler JV, Wedzicha JA (2003) Non-invasive positive pressure ventilation for treatment of respiratory failure due to exacerbations of chronic obstructive pulmonary disease. Cochrane Database Syst Rev CD004104
84. Redfern J, Ellis E, Holmes W (2001) The use of a pressure manometer enhances student physiotherapists' performance during manual hyperinflation. Aust J Physiother 47:121–131
85. Richard R, Ward RS (2005) Splinting strategies and controversies. J Burn Care Rehabil 26:392–396
86. Richards K, Nagel C, Markie M, Elwell J, Barone C (2003) Use of complementary and alternative therapies to promote sleep in critically ill patients. Crit Care Nurs Clin North Am 15:329–340
87. Richards KC (1994) Sleep promotion in the critical care unit. AACN Clin Issues Crit Care Nurs 5:152–158
88. Richards KC, Gibson R, Overton-McCoy AL (2000) Effects of massage in acute and critical care. AACN Clin Issues 11:77–96
89. Rocker GM, Mackenzie MG, Williams B, Logan PM (1999) Noninvasive positive pressure ventilation: successful outcome in patients with acute lung injury/ARDS. Chest 115:173–177
90. Roussos C (1985) Function and fatigue of respiratory muscles. Chest 88:124S–132S
91. Salter RB (1989) The biologic concept of continuous passive motion of synovial joints. The first 18 years of basic research and its clinical application. Clin Orthop Relat Res 242:12–25
92. Schwartz Cowley R, Swanson B, Chapman P, Mackay LE (1994) The role of rehabilitation in the intensive care unit. J Head Trauma Rehabil 9:32–42
93. Sharp JT, Druz WS, Moisan T, Foster J, Machnach W (1980) Postural relief of dyspnea in severe chronic obstructive pulmonary disease. Am Rev Respir Dis 122:201–211
94. Sim J (1998) Interpersonal aspects of care: communication, counselling and health education. In: Pryor JA, Webber BA (eds) Physiotherapy for respiratory and cardiac problems. Churchill Livingstone, Edinburgh, pp 211–226
95. Singer M, Vermaat J, Hall G, Latter G, Patel M (1994) Hemodynamic effects of manual hyperinflation in critically ill mechanically ventilated patients. Chest 106:1182–1187
96. Sivasothy P, Brown L, Smith IE, Shneerson JM (2001) Effect of manually assisted cough and mechanical insufflation on cough flow of normal subjects, patients with chronic obstructive pulmonary disease (COPD), and patients with respiratory muscle weakness. Thorax 56:438–444
97. Squadrone V, Coha M, Cerutti E, Schellino MM, Biolino P, Occella P, Belloni G, Vilianis G, Fiore G, Cavallo F, Ranieri VM (2005) Continuous positive airway pressure for treatment of postoperative hypoxemia: a randomized controlled trial. JAMA 293:589–595
98. Stiller K (2000) Physiotherapy in intensive care. Towards an evidence based practice. Chest 118:1801–1813
99. Stiller K, Jenkins S, Grant R, Geake T, Taylor J, Hall B (1996) Acute lobar atelectasis: a comparisosn of five physiotherapy regimens. Physiother Theory Pract 12:197–209
100. Stiller K, Philips A (2003) Safety aspects of mobilising acutely ill patients. Physiother Theory Pract 19:239–257
101. Stoll C, Schelling G, Goetz AE, Kilger E, Bayer A, Kapfhammer HP, Rothenhausler HB, Kreuzer E, Reichart B, Peter K (2000) Health-related quality of life and post-traumatic stress disorder in patients after cardiac surgery and intensive care treatment. J Thorac Cardiovasc Surg 120:505–512
102. Stoller JK, Mascha EJ, Kester L, Haney D (1998) Randomized controlled trial of physician-directed versus respiratory therapy consult service-directed respiratory care to adult non-ICU inpatients. Am J Respir Crit Care Med 158:1068–1075
103. Thomas DC, Kreizman IJ, Melchiorre P, Ragnarsson KT (2002) Rehabilitation of the patient with chronic critical illness. Crit Care Clin 18:695–715
104. Topp R, Ditmyer M, King K, Doherty K, Hornyak J III (2002) The effect of bed rest and potential of prehabilitation on patients in the intensive care unit. AACN Clin Issues 13:263–276
105. Unoki T, Kawasaki Y, Mizutani T, Fujino Y, Yanagisawa Y, Ishimatsu S, Tamura F, Toyooka H (2005) Effects of expiratory rib-cage compression on oxygenation, ventilation, and airway-secretion removal in patients receiving mechanical ventilation. Respir Care 50:1430–1437
106. Van 't Hul A, Gosselink R, Hollander P, Postmus P, Kwakkel G (2006) Training with inspiratory pressure support in patients with severe COPD. Eur Respir J 27:65–72

107. Walsh D (1991) Nocioceptive pathways – relevance to the physiotherapist. Physiotherapy 77:317–321
108. Wenger NK (1982) Early ambulation: the physiologic basis revisited. Adv Cardio 31:138–141
109. Winkelman C, Higgins PA, Chen YJ, Levine AD (2007) Cytokines in chronically critically ill patients after activity and rest. Biol Res Nurs 8:261–271
110. Wood CJ (1998) Endotracheal suctioning: a literature review. Intensive Crit Care Nurs 14:124–136
111. Yang KL, Tobin MJ (1991) A prospective study of indexes predicting the outcome of trials of weaning from mechanical ventilation. N Engl J Med 234:1445–1450
112. Yohannes AM, Connolly MJ (2003) Early mobilization with walking aids following hospital admission with acute exacerbation of chronic obstructive pulmonary disease. Clin Rehabil 17:465–471
113. Zafiropoulos B, Alison JA, McCarren B (2004) Physiological responses to the early mobilisation of the intubated, ventilated abdominal surgery patient. Aust J Physiother 50:95–100
114. Zanotti E, Felicetti G, Maini M, Fracchia C (2003) Peripheral muscle strength training in bed-bound patients with COPD receiving mechanical ventilation. Effect of electrical stimulation. Chest 124:292–296

R. Gosselink (✉)
Katholieke Universiteit Leuven, Respiratory Rehabilitation, Faculty of Kinesiology and Rehabilitation Sciences,
Tervuursevest 101, 3000 Leuven, Belgium
e-mail: rik.gosselink@uz.kuleuven.ac.be

J. Bott
Surrey Primary Care Trust, Respiratory Care Team,
Chertsey, UK

M. Johnson
Meath and National Children's Hospital, Physiotherapy Department,
Dublin, Ireland

E. Dean
University of British Columbia, School of Rehabilitation Sciences,
Vancouver, Canada

S. Nava
Fondazione S. Maugeri Istituto Scientifico di Pavia, Respiratory Intensive Care Unit, I.R.C.C.S. Pavia, Italy

M. Norrenberg · J. L. Vincent
Erasme Hospital (Free University of Brussels), Department of Intensive Care,
Brussels, Belgium

B. Schönhofer
Klinikum Region Hannover, Krankenhaus Oststadt-Heidehaus, Abteilung Pneumologie und Internistische Intensivmedizin,
Hannover, Germany

K. Stiller
Royal Adelaide Hospital, Physiotherapy Department,
Adelaide, South Australia, Australia

H. van de Leur
Hanze University Groningen, Faculty for Health Studies, School of Physiotherapy,
Groningen, The Netherlands