31 Respiratory intensive care

Introduction

Key points

- Intensive care medicine has progressed considerably and improved survival after long-term ventilation has led to a greatly increased demand for intensive care facilities.
- Historically, intensive care units were led by anaesthetists. Increasingly, however, respiratory intensive care is supervised by respiratory physicians.
- Respiratory intermediate care units and ventilator-weaning units are likely to grow in size and number as the number of patients surviving prolonged ventilation increases and demands on conventional intensive care units grow.
- The technology of extracorporeal oxygenation has improved considerably and the development of an artificial lung has become a realistic prospect.

In recent decades, no branch of medicine has made more progress than intensive care. Important advances include: technological developments to overcome single-organ failure (for example, the development of respirators and extracorporeal oxygenation to treat acute lung failure); improvements in pharmacotherapy based on better understanding of the underlying pathophysiology; and new or improved monitoring systems for surveillance of organ function and to help to direct therapies.

As a consequence of these technological, diagnostic and therapeutic advances, demand for intensive care medicine has escalated continuously. Increasingly, elderly patients with multiple comorbidities are now treated in intensive care units and the boundaries of possible treatments are ever-widening. As recently as 30 years ago, patients needing invasive ventilation for more than 3 days were unlikely to survive. Today, patients requiring long-term ventilation are a common occurrence in every intensive care unit. With the expansion of mechanical ventilation and other organ-replacement techniques, large new areas of medicine have been added to classical acute intensive care. The differences between the 'high-tech' intensive care unit and regular wards have widened. Intermediate care units have also become established, with better monitoring and a greater therapeutic spectrum than is found in conventional wards, but without the organ-replacement techniques of the intensive care unit.

> *Respiratory physicians in many countries have established, or are now involved in, specialised weaning centres*

Weaning from prolonged mechanical ventilation is an important aspect of modern intensive care medicine. Specialised units have grown up in many hospitals (long-term care facilities/weaning units), and home mechanical ventilation has also expanded greatly in recent years.

New professions have developed, such as the respiratory therapist. However, the development of legal and administrative structures associated with intensive care medicine, the skills of the staff and the definitions of their job profiles have not always kept pace with the rapid changes in medical reality. Historically, the structure of intensive care medicine developed differently in different European countries. Consequently, there are variations in professional responsibility, recruitment and training of staff, career perspectives in intensive care medicine and quality standards.

With the growth of intensive care units, intensive care medicine has become economically more important for hospitals and, consequently, for the financing of the whole healthcare sector. These developments will continue, increasing the pressure to create adequate legal and administrative structures in this area. At the same time, the need for qualified specialised personnel and for internationally equivalent and mutually recognised training programmes will increase.

Standards of end-of-life care and decision-making have become an increasingly important issue in intensive care medicine, in particular in patients with end-stage respiratory failure. A European Respiratory Society task force found that in European respiratory intermediate care units and high-dependency units this is highly relevant: an end-of-life decision was taken in 21.5 % of the patients admitted.

The role of respiratory medicine in intensive care

Modern intensive care medicine began in the 1920s with the introduction of the iron lung for the treatment of respiratory failure associated with polio. This expands the lungs with each breath by applying a suction (negative) pressure around the trunk. The next important step was the availability of artificial airway tubes and positive-pressure ventilators, which deliver air directly into the patient's airways. These developed from the requirements of modern surgery to facilitate better control of anaesthesia during operations. Intensive care medicine benefitted from the new ventilation techniques, which at first were applied exclusively to surgical patients.

By the mid 20th century intensive care medicine consisted primarily of mechanical ventilation *via* an endotracheal or tracheostomy tube. In the USA, intensive care became an integral part of respiratory medicine but in most European countries, anaesthetists (anaesthesiologists) became responsible for most general medical and postoperative intensive care units. However, this pattern did not develop uniformly across Europe. In some countries a new specialty of intensive care medicine developed, while in some others training in intensive care was incorporated in the curriculum of several specialties, including anaesthetics (anaesthesiology), internal medicine, surgery and paediatrics. Within the medical specialties more specialised care facilities were developed to care for patients with failure of a single bodily system, *e.g.* coronary care, respiratory care and, latterly, stroke units. In some countries, the representation of respiratory medicine in intensive care is still relatively low, even though acute respiratory failure is one of the three main issues in modern intensive care medicine, along with circulatory failure and severe infection.

The increasing focus of respiratory medicine on patients with chronic respiratory disease has led to the development of respiratory intermediate care units, which specialise in treating respiratory insufficiency as a single-organ problem. Therapeutic techniques were developed that could be performed outside fully equipped intensive care units, including specialised physiotherapy, respiratory therapy, mechanical support systems for the expectoration of secretions, and improved oxygen delivery systems.

The introduction of noninvasive ventilation (NIV) about 20 years ago was a major advance. A face-mask or other device is used to deliver air without the need for intubation and its attendant risks such as infection. Initially, NIV was applied to patients with chronic ventilatory insufficiency caused by diseases that do not originate from the lung, *i.e.* neuromuscular disorders such as the postpolio syndrome and muscular dystrophies, and severe deformation of the thorax and vertebral column such as scoliosis (figure 1). In these patients, ventilation is inadequate due to failure of the 'ventilatory pump', which results in hypercapnia (high arterial carbon dioxide pressure); this is readily corrected by use of NIV applied intermittently (usually during sleep), resulting in a tremendous improvement of quality of life and survival. Long-term domiciliary NIV is now used routinely to treat these conditions.

With better understanding of the pathophysiology of severe chronic obstructive pulmonary disease (COPD) (which results in hypercapnia due, in part, to relative weakness of the respiratory muscles), the use of NIV has been extended

to patients with advanced COPD and hypercapnic respiratory failure, particularly during acute exacerbations (AE-COPD). These patients are a large group, and in many hospitals NIV is now used routinely to treat patients with hypercapnic, acidotic AE-COPD outside traditional intensive care units, in high-dependency units or in the general respiratory ward setting. For many such patients, this avoids the need for intubation and its complications, in particular infection and difficulty in weaning from the ventilator. Long-term home NIV is also used in some patients with COPD and chronic hypercapnia (figure 1), but the optimal indications and selection criteria are the subject of ongoing research. In intensive care units NIV is also often used during tracheal intubation prior to commencing full assisted ventilation, during weaning from mechanical ventilation and after failure of extubation.

Increasing numbers of elderly patients undergo major surgery or need intensive care because of comorbidities or for other reasons. Improvements in ventilation strategies and the consequent reduction of ventilator-associated lung injury, in combination with advances in intensive care medicine, have allowed much longer periods of ventilation. In the past, unless patients were extubated after 3 days they usually died, but now intubation and ventilation for weeks or months is feasible. However, weaning from mechanical ventilation becomes more difficult with every additional day of ventilation. During prolonged mechanical ventilation, patients experience progressive wasting of skeletal muscles and may also develop a peripheral neuropathy, both of which can affect the muscles of the ventilatory pump. Respiratory physicians in many countries have established, or are now involved in, specialised weaning centres. Relevant teaching courses have been developed for physicians, nurses, physiotherapists and respiratory therapists.

Future prospects

Intensive care medicine is likely to be responsible for an increasing proportion of the care of hospitalised patients in nearly all medical areas in the next few years. It will be a major, if not the largest, economic factor for all hospitals. It is likely that intensive care medicine will become even more specialised (figure 2). In addition to the classical

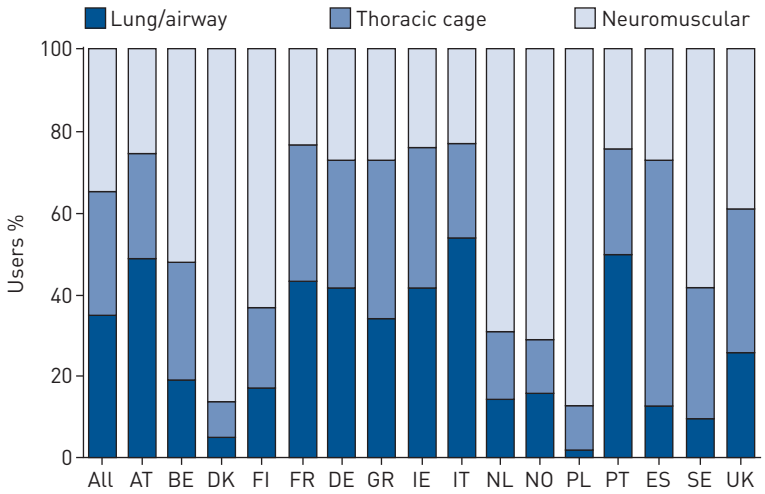

Figure 1 – Indications for home mechanical ventilation in Europe. Reproduced from Lloyd-Owen *et al.*, 2005.

management of acute and life-threatening complex problems in conventional intensive care units, with high staffing ratios and modern technical equipment, a considerable increase is likely in the number of intermediate care units in which organ-specific problems are treated. Respiratory intermediate care units focus on respiratory failure, in an analogous fashion to coronary care units and stroke units. These wards do not have the complete infrastructure and staff of conventional intensive care units, but are much better equipped and staffed than regular wards. The leadership of individual units depends on the organ in focus, since specialised knowledge is essential for successful patient management.

"The overall relationship between respiratory medicine and intensive care medicine across Europe is unclear"

The development of specialised weaning centres and long-term care facilities for patients who cannot be weaned from ventilation has important economic advantages as every long-term ventilated patient in a regular intensive care unit reduces the capacity for surgical operations, which, inevitably, are an important source of finance for hospitals. Specialised units for long-term ventilation, sometimes outside hospitals, are likely to develop further; they will care not only for the above-mentioned patients with chronic ventilatory failure, but also for patients discharged from intensive care units who cannot be weaned, and who need long-term invasive or noninvasive ventilation.

Important recent developments in intensive care include devices for extracorporeal oxygenation and removal of CO_2. Extracorporeal membrane oxygenation is becoming available in highly specialised centres. CO_2 removal systems are already being applied in weaning and might be useful in respiratory intermediate care units as a short-term 'bridge' in patients with acute on chronic respiratory failure, *e.g.* in patients with AE-COPD. The development of permanent extracorporeal lung replacement for the treatment of chronic respiratory insufficiency appeared to be unrealisitic until

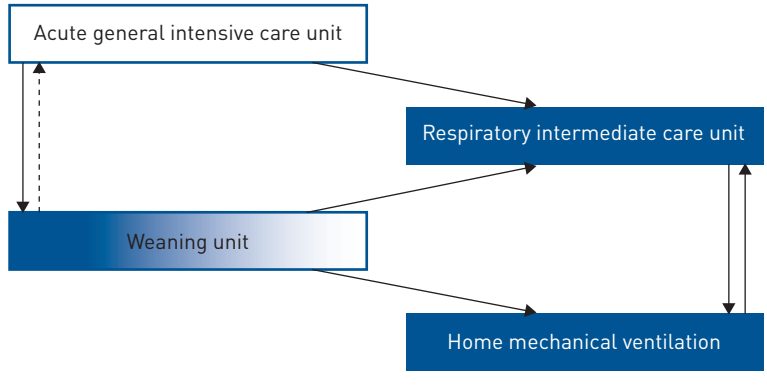

Figure 2 – Levels of care for patients with respiratory failure. Aspects shaded in blue are led by respiratory physicians.

recently, but with improvements in membranes, miniaturised pump systems, and longer-lasting catheters, the artificial lung has become a realistic prospect. Intensive care medicine is thus generating new challenges for respiratory physicians, which extend their range and for which educational programmes will be necessary in order to meet the growing requirements.

As mentioned previously the organisational models of intensive care medicine differ considerably between, and sometimes within, European countries, with variation in personnel, educational standards, infrastructure and responsibilities. The overall relationship between respiratory medicine and intensive care medicine across Europe is unclear, apart from in the field of domiciliary ventilation. In some countries, respiratory medicine is only partly involved in respiratory intermediate care units, weaning centres and the initiation and management of home ventilation. Similarly, respiratory medicine is still under-represented in conventional intensive care and the subject is not part of the respiratory physician's curriculum in all countries. Several training programmes have been developed to harmonise educational and training core curricula in intensive care in Europe. The European Society of Intensive Care Medicine (ESICM) has produced the Patient-centred Acute Care Training curriculum, an up-to-date, online, modular curriculum for intensive (critical) care medicine. This is an educational resource aimed at advancing and harmonising the quality of acute and critical care medicine training and practice. The European Board of Anaesthesiology, under the auspices of the Union Européenne des Médecins Spécialistes, has developed the Anesthesiology, Pain and Intensive Care Medicine Curriculum. Additionally the ESICM has developed the European Diploma in Intensive Care, while the European Society of Anaesthesiology has developed a European Diploma in Anaesthesiology and Intensive Care.

A respiratory critical care syllabus has been developed and published under the European Respiratory Society HERMES initiative (see chapter 36) and this will be followed by a specific curriculum and diploma. Quality indicators for staff and infrastructure need to be refined for all areas of intensive care medicine (full intensive care units, respiratory intermediate units, weaning centres, home ventilation). Respiratory physicians should be responsible for defining the criteria for the last three.

Respiratory medicine should also contribute to the standards and curricula for other professional groups involved in intensive care medicine and should be the lead speciality for defining educational standards for respiratory intermediate care units, weaning units and home ventilation.

Further reading

General

- Adhikari NK, RA Fowler RA, Bhagwanjee S, *et al*. Critical care and the global burden of critical illness in adults. *Lancet* 2010; 376: 1339–1346.
- Nava S, Sturani C, Hartl S, *et al*. End-of-life decision-making in respiratory intermediate care units: a European survey. *Eur Respir J* 2007; 30: 156–164.

- Offenstadt G, Moreno R, Palomar M, *et al*. Intensive care medicine in Europe. *Crit Care Clin* 2006; 22: 425–432.
- Perez d'Empaire PA, Kajdacsy-Balla Amaral AC. Year in review 2011: critical care - resource management. *Crit Care* 2012; 16: 244.
- Rhodes A, Ferdinande P, Flaatten H, *et al*. The variability of critical care bed numbers in Europe. *Intensive Care Med* 2012; 38: 1647–1653.
- Van Aken H, Mellin-Olsen J, Pelosi P. Intensive care medicine: a multidisciplinary approach *Eur J Anaesthesiol* 2011; 28: 313–315.
- Wunsch H, Angus DC, Harrison DA, *et al*. Variation in critical care services across North America and Western Europe. *Crit Care Med* 2008; 36: 2787–2793.

Respiratory intermediate care units and weaning units

- Ambrosino N, Venturelli E, Vagheggini G, *et al*. Rehabilitation, weaning and physical therapy strategies in chronic critically ill patients. *Eur Respir J* 2012; 39: 487–492.
- Corrado A, Roussos C, Ambrosino N, *et al*. Respiratory intermediate care units: a European survey. *Eur Respir J* 2002; 20: 1343–1350.
- Lone NI, Walsh TS. Prolonged mechanical ventilation in critically ill patients: epidemiology, outcomes and modelling the potential cost consequences of establishing a regional weaning unit. *Crit Care* 2011; 15: R102.
- Pilcher DV, Bailey MJ, Treacher DF, *et al*. Outcomes, cost and long term survival of patients referred to a regional weaning centre. *Thorax* 2005; 60: 187–192.
- Scala R. Respiratory high-dependency care units for the burden of acute respiratory failure. *Eur J Intern Med* 2012; 23: 302–308.

Home mechanical ventilation

- Farre R, Lloyd-Owen SJ, Ambrosino N, *et al*. Quality control of equipment in home mechanical ventilation: a European survey. *Eur Respir J* 2005; 26: 86–94.
- Heinemann F, Budweiser S, Jörres RA, *et al*. The role of non-invasive home mechanical ventilation in patients with chronic obstructive pulmonary disease requiring prolonged weaning. *Respirology* 2011; 16: 1273–1280.
- Lloyd-Owen SJ, Donaldson GC, Ambrosino N, *et al*. Patterns of home mechanical ventilation use in Europe: results from the Eurovent survey. *Eur Respir J* 2005; 25: 1025–1031.

Extracorporeal ventilation

- Kluge S, Braune SA, Engel M, *et al*. Avoiding invasive mechanical ventilation by extracorporeal carbon dioxide removal in patients failing noninvasive ventilation. *Intensive Care Med* 2012; 38: 1632–1639.
- Zanella A, Scaravilli V, Grasselli G, *et al.* Extracorporeal membrane oxygenation. *In:* Ferrer M, Pelosi P, eds. New Developments in Mechanical Ventilation. *Eur Respir Monogr* 2012; 55: 133–141.

Education in intensive care medicine

- Artigas A, Pelosi P, Dellweg D, *et al*. Respiratory critical care HERMES syllabus: defining competencies for respiratory doctors. *Eur Respir J* 2012; 39: 1294–1297.
- Artigas A, Vassilakopoulos T, Brochard L, *et al*. Respiratory Critical Care HERMES: a European core syllabus in respiratory critical care medicine. *Breathe* 2012; 8: 217–229.
- Buckley JD, Addrizzo-Harris DJ, Clay AS, *et al*. Multisociety task force recommendations of competencies in pulmonary and critical care medicine. *Am J Respir Crit Care Med* 2009; 180: 290–295.
- European Society of Intensive Care Medicine. CoBaTrICE: in international Competency Based Training programme in Intensive Care medicine. www.cobatrice.org/en/index.asp

- Pastores SM, O'Connor MF, Kleinpell RM, *et al*. The Accreditation Council for Graduate Medical Education resident duty hour new standards: history, changes, and impact on staffing of intensive care units. *Crit Care Med* 2011; 39: 2540–2549.
- Whereat SE, McLean AS. Survey of the current status of teaching intensive care medicine in Australia and New Zealand medical schools. *Crit Care Med* 2012; 40: 430–434.