The physiological after-effects of critical care
Wayne P Robson

SUMMARY
• After a stay in intensive care, patients may suffer physiological after effects, such as muscle wasting, polyneuropathies, disturbed sleep, itching and poor mobility
• The care that patients receive whilst on intensive care may contribute to the severity of some of these physical problems
• Raising awareness amongst critical care nurses may help reduce the severity of some of the physiological after effects
• Increased awareness amongst nurses on the wards about the physical impact of intensive care may lead to a greater understanding of the needs of this group of patients and may improve discharge planning

Key words: Discharge • Follow up • Intensive care • Muscle wasting • Physiological • Rehabilitation

INTRODUCTION
In the past decade, there has been increasing interest in the problems faced by patients once they have left the intensive care unit (ICU). This interest has received fresh impetus from the Audit Commission (1999) report Critical to Success and Department of Health (2000) report Comprehensive Critical Care, both of which recommended the provision of ICU after care, such as follow-up clinics. Some of the first intensive care follow-up clinics were established in the early 1990s at Whiston Hospital Merseyside and at The Royal Berkshire Hospital in Reading (Waldman and Gaine, 1996). Various psychological problems were identified in this group of patients, including anxiety, depression and even post-traumatic stress disorder (Scragg et al., 2001). As well as the psychological problems identified from follow-up studies, a number of physiological side effects have also been revealed. Eddleston et al. (2000), in a follow-up study of 143 ICU patients, found that prolonged weakness and fatigue occurred commonly. Some patients also reported significant hair loss. Problems such as peripheral neuropathy, poor balance and skin irritation and rashes have also been reported (Waldmann and Gaine, 1996).

A literature search was carried out using the Medline and Cinahl databases. The following key words were entered singularly and then in various combinations: intensive care, critical care, after effects, follow up, muscle wasting, polyneuropathy, rehabilitation and sleep. Other sources of literature were also found from a hand search of relevant journals and reference lists of other studies.

Some of the more common physiological after effects of intensive care will be discussed in this article, and the ways in which critical care nurses, nurses on the general wards, physiotherapists and occupational therapists can all contribute to reduce the incidence, severity and impact of such problems will be examined.

SLEEP DISTURBANCE
Disruption of the sleep wake cycle is common in critically ill patients (Herdegen, 2002), and patients discharged from ICU to the wards often have difficulty sleeping. Sleep disturbance in critical care is commonly caused by loss of circadian rhythm, because of acute illness and environmental factors such as noise and light (Woodrow, 2000). One of the less well-known reasons for this may be reduced secretion of melatonin (Shilo et al., 1999; Mundigler et al., 2002). Melatonin is a neurohormone secreted by the pineal gland. It controls the sleep wake cycle, and its release is stimulated by darkness and inhibited by light. Shilo et al. (1999) suggest that treatment with melatonin may improve sleep in ICU patients. It may also subsequently help prevent the development of the ICU syndrome and shorten weaning times from mechanical ventilation. A more recent pilot study by Bourne (2001) also appears to show that melatonin may be effective in enhancing sleep in ICU patients. Ryan (2002) argues that it is safe and non-toxic and apart
from being contraindicated in pregnancy, autoimmune diseases and lymphoma, it may be a useful treatment for difficult cases of sleep deprivation.

Another cause of sleep disturbance may be the sedative agents that are given to patients being mechanically ventilated. Bell (2002) argues that in order to meet the goals of sedation, there may be a tendency to oversedate patients. Heffner (2000 p. 1521) states:

‘it is now common in a busy ICU to find that most, if not all, patients receiving mechanical ventilation are in a drug induced state of suspended animation’

Sedative drugs can deprive patients of their rapid eye movement (REM) sleep (Shelly, 1993), causing them to become sleep deprived. If patients can be nursed with less sedation or are sedated for a shorter duration, this may help reduce the degree of sleep deprivation they experience. Stopping sedative infusions once a day until the patient wakes up and then restarting them at the minimal dose that achieves optimal sedation has been shown to reduce the time patients spend on mechanical ventilation (Kress et al., 2000), and this may be one way of also reducing the sleep disturbance that ICU patients’ experience. This idea is now being promoted as a good practice by the National Health Service Modernisation Agency Critical Care Programme (2002). Nurses need to be made more aware of the longer term effects of sedative infusions and how potentially they can prolong recovery and rehabilitation. Heffner (2000) argues that although stopping sedation on a daily basis may be beneficial, there may be a price to pay. The patient may experience distress and discomfort being woken up and then resedated. However, if the patient can be liberated from the ventilator much sooner with this intervention, then it may be a price worth paying.

New sedative drugs may cause less sleep disruption. Lane et al. (2002) describe the use of remifentanil for sedation and analgesia in ICU. Remifentanil is a new type of opiate, but unlike morphine or alfentanil, its effects are much more predictable and include a rapid onset and rapid offset or recovery time, and it does not accumulate in renal failure. (Park, 2002). In Lane et al.’s (2002) study, patients sedated with remifentanil received less hypnotic agents such as propofol or midazolam, and in eight of the 17 patients, no hypnotic was required, and patients were sedated using only remifentanil. Lane et al. (2002) argue that if pain is treated first with opiates, then many patients are less anxious, and the need for hypnotic sedatives is reduced. These patients who may previously have been unconscious were now being nursed awake. The use of remifentanil may, as a result, help promote a more normal sleep pattern, which might lessen sleep disturbance post-ICU discharge. As the findings of Lane et al. (2002) are only based on the use of remifentanil in 17 patients in one ICU, further research is indicated before this approach to sedation can be widely adopted. As well as new drugs, new monitoring techniques such as the bispectral index (BIS) may encourage a more cautious and objective use of sedation (Bell, 2002). BIS is obtained from the analysis of the patients electroencephalogram (EEG) (Struys et al., 1998) and is meant to give a continuous and more objective assessment of the patients’ level of sedation (Bell, 2002).

Patient restraints may be another way of preventing patients from receiving excessive doses of sedation. Tominaga et al. (1995) examined ways to decrease unplanned extubations in a surgical ICU. They found that restricting the use of hand restraints was associated with a significant increase in accidental extubations, whilst no difference was seen when sedation was given liberally rather than cautiously. Although this practice is not unknown in the USA, its adoption in the UK is unlikely because of the ethical and moral questions it raises. Physical patient restraints do not relieve pain or anxiety, unlike intravenous sedation using opiates and hypnotics, and they may also breach the Human Rights Act (1998). Patient restraints may result in less sedation being used, but this may be at the price of the patients’ comfort.

MUSCLE WASTING

Patients in intensive care can lose about 2% of their muscle mass every 24h, and some may lose up to 50% of their total muscle mass during their stay (Griffiths and Jones, 1999). As patients are often oedematous after a stay in ICU, the extent of the muscle wasting is not always apparent (Griffiths, 2002). Nurses on the wards therefore may not realize why post-ICU patients feel so weak and may expect that such patients are able to do more for themselves.

Amnesia regarding the time spent in ICU is common and, as a result, patients often do not appreciate why they feel so weak and exhausted. They may also have unrealistic expectations about their recovery. To rebuild such profound muscle loss, however, can take many months (Griffiths, 2002). The use of patient diaries may help patients to realize why they are experiencing these profound physiological side-effects (Griffiths and Jones, 2001). Patient diaries are compiled by the nursing staff on ICU. Entries are made in the diary to record, in a language the patient will understand, the major events of their stay in critical care. The patients’ relatives are also encouraged to make entries. The diary includes photographs, which are taken when the patient is fully ventilated and then
at significant points during their stay (Backman and Walther, 2001). For example, a photograph might be taken when the patient first sits out of bed. If some of the patients show their diaries to the nurses looking after them in the wards, then this might help the ward staff to appreciate why the patient is so dependent and may encourage them to think more about the discharge process and the ongoing support the patient may need at home.

**CAN MUSCLE WASTING BE PREVENTED OR MINIMIZED?**

Muscle wasting will be compounded by malnutrition or delayed feeding, and the prevention of malnutrition during critical illness is a major therapeutic goal (Gabe and Grimble, 1999). Nutritional support is now well recognized as an essential part of the care given in ICU. There is some evidence that the addition of arginine and glutamine to patients’ feed may help minimize muscle wasting. Berard et al. (2000) reported that parenteral nutrition enriched with glutamine and arginine produced a more positive nitrogen balance, suggesting that it may help limit protein catabolism. Nurses have a vital role to play in ensuring that feeding is initiated early in the patients’ stay.

Physiotherapists in ICU do not only treat or try to prevent respiratory complications, but they also play an important role in the positioning of patients, care of their limbs and rehabilitation. Physiotherapists often perform passive range of movement exercises on very sick mechanically ventilated patients and more active exercises on patients who are recovering (Mackenzie et al., 1989). Whilst there appears to be strong evidence that physiotherapy in ICU is beneficial for pulmonary complications, such as acute lobar atelectasis, there is only limited evidence that limb exercises improve muscle strength and function or prevent loss of joint range (Stiller, 2000). Griffiths et al. (1995) showed that passive stretching appears to help preserve muscle mass in the legs of critically ill patients. Stiller (2000) recommends that further research is needed to evaluate the physiotherapy role in ICU but suggests that physiotherapists can have a valuable role to play in neurological assessment, promoting early recognition of polynuropathies.

The National Health Service Modernisation Agency (2002) document *The Role of Healthcare Professions Within Critical Care Services* sees allied health professional such as physiotherapists and occupational therapists as key to modernization. The document states that occupational therapy should start whilst the patient is still critically ill but that unfortunately the occupational therapist role in critical care is not always recognized. The physiological side-effects of ICU such as muscle wasting and polynuropathies can have a huge impact on the patients’ ability to carry out activities of daily living such as eating, toileting and washing. Occupational therapists can provide valuable input to help overcome these problems. Occupational therapists must be welcomed into the fold, and nurses on ICU and on the wards must be reminded to utilize this service in discharge planning, both to the ward and back into the community.

As well as passive movements and stretching, electrical stimulation of the patients’ muscles may possibly be of benefit, by reducing muscle atrophy (Gibson et al., 1988). Gibson et al. (1988) looked at the use of percutaneous electrical stimulation in men with tibial fractures who had their legs immobilized in a cast. There appeared to be less atrophy of the quadriceps muscles in the group having the electrical stimulation via windows in their plaster cast. Although this was a small study (21 subjects) carried out on otherwise healthy patients, it may be applicable to fully sedated and ventilated patients on ICU who are immobile. More research needs to be carried out in ICU to determine the most effective ways for nurses, physiotherapists and occupational therapists to help prevent muscle wasting and help regain lost muscle mass and function.

**POLYNEUROPATHIES**

Polyneuropathies are disorders affecting motor and sensory peripheral nerves, and can be caused by diabetes, alcoholism or critical illness. Critical illness polynuropathy (CIP) affects the axons of sensory and motor nerves and appears to occur most commonly in elderly ICU patients with sepsis and multiorgan failure (Murray et al., 2002). The exact cause is unknown (Hund et al., 1996). Patients can be left with muscle weakness and reduced sensory function and these effects can be long lasting. Van der Schaaf et al. (2000) report that such symptoms may still be frequently observed up to 1 year after the critical illness. Some studies have linked the use of neuromuscular blocking agents or paralysing agents to the development of CIP (Hansen-Flaschen et al., 1993).

Neuromuscular blocking agents are also thought to be associated with another similar side effect, Acute Quadriplegic Myopathy Syndrome (Murray et al., 2002). This is characterized by acute paresis, muscle necrosis and a raised creatine phosphokinase (CPK). This syndrome can develop after prolonged use of neuromuscular blocking agents, especially if given concurrently with corticosteroids and may be influenced by hyperglycaemia.

Murray et al. (2002) recommend only using neuromuscular blocking agents as a last resort and stopping
them once a day until the patient condition requires that they are restarted. Neuromuscular blocking agents should be stopped as soon as possible if the patient is also receiving corticosteroids, and the degree of neuromuscular blockade in all patients should be monitored with a peripheral nerve stimulator (Murray et al., 2002).

Nurses may be able to play a part in trying to reduce the risk of patients developing CIP and acute quadriplegic myopathy syndrome (AQMS) by acting on some of the above recommendations such as the use of peripheral nerve stimulators. Peripheral nerve stimulators allow the assessment of the depth of neuromuscular blockade and facilitate the titration of neuromuscular blocking agents (Kleinpell et al., 1996). Electrodes are placed over a peripheral nerve, usually the ulnar nerve, and a series of four impulses are delivered (train of four). The degree of blockade corresponds to the number of twitches that are produced in response to the train of four stimuli. When using infusions of neuromuscular blocking agents, 75–90% blockade is adequate indicated by one or two twitches (Whiteley et al., 2002). Kleinpell et al. (1996) sent 2000 questionnaires to American critical care nurses. The response rate was poor [744 (37%)], but showed that 41% reported using a peripheral nerve stimulator and train of four stimuli to monitor the depth of neuromuscular blockade in patients receiving neuromuscular blocking agents. Amongst the nurses in the study who did report using a peripheral nerve stimulator, variations existed in the way they were used and the frequency that patients were monitored. Kleinpell et al. (1996) argue that peripheral nerve stimulators are an objective way of assessing the depth of neuromuscular blockade and may help ensure that the patient does not receive excessive doses of neuromuscular blocking agent.

Another way that nurses might be able to reduce the risk of patients developing polyneuropathies is by checking the patients’ blood sugars regularly and using an intensive insulin protocol to prevent hyperglycaemia. Van den Bergh et al. (2001) researched the use of intensive insulin therapy in critically ill surgical patients. Intensive insulin therapy is the use of a more aggressive insulin sliding scale designed to maintain blood glucose between 4-4 and 6-1 mmol/L. In a prospective randomized controlled trial involving 1548 patients, the two groups were randomized to receive conventional insulin therapy to maintain their blood glucose levels between 10 and 11.1 mmol/L or to receive intensive insulin therapy to maintain their blood glucose levels between 4-4 and 6-1 mmol/L.

The study showed a 44% reduction in CIP in the intervention group treated with intensive insulin therapy, and cases of CIP that did develop in the intervention group resolved more rapidly than for those in the control group. Both groups showed a positive linear correlation between the mean glucose level and the risk of developing polyneuropathy.

Intensive insulin therapy is now being adopted by some UK hospitals as part of a package of elements of care designed to improve patient outcome. Other elements include ensuring that ventilated patients are nursed at 30° head up to prevent nosocomial pneumonia and stopping patients’ sedative infusions once per day. This grouping together of elements of care is referred to as a care bundle (Berenholtz et al., 2002).

Neuropathies caused by pressure damage have also been reported, resulting in foot or wrist drop (Kennedy et al., 2002). Eddleston et al. (2000) found that 12 patients from a group of 143 post-ICU patients followed up at 3 months exhibited compressive neuroopathies. Eleven of these exhibited ulnar nerve problems at the elbow and one involved the common peroneal nerve in the lower leg. Nursing patients with their arms in the neutral position may help reduce nerve compression at the elbow (White, 1998). Nurses within critical care need to liaise closely with physiotherapists when positioning patients, especially when using less familiar positions such as prone, to ensure that undue pressure is not exerted on nerves such as the peroneal, radial and ulnar.

ITCHING AND HAIR LOSS
Speight et al. (1997) reported a number of cases of severe itching caused by the administration of starch plasma expanders given after heart surgery. These fluids are often given as fluid challenges to patients in ICU. In patients who develop severe and persistent itching following ICU, this might be considered as one of the possible causes.

Eddleston et al. (2000) reported that 32 women and six men from a sample of 143 ICU patients followed up at 3 months had experienced significant hair loss. If ward nurses are made aware of the possibility of itching and hair loss in patients transferred from intensive care, they will feel more confident about explaining this to patients.

DISCHARGE INTO THE COMMUNITY AND REHABILITATION
Rehabilitation is well established for other types of illness such as post myocardial infarction. For patients recovering from a critical illness that involved a long stay in intensive care, rehabilitation provision is still in its infancy. The smaller numbers of patients recovering from critical illness as compared with the numbers...
recovering from a myocardial infarction make a structured rehabilitation programme harder to organize and justify financially, especially, for the units with fewer beds.

As many of these patients are recovering from muscle wasting and neuropathies, aerobic exercises may not be the most appropriate form of physical exercise to provide on a rehabilitation programme. Tia Chi, however, may be more suitable as it is a more gentle form of movement. It has been shown to be a useful alternative to formal aerobic exercise in cardiac rehabilitation (Channer et al., 1996). There do not appear to be any published studies to date that have used Tia Chi with patients recovering from critical illness, but this would be an interesting approach to research.

Jones et al. (2001a) reported that a rehabilitation package consisting of a self-directed rehabilitation manual, given in addition to standard ICU outpatient clinic follow up, appeared to have a positive effect on the patients physical recovery. The rehabilitation package was developed by a team from Whiston Hospital in Merseyside and includes an intensive care recovery manual. The manual includes a 6-week progressive exercise plan and stress management techniques. As well as having a positive impact on the patients' physical recovery, the rehabilitation package also appeared to make patients who were smokers pre-ICU admission less likely to return to smoking (Jones et al., 2001b). This type of package including a rehabilitation manual with self-directed exercises may be a simple and relatively inexpensive first step towards a more structured rehabilitation programme. This could be supported by district nurses, health visitors, practice nurses or by home visits from the hospital critical care outreach team.

CONCLUSION

For the recovering ICU patient, there may be physical as well as mental reminders of their experience. Muscle wasting, polyneuropathy and myopathy may combine to produce profound weakness and fatigue. This will impact on all activities of daily living, and at a very basic level may leave patients too weak to cough or feed themselves. To compound this, the patient may have a disturbed sleep pattern and might be troubled by itching.

Nurses on ICU may be able to reduce the incidence and severity of some of these side effects. For septic patients maintaining their blood glucose within the range of 4.4–6.1 mmol/L may lessen the risk of developing a polyneuropathy (Van den Berghe et al., 2001). More rigorous monitoring of patients receiving neuromuscular blocking agents with, for example, peripheral nerve stimulators, may mean that the patient receives less of the paralysing agent, and hence may be at less risk of developing polyneuropathy (Kleinpell et al., 1996).

Being especially vigilant when patients are receiving neuromuscular blocking agents and steroids to stop these infusions as soon as possible may help reduce the risk of developing myopathy (Murray et al., 2002).

To help prevent muscle wasting, it appears that further research is needed to establish the value of physiotherapy (Stiller, 2000). However, some evidence suggest that passive stretching may be beneficial (Griffiths et al., 1995).

There might also be a role for electrical stimulation of muscles to prevent wasting (Gibson et al., 1988). Sleep disturbance could be reduced by ICU nurses adopting the practice of daily sedation holds, as recommended by Kress et al. (2000). For patients who are sleep deprived on the unit and when discharged to the ward, melatonin would appear to be a useful drug to try (Ryan, 2002). Junior nurses on ICU may not be aware of the physiological side effects of a stay in ICU and how the care they deliver might impact on the severity. As well as teaching nurses about ICU psychosis, we should also tell them about the physical impact of critical care. This information could be included as part of the introductory competency packages that new starters to critical care would be expected to complete.

Treating the physical side effects should begin in ICU. The National Health Service Modernisation Agency Critical Care Programme (2002) have proposed that occupational therapists could play a more active role in intensive care. Nurses on ICU need to establish stronger links with their OT departments. The physical side effects become most apparent when the patient is transferred to the ward and slowly begins to try and become more independent. Ward nurses are known to find accepting patients from ICU stressful and find them highly dependent (Haines et al., 2001).

The ward nurses are unlikely to know about the high degree of muscle wasting that can occur or about polyneuropathies or the effects of sedative drugs on REM sleep. Education is needed for both ICU and ward nurses on the physical side effects and their impact. This education could be provided by critical care outreach teams. If ward nurses are given this knowledge, they are more likely to think about the patients’ continuing needs on discharge into the community. Jones and Griffiths (2000) in a follow-up study of patients discharged from ICU found that at 8 weeks
post discharge many patients were still using wheelchairs outside and had difficulty climbing stairs. Despite this, the majority of patients had not been offered physiotherapy once they had left hospital. Practice nurses, district nurses and health visitors are known to visit recovering cardiac patients in the community. It could be suggested that critical care outreach teams should host study days for primary care staff to tell them about the after effects of critical illness and the part that they can play in the post-ICU rehabilitation process.

REFERENCES


Warm and adequately humidified gas delivered at high flow has apparent beneficial physiological effects. Although recently, results of large randomized clinical trials have been reported, even before those trials, HFNC was widely applied to critically ill patients with diverse underlying diseases.