Early mobility in ICU

Introduction

The number of critically ill individuals, complexity of illness, and cost of care continue to increase with time (Bauman & Hyzy 2012). Intensive care unit (ICU) patients frequently have extreme derangement of physiological function and as such there is focus on aggressive life support, continuous monitoring and treatment of acute organ failure (Kress 2009). In the midst of providing this care, ICU management of the critically ill patient has traditionally involved supine or semi-recumbent bed rest, mechanical ventilation, analgesia and sedation with little attention towards longer term outcomes and in particular neuromuscular function.

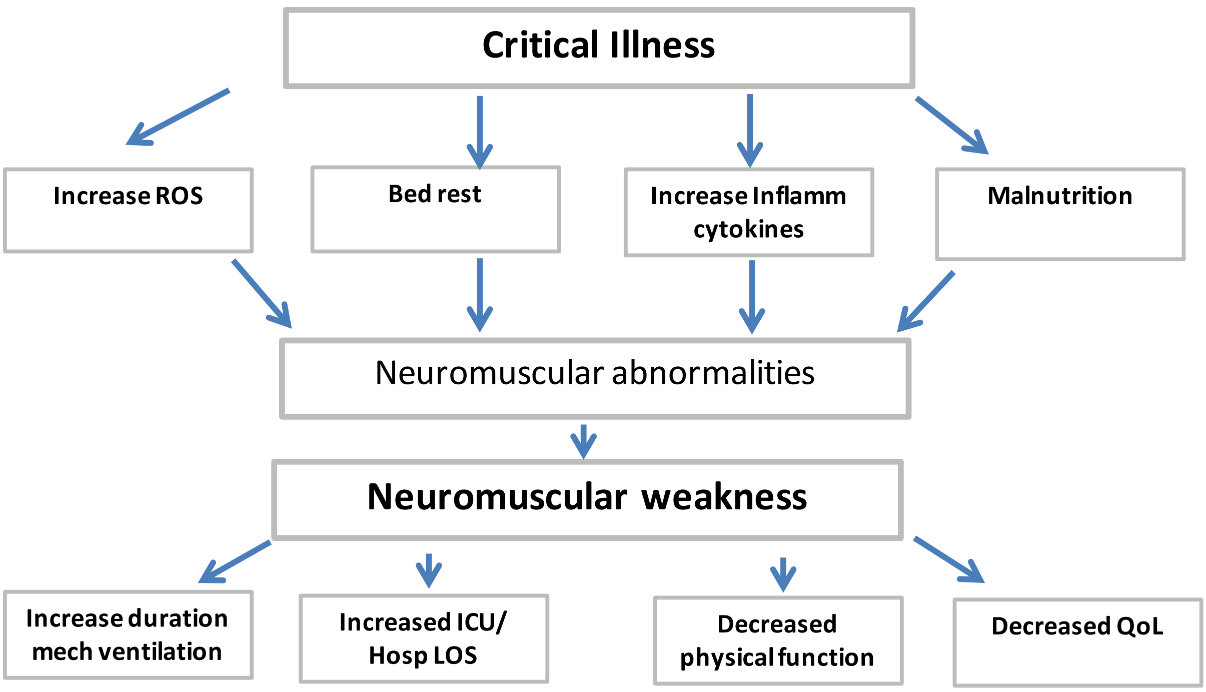
Bed rest in ICU is not benign (Truong et al 2009). Within less than 24 hours many body systems are affected by interrelated pathophysiological changes associated with immobility and critical illness. The most common of these are associated with the systems of respiration (e.g. atelectasis and delayed weaning from mechanical ventilation [De Jonghe et al 2007].), cardiovascular system (e.g. postural hypotension, cardiac muscle atrophy), skin (e.g. pressure injuries), renal (e.g. calculi & nephritis), gastrointestinal (constipation and faecal impaction), metabolic (e.g. glucose intolerance & negative nitrogen balance indicative of catabolism), musculoskeletal (e.g. osteoporosis, muscle atrophy) and neurological (depression, delirium and psychosis) (Goldhill 2007, Truong et al 2009).

This article will discuss the epidemiology and the mechanisms involved in ICU associated neuromuscular weakness, detail the outcomes clinical research that has been undertaken and review the literature describing the approaches and challenges that have been used to address this condition.

Pathophysiology and epidemiology

Bed rest has been identified as being associated with significant muscle loss. In a study of healthy older adults subjected to bed rest for 10 days and receiving a recommended dietary protein diet, it was found that there were significant decreases in muscle protein synthesis, whole lean body mass, lower extremity lean mass and strength (Kortebein et al 2007). Although these results cannot be directly extrapolated to critically ill patients, these findings are suggestive that additional physiological stress and disease processes, present in all critically ill patients, will result in even more loss of muscle size and function.

In healthy subjects, muscle catabolism is balanced by anabolism; it is this balance that is frequently altered in critical illness but may also be influenced synergistically by factors including age, immobility, inflammation, feeding, insulin and drugs (Puthucheary et al 2010). The presence of inflammatory disease states results in accelerated proteolysis and an additional problem is that there may also be functional denervation related to a decrease in frequency and intensity of nerve impulses to the muscle membrane (Morris & Herridge 2007, Puthucheary et al 2010). It is clear that the mechanisms by which critical illness leads to muscle weakness are complex and involve several inter-related processes both local and systemic (Truong et al 2009). These are summarised in the diagram below:



From Truong et al (2009)

ROS - reactive oxygen species which trigger cellular damage and increase the inflammatory state

LOS – length of stay

QoL – quality of life

Herridge et al (2003) identified that in a study of 109 long stay (median 25 days) ICU patients with acute respiratory distress syndrome (ARDS) being cared for in a traditional ICU approach, patients lost on average 18% of their baseline body weight by the time they were discharged from the ICU. Muscle weakness and wasting were prominent. After 1 year, only half of the cohort had been able to return to work. It is important to realise that at the time of onset of ARDS, patient median age was just 44 years, 83% had no or only one co-morbid factor and 83% were working full time (Herridge et al 2011). In a prospective longitudinal study of this same patient group (Herridge et al 2011), although pulmonary function had returned to normal, exercise limitation, physical and psychological problems alongside decreased quality of life and increased healthcare costs were identified as still persisting after 5 years by the patients themselves and also when compared to age and sex matched healthy controls.

Physical therapy has been part of standard ICU care for many years but has focussed on patient positioning, passive and active range of motion exercises; generally this has occurred late in the patient's ICU stay (Hopkins 2010). Some of these interventions such as semi-recumbent, side to side and prone positioning can offer improved physiological parameters for some patients. However, ultimately, survival rates have not changed or changed only to a small degree (Zhu et al 2009). Schweickert et al (2009), established that in the standard care of intubated ICU patients (unless they had neuromuscular disease), no patient would routinely receive physical or occupational therapy programmes of care (ad hoc therapy may have been given) if they received mechanical ventilation for less than 2 weeks and that this finding was typical amongst most ICUs.

Early initiation of mobility in ICU patients has been shown to improve physiological and psychological parameters both in the short term and long term. In addition to improved strength, exercise can decrease oxidative stress, shifting the patient from a pro-inflammatory state to one that can assist in muscle preservation and protection (Truong et al 2009). Qualitative work demonstrates positive outcomes from both patients and family members who have experienced early mobilisation (Needham 2008, Winkelman et al 2012) and the deleterious outcomes from those that have not (Herridge et al 2011). In recent years there has been increased attention paid to initiating early activity and mobility programmes to prevent or mitigate the weakness and physical morbidity associated with ICU care (Truong et al 2009, Hopkins 2010).

Studies demonstrating positive outcomes where early mobility was instigated

In one of the first studies undertaken looking at the effects of early mobility in ICU patients, Bailey et al (2007) assessed safety and feasibility of early activity in 103 consecutive patients that had received mechanical ventilation for more than 4 days. Activities included progressing from sitting on the bed edge, sitting on the chair and then ambulating. Adverse events were low at <1% and 69% were able to ambulate > 100 feet at ICU discharge. As there was no control group, it was not possible to make any judgement about hospital discharge or long term outcomes but the authors concluded how early activity is a candidate for preventing or treating neuromuscular complications of critical illness.

In a large prospective cohort study, Morris et al (2008) compared 165 ICU medical patients receiving "standard care" vs. another group of 165 patients where mobility was initiated within 48 hours of ICU admission by a dedicated mobility team. The mobility protocol comprised of a progressive series of 4 levels of activity dependent upon the patient's ability and level of illness. The first exercises were passive and performed on an unconscious patient, level II involved active assistive and active resistance exercise. Levels III and IV were increasingly focussed on functional activities such as transfers and ambulation. There was a significant difference between the usual care and protocol groups for both ICU and hospital length of stay (ICU LOS: 6.9 days usual care vs. 5.5 days protocol group; hospital LOS usual care 14.5 days, 11.2 days protocol group). Cost of care was also identified between the 2 groups with mean usual care costs being $44,302 per patient and mobility protocol patients being $41,142 per patient. These costs were inclusive of the mobility team's salaries.

Using a RCT design and 90 patients with an expected ICU stay of >7 days, Burtin et al (2009) investigated whether daily exercise using a bedside bicycle ergometer (patient was supine or semi upright in bed and "cycled") for 20 minutes was safe and effective in prevention or attenuation of exercise capacity, functional status and quadriceps force. Eighty-four percent of subjects were ventilated and the remaining had recently been weaned from ventilation.

No adverse events occurred. Mortality was similar in both groups at hospital discharge but 6 minute walking distance, quadriceps force and the subjective feeling of well-being were significantly better in the treatment group. More patients in the control group (17%) were referred to a rehabilitation setting on discharge rather than home compared to the intervention group (10%). It was concluded that early exercise enhances recovery in ICU patients.

Schweickert et al (2009) undertook a randomised controlled trial in 2 US based ICUs assessing efficacy of combining daily interruption of sedation with physical and occupational therapy on patients receiving mechanical ventilation in ICU. There was random assignment of 104 patients who had been on mechanical ventilation for less than 72 hrs to either early exercise and mobilisation during sedation interruption or daily cessation of sedation only alongside standard passive exercise. Interventions consisted of passive moving through to active exercise including activities of daily living (ADLs), sitting, gait training and standing/ transfers. The primary endpoint was patient independent functional status at hospital discharge (undertaking at least 6 ADLs). There was a statistically significant increase in the number of patients having independent functional status at end in intervention (59%) vs. control (35%). Serious adverse events related to mobilisation were uncommon and the mean duration of ICU acquired delirium was half as long in patients in the intervention group as it was in the control group. Despite the positive outcomes, length of stay both in the hospital and ICU did not differ between the 2 groups.

In an observational study over a 5 month period to assess for feasibility and effects of early mobility, 20 consecutive patients were evaluated after a median stay of 5 days in the ICU (Bourdin et al 2010). Early mobility was already part of standard care in this ICU and was performed by physiotherapists with a median of 2 mobility sessions per day. Contraindications to mobility interventions were present in 43% of possible times when it could have occurred; the most common of these were sedation (15%), shock (11%) and renal support (9%). Chair sitting was the most frequent intervention followed by tilting up with arms unsupported, walking and tilting up with arms supported. Tilting up was associated with significant increases in heart and respiratory rates suggestive that this activity requires substantial patient effort. Thirteen of the 20 patients began the programme whilst mechanically ventilated. Adverse events (drop in muscle tone, was the most common but this did not result in any patient falls) occurred in 3% of the interventions.

Pohlman et al (2010) undertook a descriptive detailed study whereby physical and occupational therapy in 49 ICU patients was commenced soon after mechanical ventilation (median 1.5 days after intubation) during daily sedation interruption. Each session lasted for 26 $\pm$ 14 minutes whilst patients were ventilated. Mobility was initiated sequentially and patients whilst intubated sat on the edge of the bed in 69% of episodes, transferred bed to chair in 33%, stood in 33% and ambulated in 15% of cases. Adverse events were noted in 16% of all sessions but therapy was only stopped on a given day in 4% of sessions and rarely needed to be discontinued permanently. This study was unique in that mobilisation occurred very early after intubation whereas in many other studies it occurred much later in the ICU journey. So called "barriers" to mobilisation were present in many of the patients who successfully mobilised; for example, acute lung injury was present during 58% of therapy sessions, a single vasoactive drug was infusing during 17% of therapy sessions and 2 or more vasoactive drugs were present during 14% of therapy sessions. There was a single central venous catheter in 75% of patients and arterial lines present in 47% of therapy sessions. The authors concluded that early initiation of mobility and occupational therapy can occur despite high illness acuity and presence of life support devices.

In a quality improvement project at John Hopkins University Hospital in Baltimore (this ICU department has undertaken a significant amount of research in the area of early mobility in ICU patients), Needham et al (2010) undertook a prospective (3 months) before and after (4 months) study to evaluate reducing deep sedation and delirium, increase the frequency of mobilisation and then evaluate this on patient length of stay both in the medical ICU where the study took place as well as hospital length of stay. Twenty-seven eligible patients were in the "before" period and 30 in the "after" period. The results showed a reduced use of sedation and a corresponding improvement in sedation and delirium status. Significantly more rehabilitation treatments occurred for each patient (1 before vs. 7 after) and leading from this a decrease in ICU and hospital length of stay by 2.1 and 3.1 days respectively. As a result the ICU had a 20% increase in admissions (from a faster patient through time) compared to the same period in the prior year. Qualitative patient interviews from this ICU can be viewed at:

http://www.hopkinsmedicine.org/pulmonary/research/outcomes_after_critical_illness_surgery/oacis_videos_news.html

Morris et al (2011) assessed the impact of a series of interventions and patient characteristics including an ICU early mobility programme on subsequent hospital re-admissions for 12 months post discharge of survivors of acute respiratory distress syndrome. Data were analysed for 258 survivors and indicated that 4 variables predicted hospital readmission: tracheostomy, female gender, lack of early ICU mobility and high co-morbidity scores. The authors highlight how early ICU mobility represents a potentially modifiable in-patient variable.

Bassett et al (2012) undertook a study to evaluate the outcomes of a multi disciplinary mobility programme in 13 ICUs within 8 US hospitals. The goal was to help ICU teams accomplish early mobility into daily care activities using an evidence based mobility continuum over a 14 month period with organisations being able to learn and communicate with each other alongside access to recognised expert advice. The success of the programme was undertaken using retrospective chart analysis and direct observation, differences in the number of patient mobility interventions and outcomes between pre and post intervention of the programme. Although quantative data demonstrated a trend towards a shorter number of ventilator days (3 days pre intervention vs. 2.1 days post), other interventions such as compliance measures such as number of days to ambulating, number of days to transfers and number of days to first physiotherapy session demonstrated no significant differences. Although qualitative data identified that the collaborative methods used improved the culture and team focus, this study illustrates the challenges in initiating and maintaining early mobility programmes.

In a retrospective cohort study, Clark et al (2012) compared pre and post early mobilisation programme patients (n=2,176) from a burns and trauma ICU. The early mobility group were identified as having no increase in iatrogenic complications and ambulation with an ET tube in situ was found to be safe. There was a significant reduction in pneumonia and pulmonary complications alongside vascular complications including DVT but there was no significant differences in ventilator days ICU and hospital length of stay days (although hospital LOS reduced by 1.5 days this was non-significant). As a result of the findings there are now 2 new full time physiotherapists and development of an early mobility protocol has empowered nursing staff and physiotherapists in ongoing support of the programme.

In a comparative trial pre and post implementation of an ICU early mobility protocol in intubated ICU patients, Winkelman et al (2012) investigated whether exercise was associated with adverse changes in vital signs, whether there was a change in the levels of the inflammatory mediators IL-6 or IL-10, were there any associations between change in these inflammatory markers and patient outcomes and finally if there was a difference in patient outcomes where early mobility was instigated vs. standard care. The mobility intervention group consisted of 55 patients who received 20 minutes of exercise (in or out of bed) every day for 2-7 days on average commencing on day 6 of ICU care with a mean of 123 in bed exercise sessions. The control group received their first session of exercise on day 9 (mean), with a mean of 37 in bed exercise sessions. Results demonstrated that exercise is safe in ICU patients, exercise does not contribute to a pro-inflammatory state and in fact is associated with an increase in IL-10, an anti-inflammatory biomarker. There were no significant differences in the changes for heart rate (increased by 6-7 beats per minute), respiratory rate (increased 5-6 breaths per minute), systolic blood pressure (increased 13-16 mmHg) and peripheral oxygenation (decreased 2%) between periods of rest or exercise. The exercise protocol was associated with a decreased length of ICU stay with the mobility group (n=14.6 days) receiving 5 fewer days of ICU care compared to the control group (n=19.6). Patient feedback indicated there was a high level of patient and family acceptance in participating in early mobility with many patients eager to engage at each opportunity.

Titsworth et al (2012) undertook a comparative trial comparing pre and post intervention of a mobility (progressive upright mobility protocol [PUMP]) programme in a neuro ICU setting. Consecutive patients (n=3,291) were enrolled in the trial relative to the inclusion and exclusion criteria. The mobility intervention was progressive starting with elevation of the head of bed, sitting upright in bed, sitting on edge of bed, standing, sitting in a chair, ambulating in the room, outside the room and other exercises as determined by the PT. Implementation of this programme increased mobility by 300% and correlated positively with a reduction in ICU length of stay (significant reduction of 13%), hospital acquired infections (decreased by 60%, $p<0.05$), most especially ventilator associated pneumonia) and decreased the number of restraints used. There were no increases in adverse events.

No differences were noted in the pressure ulcer incidence rate although this was at a low level for both cohorts. Although there is strong evidence suggestive that increased mobility will decrease rates of VTE, the data could not be reliably evaluated as there is not routine screening.

ICU mobility programmes

The challenges of early mobilisation in the ICU are unique and many and include safety issues, clinician knowledge deficit , sedation practices, vascular access, patient physiologic instability, cost benefit, obesity and lack of human and equipment resources (Morris & Herridge 2007, Bassett et al 2012). Specific issues include:

- ***When to commence mobilisation?***

Truong et al (2009) argue that to obtain most benefit, mobilisation should occur immediately after physiological stabilisation. The definition of physiological stability varies but takes into account neurological, respiratory and cardiovascular stability. The presence of various devices can also be seen as a barrier. Many studies however have demonstrated that the presence of an endotracheal tube does not prevent mobility and that with forethought, there can be appropriate placing of vascular devices so that exercise can occur without incident (Leditschke et al 2012). It is clear from the literature reviewed that there are diverse views about what is defined as being sufficiently physiologically stable for the patient to commence mobility. Although there was diverse patient heterogeneity, studies ranged from a median of 1.5 days post-intubation (Schweickert et al 2009, Pohlman et al 2010) to as long as 6 days post-intubation (Winkelman et al 2012).

- ***Safety***

Ambulation of critically ill patients is difficult and potentially dangerous but with a dedicated and trained team, early mobility can be both safe and feasible (Hopkins et al 2010). In terms of safety, all studies reviewed where there has been early mobilisation have demonstrated success and very low levels of serious adverse events (Bailey et al 2007, Morris et al 2008, Bourdin et al 2010, Pohlman et al 2010, Leditschke et al 2012, Clark et al 2012, Winkelman et al 2012,Titsworth et al 2012). To be engaged in physical activity, the patient has to be mentally alert and cognitively engaged (Hopkins 2010) thus it is a holistic activity and well suited to being a protocolised or part of a bundle of care; see later text on care bundles.

A recently published 4 week audit of 106 patients in an Australian ICU where early mobilisation and reduced sedation has been in place for several years showed that although patients were mobilised on 54% of patient days, this could have been increased by almost a half by potentially avoidable factors such as different sites for vascular access devices, better timing of procedures and improved sedation practice (Leditschke et al 2012).

- ***Frequency and duration***

The majority of early mobility programmes describe how a sequential and protocol driven approach to mobilisation was used with patients commencing with passive bed based exercise and dependent upon physiological response commencing along a continuum to full ambulation where possible over a daily flexible programme by both nurses and physiotherapists.

Also needing consideration is the complete patient journey meaning that even if mobilisation occurs early in the ICU, the programme needs to be continued right through to hospital discharge. One cohort study of 72 medical ICU patients identified that when the patient was transferred to the wards, levels of physical therapy dramatically decreased despite them being extubated and less ill (Hopkins et al 2012).

- ***Which professionals are responsible for the programme?***

It has been highlighted that to be successful in the implementation of an early ICU mobility plan, teams must shift from a multidisciplinary approach to that of a interdisciplinary care team and "intentional synergy" (Vasilevskis et al 2010, Bassett et al 2012).

A US based national postal survey of 984 physical therapists was undertaken in 2007 to establish the practices for patients recovering from critical illness, the hospital staffing patterns, the likelihood that patients would receive physiotherapy and the common types of physiotherapy performed (Hodgin et al 2009). There were four hundred and ninety respondents and the findings illustrated high variability between the type of hospital and the clinical scenario. Physicians were required to provide authorisation to enable physiotherapists (PTs) to deliver physiotherapy in nearly 90% of cases and only 10% of hospitals had established criteria in place. Community hospitals provided more care at weekend. The most common type of PT delivered was functional mobility training and therapeutic exercise.

Garzon-Serrano et al (2011) evaluated in a prospective observational study whether barriers for progressing mobilisation in ICU patients differed between physiotherapists and nursing staff in a cohort of 63 consecutive patients. A standardised protocol was developed by a multi-disciplinary team to assess levels of patient mobilisation. Different barriers were found to be identified by RNs compared to physiotherapists. For example, haemodynamic instability and renal replacement therapy were rated as significantly more risky by RNs vs. PTs whereas neurologic impairment was rated higher by PTs. There were no adverse events in the study. Results showed that PTs achieved significantly higher levels of mobilisation compared to RNs – this was independent of examination and severity of disease.

- ***Developing early mobilisation programmes***

Many valuable principles are also associated with other rehabilitation programmes such as those related to pulmonary conditions and stroke. Goals include alleviation of symptoms and restoration of maximum functional capacity, both of which optimise quality of life outcomes. Such programmes use multiple modalities of exercise training, psychosocial support and education through the entire hospitalisation and community recovery trajectory. It is also important to identify any absolute and relative contraindications to participation. Of interest is the fact that many British ICUs for the past 20 years undertake long term follow up for patients, carers and members of the multi disciplinary team (Morris & Herridge 2007).

- ***Bundles of care***

Since early ICU mobilisation cannot occur in isolation and is dependent upon other aspects of care, it has been suggested that it should be part of a care bundle defined as the use of 3-5 evidence based practices (IHI.org).

ABCDE bundle of care– (Pandharipande et al 2010, Vasilevskis et al 2010, Balas et al 2012)

a. **A**wakening the patient daily – sedation cessation
b. **B**reathing – daily interruption of mechanical ventilation
c. **C**oordination of daily sedation and ventilator removal
d. **D**elirium monitoring
e. **E**arly mobilisation and exercise

Although not as yet an Institute for Healthcare Improvement (IHI) recognised bundle, it is of interest to note that only in November 2012 the IHI commenced a 5 stage web based comprehensive training session dealing specifically with the topic of early immobilisation in the ICU patient (see: http://www.ihi.org/offerings/VirtualPrograms/Expeditions/MobilityintheICU/Pages/default.aspx)

- ***Mobilising obese ICU patients***

The prevalence of obesity has risen dramatically in recent years and projected to rise still further. It has been estimated that 25% of patients in ICU care are obese and 7% morbidly obese (Korupolu et al 2010). Critical illness in an obese person creates unique challenges. Although ICU mortality rates in obese patients are no higher than a normal weight ICU population, longer time is spent receiving mechanical ventilation and there is a longer ICU length of stay (Akinnusi et al 2008); leading from this, unless otherwise initiated, many obese patients would spend longer on bed rest and thus be more at risk of the associated harmful effects (Redlin Rowe 2009, Korupolu et al 2010).

Relatively little has been published on early mobilisation of the critically ill obese patient however a cohort study of 31 obese ICU patients (Genc et al 2012), one case report (Korupolu et al 2010) and a cohort of obese patients (n=6) in another study (Bailey et al 2007) all report safety, feasibility and functional benefit of early mobilisation.

Economic benefit

ICU care is arguably the most expensive clinical areas in hospital with direct costs having recently been identified in & European countries as ranging from €1168 to €2025 per day with labour (€711 $\pm$ 115) being the most important cost driver (Tan et al 2012).

Achieving enhanced outcomes from instigating early ICU mobility undoubtedly can save valuable healthcare expenditure however of the studies highlighted in this current review, only one has explicitly looked at cost as an outcome measure. Morris et al (2008) identified that direct inpatient costs for patients receiving a mobility programme inclusive of mobility team salaries was $6,805,082 vs. usual ICU care group being $7,309,871. Per patient this was calculated as an average cost of $41,142 for mobility protocol patients vs. $44,302 for usual care patients. Although this is a non-significant difference, length of patient stay is the major factor driving patient cost downwards.

Waste has been defined as being costs that could have been avoided without negatively affecting quality (Price Waterhouse Coopers Health Research Institute 2008). Research by PWC (2008) identified that wasteful spending in the health system may be up to US$1.2 trillion of the $2.2 trillion spent in the US. Defensive medicine such as unnecessary tests, redundant or inappropriate tests and procedures were the biggest area of excess. A common set of barriers were identified as standing in the way of improving efficacy in (US) healthcare; these were identified as: culture change, politics, lack of incentives and funding and lack of a coordinated focus. Although these findings were discussed as part of overall US health policy, it is also clear that there are common denominators with initiating early mobility in ICU patients.

In a study in one Canadian ICU with respect to sedation, analgesia and delirium costs associated with ICU, Skrobik et al (2010) collected data pre and post implementation of a new protocol whereby individualised non-pharmacological approaches were used alongside titration of drugs according to patient assessment scores in a pre-implementation group of 604 patients vs. a post implementation group of 610. The results illustrated that there was less patient delirium and better patient outcomes with reduced duration of mechanical ventilation combined with lower ICU and hospital LOS, reduced dependency at discharge and a lower 30 day mortality risk. In an economic evaluation of the same study, Awissi et al (2012) calculated that the improvement in outcomes led to a reduced average cost of $932.74 per patient, per hospitalisation. Although no early mobility was instigated, it demonstrates the potential cost savings associated with implementation of evidence based quality initiatives.

Conclusion

Despite being largely preventable, ICU acquired weakness and delirium are disorders of epidemic proportion. Early mobilisation has been shown to be safe, feasible and improves outcomes however it requires an operational ICU culture change and implementation of quality processes that liberates patients from prolonged sedation, mechanical ventilation and bed rest (Vasilevskis et al 2010, Bassett et al 2012). Despite the mounting evidence of the benefits, early mobilisation of ICU patients appears still not to have been widely applied (Vasilevskis et al 2010). Further research is needed to fully ascertain public health implications, health care utilisation and costs (Lipschutz et al 2012).

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