

# Should we mobilise critically ill patients? A review

Enda D O'Connor and James Walsham

Survivors of critical illness frequently suffer long-term physical and psychological complications.<sup>1,2</sup> Critical illness weakness, a common finding in intensive care patients, contributes greatly to this morbidity.<sup>1,3</sup> More than 70% of patients with sepsis and multiorgan failure and 90% of long-term ICU survivors have electrophysiological evidence of neuromuscular weakness,<sup>4</sup> with clinically significant weakness present in 25% of those who are mechanically ventilated for more than 7 days.<sup>3</sup> A finding of critical illness weakness is associated with longer ICU stay and poor survival.<sup>5</sup> Measures to prevent or ameliorate the condition therefore may improve ICU outcomes and accelerate the process of functional recovery. These measures may also reduce the financial burden of rehabilitation after critical illness, a treatment that does not guarantee restoration of premorbid function.<sup>6</sup>

Aerobic exercise has significant health benefits. Regular physical activity contributes to primary prevention of cardiovascular disease and death, malignancy, psychological illness and cognitive decline.<sup>7-12</sup> However, for most hospital inpatients, exercise therapy does not so much improve aerobic fitness as facilitate rehabilitation after an episode of illness and neuromuscular deconditioning. The process of rehabilitation employs mobilisation therapy: any therapy that promotes passive or active body movements.<sup>13</sup> Specific types of mobilisation therapy are tailored to patient needs, depending on conscious state, physiological status and physical strength.

Although the use of mobilisation therapy in patients with acute illness is not a novel intervention,<sup>14</sup> it has been subject to renewed interest in recent years. This is particularly the case for postoperative and critically ill patient groups.

In view of these changes in attitudes, we reviewed the literature to evaluate the role of mobilisation therapy in patients with acute illness requiring high dependency or intensive care. We searched PubMed (1980 to August 2009) using the MeSH terms "physiotherapy" and "intensive care". Additional keyword search terms, "mobilisation", "mobilization", and "fast-track", were used. In addition, we examined reference lists in recent studies and reviews.

## Complications of prolonged immobility and bed rest

The adverse effects of immobility have been well described in ICU and non-ICU populations. After 1 week of bed rest, healthy volunteers show 10% loss of postural muscle strength.<sup>15</sup> In critical illness, the additional factors of multi-

## ABSTRACT

**Background:** Neuromuscular weakness, a frequent complication of prolonged bed rest and critical illness, is associated with morbidity and mortality. Mobilisation physiotherapy has widespread application in patients hospitalised with non-critical illness.

**Objectives:** We reviewed the literature to evaluate the worldwide availability of mobilisation therapy in intensive care units and the role of mobilisation therapy in patients requiring medical or surgical high dependency or intensive care.

**Methods:** We searched PubMed (1980 to August 2009) using the MeSH terms "physiotherapy" and "intensive care". Additional keyword search terms, "mobilisation", "mobilization", and "fast-track", were used. In addition, we examined reference lists in recent studies and reviews.

**Results:** Routine mobilisation physiotherapy is least likely to be available in ICUs in the United States. Early mobilisation is appropriate for patients with pulmonary thromboembolic disease, community-acquired pneumonia and in elderly hospitalised patients. Although fast-track cardiac and non-cardiac surgery with early ambulation is safe and reduces hospital length of stay, it does not alter postoperative mortality. Up to 25% of patients can be safely mobilised within 72 hours of ICU admission. This therapy may reduce hospital and ICU length of stay, shorten duration of mechanical ventilation, and improve muscle strength and functional independence scores. Pooled data show a non-significant mortality benefit in favour of early mobilisation (odds ratio, 0.77; 95% CI, 0.49–1.21).

**Conclusions:** The data in support of mobilisation therapy for perioperative and critically ill patients, while of a low level of evidence, are substantial. This justifies a paradigm shift in attitudes towards physiotherapy and the prevention of critical illness weakness.

Crit Care Resusc 2009; 11: 290–300

organ failure, mechanical ventilation, drugs (corticosteroids and muscle-paralysing drugs), inflammatory cytokines, nitric oxide and catabolic processes all contribute to the progression of weakness.<sup>4,16</sup> The onset can be rapid; reduction in evoked skeletal muscle force has been noted as early as 24 hours after the onset of sepsis and multiorgan failure.<sup>17</sup> Moreover, the risk of developing critical illness

**Table 1. Range of mobilisation therapies available for patients in the intensive care unit**

Passive	
<b>Total passive</b>	<b>Semi-passive</b>
Limb movements	Standing hoist
Side-to-side turning in bed	
Chair hoist	
Tilt table	
Electrical interferential therapy	
Active	
<b>Active-assisted</b>	<b>Active-independent</b>
In-bed exercises (weights, cycling)	Ambulation
Sitting on edge of bed	
Standing out of bed	
Standing transfer to chair (able to lift at least one upper limb against gravity)	
Assisted ambulation (with walking aid or therapist assistance)	

weakness rises with increasing illness severity.<sup>3,18</sup> The weakness affects both skeletal and diaphragmatic muscles, delaying functional recovery and weaning from positive pressure ventilation.<sup>3</sup>

The adverse effects of bed rest on cardiovascular function, work performance and endurance have been recognised for over 50 years.<sup>19</sup> More recent studies of head-down bed rest (HDBR) in spaceflight subjects have added to this knowledge.<sup>20</sup> After 4 hours of HDBR, altered neurohumoral control of vascular resistance predisposes normal subjects to orthostatic intolerance, abnormal splanchnic autoregulation, reduced stroke volume and hypotension.<sup>20</sup> A similar effect has been seen after critical illness.<sup>16</sup> More prolonged HDBR is associated with a reduction in left ventricular mass and diastolic function, which can be prevented by regular daily exercise.<sup>21</sup> Vascular endothelial dysfunction has also been seen after bed rest.<sup>22</sup>

The supine phenomena of reduced lung volumes, reduced functional residual capacity and unfavourable ventilation–perfusion matching are well-recognised factors contributing to hypoxia, atelectasis and prolonged mechanical ventilation.<sup>16,23</sup> The risk of developing osteopenia, pressure skin defects, thromboembolism, sleep disturbance or joint contractures increases with immobility or reduced weight-bearing.<sup>13,16</sup> Prolonged sedation and confinement to bed are likely to have cognitive and psychiatric implications.<sup>24</sup>

### What is mobilisation therapy?

A recently published consensus document defines mobilisation therapy as

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.<sup>25</sup>

Therapies used to mobilise ICU patients can be passive or active and are summarised in Table 1. Passive joint movements maintain range of movement and muscle length. Passive turning of the ventilated ICU patient facilitates postural lung drainage and can improve ventilation–perfusion matching.<sup>25</sup> Passive tilt-table testing helps restore the cardiovascular response to an orthostatic challenge, improves functional residual capacity and permits safe lower limb weight-bearing.<sup>26</sup> Chair hoisting enables weak or uncoordinated patients to enjoy the respiratory benefits of sitting out of bed. Interferential therapy entails low-frequency electrical stimulation of motor nerves or muscles and may be used as a substitute for active muscle contraction in sedated, ventilated patients.<sup>27</sup> Its role in the rehabilitation of ICU patients is not clear.<sup>28</sup>

Active-assisted treatments enable patients to undergo therapy they are too weak to perform independently. These help strengthen weak muscles, improve joint range of movement and restore balance and coordination. Active-independent exercises are appropriate for patients preparing for hospital discharge and have limited application in HDU/ICU practice.

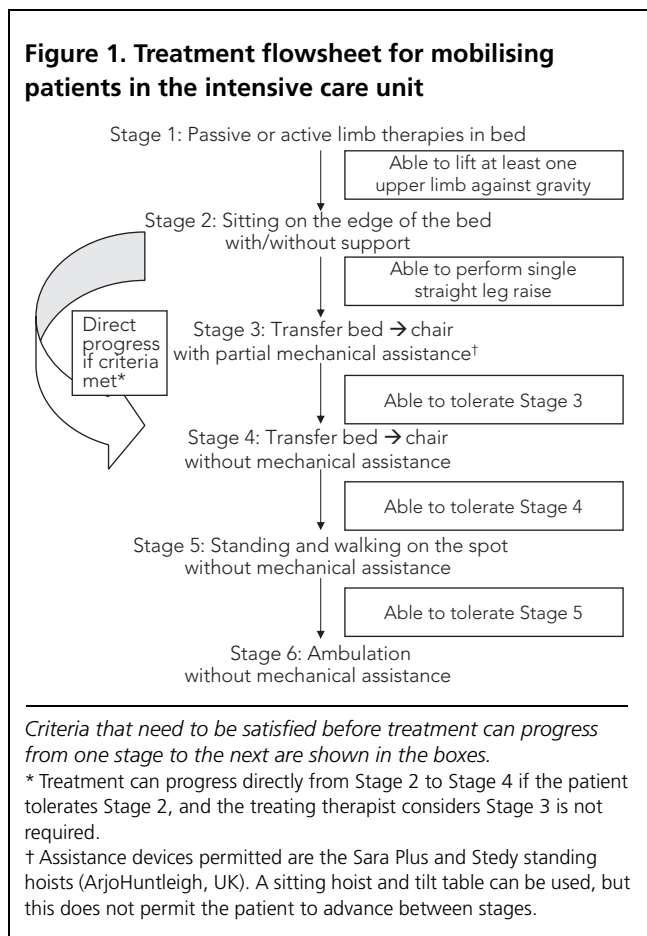
Mobilisation protocols in published trials simplify these treatments into four to six steps of increasing intensity. An example taken from a study underway in the United Kingdom (with author EOC as principal investigator) is shown in Figure 1.

### Mobilisation practices in the ICU

Several surveys of international ICU physiotherapy practice have been published.<sup>29–33</sup> While routine mobilisation therapy was readily available in ICUs in Europe, Australia and Canada, US respondents reported lower utilisation, especially for medical ICU patients. This in part explains the study design of two recent US trials, where zero and 12.5% of control group patients, respectively, received mobilisation therapy.<sup>34,35</sup> Lower intensity therapies (sitting on the bed edge, standing, bed-to-chair transfer) were more commonly employed in mechanically ventilated patients; only 56% and 55% of Canadian and Australian respondents, respectively, indicated they would “ambulate” these patients away from the bed.<sup>29,30</sup> Australian respondents were more likely to stand ventilated patients than their UK counterparts (80% v 59%).<sup>30,31</sup>

There is also a marked variation in the prescription of mobilisation therapies worldwide. In Australia, 94% of physiotherapists routinely prescribe mobilisation in the ICU.<sup>30</sup> This contrasts with the US, where 89% of physiother-

**Figure 1. Treatment flowsheet for mobilising patients in the intensive care unit**



apists require a physician referral before commencing therapy.<sup>33</sup> Comparative Canadian data are not available, but the influence of the physician on rates of ambulation is considerable.<sup>29</sup>

Although physiotherapists are the main providers of physical therapy, some studies have used a mobility team, comprising a physiotherapist, critical care nurse and nurse assistant.<sup>34-36</sup> US teams are more likely to include a respiratory therapist for patients receiving mechanical ventilation.<sup>36</sup> Some authors advocate a greater nursing role in patient mobilisation,<sup>37</sup> and this model, where nurses take responsibility for passive therapies, may represent more efficient utilisation of resources.

### Mobilisation of medical HDU patients

The value of early in-hospital mobilisation has been evaluated in patients with acute medical illness. Some of these studies are relevant to HDU and ICU practice.

### Deep vein thrombosis and pulmonary embolism

The need for bed rest during early management of acute deep vein thrombosis (DVT) and pulmonary embolism (PE)

has been evaluated in a meta-analysis.<sup>38</sup> In this analysis, five prospective controlled trials in over 3000 patients with DVT or PE compared early mobilisation (Days 0, 1 or 2 of admission) to delayed mobilisation (Days 3–9 of admission). Early mobilisation was not associated with an increased risk of clot progression or death in any individual study or the pooled analysis. Indeed, the treatment group tended to have less clot progression and a lower risk of all-cause death. A further prospective trial of 219 patients with a new DVT randomly allocated to 5 days hospital bed rest or home care with early ambulation found no significant difference in incidence of new PE.<sup>39</sup>

### Stroke

AVERT, the only randomised control trial of early mobilisation after acute stroke, has been published as a phase 2 trial<sup>40</sup> and an economic analysis.<sup>41</sup> This Australian trial randomly allocated 71 patients to “very early mobilisation” (upright and out of bed twice a day within 24 hours if possible) or to standard physical therapy. As compared with the control group, patients in the treatment group were mobilised earlier and had a significantly longer total mobilisation time, without any increase in adverse events. Two phase 3 trials of early mobilisation in stroke patients are currently being conducted.<sup>42,43</sup>

### Elderly patients with general acute medical illness

Patients older than 65 years occupy almost half of all acute medical and surgical beds in the US.<sup>44</sup> Further, current evidence supports a trend towards more elderly patients being admitted to ICUs and HDUs.<sup>45</sup> Therefore, efforts to improve mobility, with consequent earlier HDU or hospital discharge, could have enormous medicoeconomic benefits. A recent Cochrane analysis of nine controlled trials evaluating exercise regimens for patients over 65 years with acute medical illness has been published.<sup>44</sup> In addition to reducing health care utilisation, multidisciplinary care that included exercise increased the likelihood of patients going home at hospital discharge. Study treatments had no effect on mortality, rate of ICU admission, risk of fall or rate of hospital readmission after discharge.

### Community-acquired pneumonia

In 2003, Mundy et al reported on a mobilisation trial in 458 inpatients with community-acquired pneumonia.<sup>46</sup> Patients randomly allocated to a more liberal mobilisation strategy (out of bed within the first 24 hours) spent 1.1 days less in hospital than control patients. However, therapy was most beneficial for patients with less severe disease (according to the Pneumonia Severity Index) and of least benefit for those with severe disease. Hence, the results have limited applicability to HDU practice.

**Table 2. Studies evaluating early mobilisation in the postoperative period as part of a fast-track protocol in non-cardiac surgical patients\***

Study	No. of patients	Study design	Surgery performed	Fast-track interventions <sup>†</sup>	Significant outcome (of intervention group if control group present)
<b>Vascular</b>					
Podore 1999 <sup>47</sup>	50	Case series	Elective open infrarenal AAA repair	EM, EF	No control, 92% of patients discharged on postoperative Day 5
Mukherjee 2003 <sup>48</sup>	30	Case series	Elective open AAA repair	EM, EF, EA	No control, mean hospital LOS, 3 days
Murphy 2007 <sup>49</sup>	60	Controlled cohort study	Elective open aortic surgery	EM, EF, EA, ETE	Shorter hospital LOS
Muehling 2008 <sup>50</sup>	82	PRCT	Elective open infrarenal AAA repair	EM, EF, EA	Reduced DOV, ICU LOS and postoperative complications
Muehling 2009 <sup>51</sup>	101	PRCT	Elective open infrarenal AAA repair	EM, EF, EA	Reduced postoperative complications, lower mortality
<b>Upper GIT</b>					
Brodner 1998 <sup>52</sup>	91	Controlled cohort study	Abdominothoracic oesophagectomy	EM, EA, ETE	Reduced DOV and ICU LOS
Neal 2003 <sup>53</sup>	56	Case series	Oesophagectomy	EM, EF, EA, ETE, FR	No control, median hospital LOS, 10 days
Cerfolio 2004 <sup>54</sup>	90	Case series	Oesophagectomy (Ivor Lewis)	EM, EF, EA	No control, median hospital LOS, 7 days
Low 2007 <sup>55</sup>	340	Case series	Abdominothoracic oesophagectomy	EM, EF, EA, ETE, FR	No control, median hospital LOS, 11.5 days
Jiang 2009 <sup>56</sup>	114	Case series	Abdominothoracic oesophagectomy	EM, EF, FR	No control, median hospital LOS, 7 days
<b>Pancreaticobiliary</b>					
Berberat 2007 <sup>57</sup>	255	Case series	Pancreatic resection	EM, EF	No control, median hospital LOS, 10 days
Balzano 2008 <sup>58</sup>	504	Retrospective cohort study	Pancreaticoduodenectomy	EM, EF	Shorter hospital LOS, lower incidence of delayed gastric emptying
<b>Hepatic</b>					
Van Dam 2008 <sup>59</sup>	161	Controlled cohort study	Liver resection	EM, EF, EA	Shorter median hospital LOS
<b>Thoracic</b>					
Cerfolio 2001 <sup>60</sup>	500	Case series	Pneumonectomy, lobectomy or wedge resection	EM, EA, ETE	No control, median hospital LOS, 4-5 days
Muehling 2008 <sup>61</sup>	58	PRCT	Lung resection	EM, EF, EA	Fewer postoperative respiratory complications
<b>Colorectal</b>					
Bradshaw 1998 <sup>62</sup>	72	Case-control study	Colonic resection	EM, EF, EA	Shorter hospital LOS, earlier return of bowel function
Delaney 2001 <sup>63</sup>	60	Case-control study	Major abdominopelvic colorectal surgery	EM, EF	Shorter hospital LOS
Delaney 2003 <sup>64</sup>	64	PRCT	Laparotomy with intestinal resection	EM, EF	Shorter hospital LOS
Raue 2004 <sup>65</sup>	52	Prospective cohort study	Laparoscopic sigmoidectomy	EM, EF, EA	Shorter hospital and ICU LOS, earlier return of bowel function
Kariv 2007 <sup>66</sup>	200	Case-control study	Ileal pouch with anal anastomosis	EM, EF	Shorter hospital LOS, lower direct health costs
Khoo 2007 <sup>67</sup>	70	PRCT	Elective colonic tumour resection	EM, EF, EA, FR	Shorter hospital LOS
Maessen 2007 <sup>68</sup>	425	Case series	Elective open colorectal resection	EM, EF, EA, FR	No control, median hospital LOS, 5 days
Wichmann 2007 <sup>69</sup>	40	Prospective cohort trial	Elective open colorectal surgery	EM, EF, EA	Shorter hospital LOS, earlier return of bowel function, better indices of cellular immunity
Muller 2009 <sup>70</sup>	156	PRCT	Elective open colonic surgery	EM, EF, EA, FR	Shorter hospital LOS, fewer postoperative complications

AAA=abdominal aortic aneurysm. LOS=length of stay. DOV=duration of ventilation. GIT=gastrointestinal. PRCT=prospective randomised controlled trial.

\* Studies were chosen to reflect patients more likely to be admitted to a high dependency or intensive care unit. For studies with control groups, intervention group outcomes significantly different from those of the control group are shown.

† Postoperative fast-track interventions: EM=early mobilisation; EF=early feeding; EA=early ambulation; ETE=early tracheal extubation; and FR=fluid restriction.

**Table 3. Studies evaluating early mobilisation in the postoperative period as part of a fast-track protocol in cardiac surgical patients\***

Study	Study design	No. of patients	Patient description	Postoperative treatment in fast-track group <sup>†</sup>	Day of mobilisation	Outcomes
Krohn 1990 <sup>73</sup>	Case series	240	Cardiac surgical	STER, ETE, EM, FR, EF, exercise test on PO Day 3	Day of operation	76% discharged by PO Day 5
Engelmann 1994 <sup>74</sup>	Pre- and post-intervention cohort study	562	Post-CABG	STER, ETE, EM, FR	PO Day 1	Shorter DOV, ICU LOS
Ott (1)1997 <sup>75</sup>	Case series	104	Post-CABG	STER, ETE, EM, FR	PO Day 2	71% discharged by PO Day 3
Quigley 1997 <sup>76</sup>	Pre- and post-intervention cohort study	532	Post-CABG	ETE, EM, FR	PO Day 1	Shorter hospital and ICU LOS
Ott (2)1997 <sup>77</sup>	Retrospective cohort study	317	Post-CABG	STER, ETE, EM, FR	PO Day 1	See text
Lee 1999 <sup>78</sup>	Case series	487	Post-CABG	ETE, EM	PO Day 2	See text
Walji 1999 <sup>79</sup>	Case series	258	Post-CABG and elective valve surgery	EM	PO Day 1	56% discharged by PO Day 4
Ovrum 2000 <sup>80</sup>	Case series	5658	Post-CABG	ETE, EM	PO Day 1	82.5% fit for hospital discharge by PO Day 4
Loubani 2000 <sup>81</sup>	Prospective cohort study	198	Post-CABG	EM	PO Day 2	Shorter hospital LOS
Moon 2001 <sup>82</sup>	Prospective cohort study	617	Post-CABG	ETE, EM, EF	Day of operation	Shorter DOV, hospital LOS
Casula 2003 <sup>83</sup>	Case series	392	Post-CABG	ETE, EM	Not reported	60% discharged by PO Day 5

CABG = coronary artery bypass grafting. PO = postoperative. LOS = length of stay. DOV = duration of ventilation.

\* For studies with control groups, intervention group outcomes significantly different from those of the control group are shown.

† Postoperative fast-track interventions: STER = steroids; ETE = early tracheal extubation; EM = early mobilisation; FR = fluid restriction; EF = early feeding.

## Mobilisation of surgical patients

### General and thoracic surgery

A large body of literature has focused on the role of early mobilisation of postoperative surgical patients. This in part stems from studies of perioperative cardiac surgical care, but also from attempts to optimise health care resources by minimising postoperative hospital length of stay. The term “fast-track recovery” has been coined to describe multimodal strategies directed towards prompt recuperation from surgery and comprises some, but not necessarily all, of the following: appropriate anaesthetic technique, early tracheal extubation, effective analgesia, fluid restriction, early nutrition and early ambulation.

Most surgical studies evaluating early mobilisation did so in the setting of a fast-track protocol. These studies and their results are summarised in Table 2.<sup>47-70</sup> These studies were selected because they specified the use of early postoperative ambulation in the intervention group and because they represented patients who, depending on local

admission policies, might qualify for HDU or ICU admission. Although there was variation in reported endpoints, use of a fast-track postoperative strategy across a wide range of non-cardiac surgical specialties consistently shortened hospital length of stay. Multimodal management may also reduce surgical complications, expedite return of gastrointestinal function and shorten duration of ICU stay. To date, there is no evidence that early postoperative mobilisation decreases mortality.

### Cardiac surgery

Although many studies have evaluated fast-track recovery protocols and late rehabilitation after cardiac surgery, none has solely evaluated the effects of early ambulation in this patient group.

Recent fast-track strategies were comprehensively summarised in a Cochrane review<sup>71</sup> and a recent meta-analysis by van Mastrigt and colleagues.<sup>72</sup> Most studies included in these analyses evaluated treatments other than mobilisation (early versus late extubation, high-dose versus low-dose anaesthe-

sia, or intraoperative normothermia versus hypothermia) and are therefore beyond the scope of this review.

Several trials of fast-track cardiac surgery with early postoperative mobilisation have been published. In most, patients underwent elective coronary artery bypass graft surgery and were mobilised on the day of, or day after, surgery (see Table 3<sup>73-83</sup>). Although most lacked control groups, the cohort studies<sup>74,76,81,82</sup> all demonstrated a significant reduction in ICU and/or hospital length of stay with fast-track care. Moreover, most patients enrolled in non-controlled studies were discharged from hospital by the fifth postoperative day. Although younger patients had a faster postoperative recovery than elderly patients, fast-track ambulatory care still had a role to play in the management of postoperative patients older than 65 years.<sup>77,78</sup>

### Mobilisation of intubated patients in the ICU

It is almost 25 years since the first clinical experience of rehabilitation in intubated, ventilated patients was published.<sup>84</sup> Since then, ICU mobilisation protocols have developed slowly, and have received renewed attention only in the past decade. Studies evaluating the mobilisation of intensive care or high dependency patients are shown in Table 4; several points can be made about these trials.<sup>6,34-36,84-91</sup>

Firstly, over half the studies were reported in the past 18 months. Secondly, the time between ICU admission and patient enrolment has followed an interesting trend. Earlier studies enrolled patients late in their ICU stay: 10–108 days after ICU admission (or after initiation of positive pressure ventilation).<sup>35,84,86,87</sup> In contrast, recent studies<sup>34,36,91</sup> used early enrolment to mitigate the early adverse neuromuscular changes of critical illness.<sup>92</sup> This approach appears feasible — in one study, 23% of all ICU patients were eligible for a trial of mobilisation within 48 hours of intubation.<sup>36</sup>

Do the data support the use of a protocol emphasising early and aggressive mobilisation in the ICU? Although evidence levels are not optimal (only four small randomised controlled trials have undergone peer review<sup>6,34,85,91</sup>), some conclusions can be drawn. With appropriate patient selection, early mobilisation appears to be both feasible and safe.<sup>35,36</sup> Mobilisation strategies are applicable to medical, surgical and trauma ICU patients.<sup>35,89</sup> Crucially, neuromuscular function may improve simply by giving patients the opportunity to increase their level of activity. Transferring patients to an ICU where mobilisation is a priority can triple the number ambulating within 48 hours.<sup>89</sup> Mobilisation therapy can, in turn, have added benefits; it can shorten time to ambulation,<sup>34,36</sup> and ICU and hospital length of stay,<sup>36,90</sup> reduce duration of positive pressure ventilation,<sup>34,87,90</sup>

improve respiratory and limb muscle strength,<sup>6,87,91</sup> and improve functional independence.<sup>34,86,87,91</sup> Moreover, implementation of an ICU mobilisation protocol can be cost-neutral.<sup>36</sup>

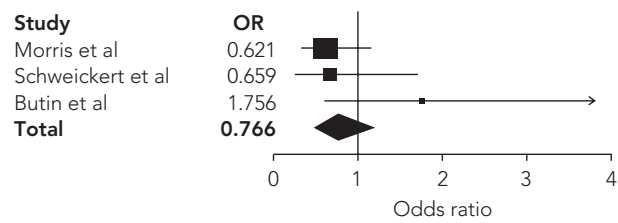
To date, no individual study has demonstrated a significant mortality benefit after early mobilisation in the ICU. The pooled in-hospital mortality data from the three early mobilisation studies that reported mortality as an endpoint are shown in Figure 2.<sup>34,36,91</sup> In-hospital death occurred in 40 of 259 intervention group patients (15.4%) and 51 of 265 control group patients (19.2%) — an odds ratio of death with mobilisation therapy of 0.77 (95% confidence interval, 0.49–1.2). The three studies were heterogeneous, although we did not attempt to quantify this heterogeneity. All were prospective: two randomised controlled,<sup>34,91</sup> and one cohort study.<sup>36</sup> Intervention and control group treatments differed: one study used a bicycle ergometer in addition to standard physiotherapy,<sup>91</sup> and another compared mobilisation plus occupational therapy to standard treatment.<sup>34</sup> As described above, control groups in the US studies were less likely to receive any mobilisation therapy, which may underpin the positive study results.<sup>34,91</sup>

### Patient safety during mobilisation

The crucial factors influencing patient safety during mobilisation are appropriate patient selection, adequate monitoring, appropriate indications for termination of treatment and an audit process to review practice.

Patient selection remains critical to the success or failure of an early mobilisation strategy. A trial of mobilisation is usually possible in 10%–20% of intubated ICU inpatients.<sup>35,36</sup> Stiller et al<sup>93</sup> published guidelines for patient assessment before mobilisation, which focused on cardiovascular and respiratory reserve, environmental factors, and

**Figure 2. Forest plot of odds ratios (ORs) for in-hospital mortality with early mobilisation of intensive care patients**



OR < 1 favours intervention (early mobilisation). Boxes represent ORs for individual studies, horizontal lines represent 95% confidence intervals, and the diamond symbol represents the pooled OR for the three studies (Morris et al,<sup>36</sup> Schweickert et al,<sup>34</sup> and Butin et al<sup>91</sup>).

**Table 4. Published studies of rehabilitation therapy in patients requiring positive-pressure ventilation or intensive care\***

Study	No.	Study design	Patient characteristics	Patient enrolment	Treatment delivered
Make 1984 <sup>84</sup>	16	Case series	Ventilator-dependent COPD (10), restrictive disease (6)	Mean, 108 days after hospital admission	5 stages: stabilisation, evaluation, rehabilitation planning, rehabilitation training and discharge
Nava 1998 <sup>6</sup>	80	PRCT	COPD, 48% IPPV, 29% NIPPV	3–5 days after admission to respiratory ICU	4 stages: pre-walking rehabilitation, walking training, bicycle/stair training and treadmill walking
Porta 2005 <sup>85</sup>	66	PRCT	COPD, 70%–78%, weaned from (N)IPPV for > 48 h	> 48 h after liberation from (N)IPPV	15 × 20-minute sessions of upper limb cycling using ergometer plus standard physiotherapy
Martin 2005 <sup>86</sup>	49	Retrospective case series	Acute respiratory illness with ≥ 2 failed weaning attempts	18.1 ± 7 days after start of PPV	4 stages: passive/active limb training, pedal exerciser, standing/walking training and stair exercise
Chiang 2006 <sup>87</sup>	39	PRCT	Medical or surgical patients with prolonged mechanical ventilation	46–52 days after start of PPV	5 stages: active ROM exercises, ROM with weights, bed to chair transfers, standing training and walking
Bailey 2007 <sup>35</sup>	103	Case series	Medical or surgical patients with respiratory failure	10.5 ± 9.9 days after ICU admission	3 stages: sitting on bed edge, bed to chair transfer and walking
McWilliams 2008 <sup>88</sup>	65	Case series	ICU patients in a large teaching hospital	Not reported	7 stage protocol from passive limb movements to independent ambulation
Thomsen 2008 <sup>89</sup>	104	Pre- and post-cohort study	Medical, surgical or trauma patients with respiratory failure	10.3 ± 7.5 days after ICU admission	3 stages: sitting on bed edge, bed to chair transfer and walking
Morris 2008 <sup>36</sup>	330	Prospective cohort study	Medical ICU patients with respiratory failure	Within 48 h of intubation	4 stages: passive movements, sitting in bed/resistance limb training, sitting on bed edge and bed to chair transfer
Schwieckert 2009 <sup>34</sup>	104	PRCT	General ICU patients, 73% with medical critical illness	Within 72 h of commencing mechanical ventilation	6 stages: passive ROM, active ROM, sitting upright, ADL training, bed to chair transfers and pre-gait/walking training
Malkoc 2009 <sup>90</sup>	510	Cohort study: prospective intervention, retrospective control group	Medical ICU patients	Not reported	Mobilisation therapy and chest physiotherapy
Burtin 2009 <sup>91</sup>	90	PRCT	80% postoperative patients	Day 5 in ICU	Both groups received mobilisation therapy, intervention group had additional therapy with cycle ergometer

COPD = chronic obstructive pulmonary disease. PRCT = prospective randomised controlled trial. IPPV = intermittent positive pressure ventilation. NIPPV = non-invasive positive pressure ventilation. ROM = range of motion. ADL = activities of daily living.

a suitable mode and intensity of mobilisation. These guidelines are cumbersome and were validated in predominantly non-intubated patients.

A simple selection strategy reported by Bailey et al<sup>35</sup> has also been shown to be safe. They selected patients who were able to respond to verbal stimuli, had a fraction of inspired oxygen (FiO<sub>2</sub>) ≤ 0.60 and a positive end-expiratory pressure ≤ 10 cmH<sub>2</sub>O, did not have orthostatic hypotension and were not receiving a catecholamine infusion. Adverse events occurred in fewer than 1% of all episodes of mobilisation therapy. None of these events related to accidental device dislodgement.

Australian investigators recently published a pilot study of an ICU exercise program whereby patients were safely mobilised with an FiO<sub>2</sub> up to 0.5, positive end-expiratory pressure of 5 cmH<sub>2</sub>O, and assisted ventilation (pressure support ventilation).<sup>94</sup>

While indications for terminating an episode of mobilisation therapy seem obvious, several guidelines have been published. In a phase 2 study, treatment was stopped if patients developed any of the following: fall to the knees, any device dislodgement, systolic blood pressure > 200 mmHg or < 90 mmHg, oxygen saturation < 80% and extubation.<sup>35</sup> Other study criteria are subjective and more

**Table 4. Continued**

Study	Significant outcome (of intervention if control present)*	Treatment duration	Other study comments
Make 1984 <sup>84</sup>	12 patients discharged home	Until hospital discharge	
Nava 1998 <sup>6</sup>	Longer 6MWD, higher maximum inspiratory pressure, better VAS score for dyspnoea	Until ICU discharge	Intervention group had longer ICU LOS
Porta 2005 <sup>85</sup>	Better endurance in upper limb ergometer test	Until 15 scheduled sessions completed or patient dropout	Patients were no longer on PPV
Martin 2005 <sup>86</sup>	30% patients weaned in < 7 days, significant improvement in motor strength and FIM score	Until ICU discharge	No control group, patients had no physiotherapy before enrolment
Chiang 2006 <sup>87</sup>	Significant increase in FIM score and limb strength, longer ventilator-free time	6 weeks	Patients had no physiotherapy before enrolment
Bailey 2007 <sup>35</sup>	Early mobilisation feasible, median distance walked at ICU discharge, 200 feet	Until ICU discharge	No control group
McWilliams 2008 <sup>88</sup>	Patients mobilised by ICU Day 5 had shorter ICU stay than those mobilised later	Not reported	No control group
Thomsen 2008 <sup>89</sup>	Increase in patients standing (21% to 32%) and ambulating (11% to 28%)	Until ICU discharge	
Morris 2008 <sup>36</sup>	Shorter ICU and hospital LOS, earlier out of bed (5.0 v 11.3 days), trend towards lower hospital mortality	Until patient transferred to non-ICU bed	Only 23% of total ICU admissions eligible for enrolment, only 12.5% of control patients began physiotherapy in ICU
Schwieckert 2009 <sup>34</sup>	Improved FIM score, longer independent walking distance, reduced duration of ventilation, lower incidence of delirium	Throughout hospital stay	< 10% of screened patients enrolled, daily therapy paired with interruption of sedation and daily occupational therapy, control group received no therapy
Malkoc 2009 <sup>90</sup>	Reduced duration of mechanical ventilation and ICU LOS	Not reported	Mobilisation as part of chest and rehabilitation physiotherapy program, control group had no physiotherapy
Burtin 2009 <sup>91</sup>	Longer 6MWD, better quality of life score at hospital discharge	Until ICU discharge	Limited information about other mobilisation therapy delivered

6MWD = 6 minute walking distance. VAS = visual analogue scale. LOS = length of stay.

\* For studies with control groups, intervention group outcomes significantly different from those of the control group are quoted.

liberal,<sup>36</sup> allowing individual ICUs to adopt guidelines best suited to local practice.

**Conclusions**

Early mobilisation therapy for patients with acute illness, if tolerated, appears to have a positive effect on rate of recovery. The evidence in support of fast-track protocols, which include early ambulation, in the postoperative phase after cardiac and non-cardiac surgery suggests that these therapies should be widely implemented. The value of mobilisation therapy in patients with medical morbidity is uncertain, and the current literature has limited application to ICU or HDU practice. In general intensive care and high

dependency wards, up to a quarter of all patients can safely undergo mobilisation therapy. Patients undergoing positive pressure ventilation with either a tracheostomy or endotracheal tube may be suitable for this therapy.

While largely based on data from US models of critical care and physiotherapy delivery, current cohort and randomised studies justify the development of early mobilisation protocols in intensive care practice, with the expectation of reducing critical illness morbidity.

Further research should be aimed at better defining the population most likely to benefit from mobilisation therapy, using clinical, biomarker or electrophysiological indices. Ultimately, we hope to be able to define the optimal timing



of mobilisation intervention and to further our understanding of individual patient benefits. This might allow us to prescribe a “dose” and “frequency” of therapy to suit individual patients’ needs, analogous to the standard method for prescribing drugs.

**Author details**

Enda D O’Connor, Specialist Registrar in General Internal Medicine<sup>1</sup>

James Walsham, Consultant in Intensive Care Medicine<sup>2</sup>

1 St Columcille’s Hospital, Loughlinstown, County Dublin, Ireland.

2 Princess Alexandra Hospital, Brisbane, QLD.

Correspondence: endamed@yahoo.com.au

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