Hans Flaatten, Rui P. Moreno and Andrew Rhodes

Introduction

Medicine used to be simple, ineffective and relatively safe. It is now complex, effective and potentially dangerous.

(Professor Sir Cyril Chantler)

Since its beginnings not more than half a century ago, intensive care medicine has undergone remarkable changes. It is now considered to be a "standard of care", and most hospitals worldwide have one or more intensive care units (ICUs) within their structure.

The citation above is more than anything else an excellent summary of the developments in our field of medicine. In addition, one is tempted to add that medicine once used to be inexpensive, and now it has become quite expensive. Many countries use around 10 % of their gross domestic product (GDP) for medical care in general, and up to 25 % of a hospital's budget has been reported to be used on intensive care and intermediate care, due to the very labour-intensive characteristics of these units. It is no wonder that funding agencies, governmental bodies and others have begun to ask the question as to whether we get "value for money" from medicine in general, and in particular from intensive care medicine.

Notwithstanding these high costs, it is important to understand the dynamics of the current population changes and to anticipate an increase in the number of patients requiring intensive care. A closer look at the probable demographic changes for the coming 15–20 years shows that the most striking change will be the increase in the cohorts above 70 years of age. Since the aged population at present is the largest consumer of intensive care resources, this demand can easily exhaust the current capacity in most countries. This is a particular challenge, because research shows that the elderly population also benefit from intensive care, although their ICU and hospital mortality rates are higher, and their hospital stay remains longer in comparison with their younger counterparts. This can easily generate a large ethical dilemma concerning how much of these ICU resources can we afford to use in regard to the very old patients above 80 years of age.

Although intensive care is in fact very similar from hospital to hospital, there are several important differences. Organisation varies con-

siderably, and this is often a consequence of the type of medical speciality or specialities from which it is anchored. In some countries nearly all ICUs "belong" to one speciality, as is the case in the Scandinavian countries, while in others there exist both "medical" and "surgical" ICUs with different bonds within the same hospital. A further consequence is that education of intensive care physicians and nurses differs; and not necessarily to the same standard even within one region.

Intensive care produces a high number of survivors, usually with an acceptable quality of life. The cost for an additional surviving year is not very high, and is often less than prescribing a number of drugs e.g. for any cardiovascular disease. These facts are in particular important to highlight in the future. In addition, a formidable challenge is to produce intensive care in a more cost-efficient way; probably, the best way will involve the capacity to afford the increase in services needed on a budget that is close to the limit. In this context, the use of resources like personnel is probably one of the most important factors. Another important factor is to use new technologies, devices, and drugs in a more cost effective manner.

A major difference between different regions is the availability of ICU beds. Even between countries on the same economic level, the availability differs 5 to 10-fold from the "bottom" to the "top". This is of importance since the availability of ICU beds seems to impact the quality of the outcome. One of the biggest costs to the ICU budget, is the one related to staffing, which often attributes as much as 75% of the overall running expenses. It is interesting, therefore how much staffing of the ICU varies within a reported range of nurse to patient ratios from > 1:1 up to 1:3. Some units are only staffed with specially trained ICU nurses, while others also employ respiratory technicians, physiotherapists, pharmacists and other health personnel.

The availability of enough personnel to work in our ICUs will probably become a major problem in the future. The demographic changes in most western European nations will not only lead to an increase in the numbers of elderly people, but it will simultaneously decrease the number of young people available to dedicate their life to careers for the health service. The competition for health care workers such as nurses will be very hard, and in particular our labour-intensive ICUs will be quite vulnerable to this phenomenon. Even the well-situated countries will be confronted with a probable lack of qualified personnel. As the prime minister of Norway recently commented: "It is not doctors and nurses we pump up from our oilfields". Other countries do not even have any oil to pump and will not be able to cope with this increase in costs.

All of the above will be important issues for the delivery of intensive care in the future. It is also of great importance to make intensive care more visible within the structure of European health care. As of today, there are no references at all to intensive care or critical care within the medical content of the European directive on the recognition of professional qualifications (EU Directive 2005/36). It has been suggested to make intensive care a medical field of "particular qualification" within this directory, but this is still not in operation.

Like to all fields of medicine, the coming 15–20 years will bring additional challenges to our "speciality". First, there is a growing acceptance that the part of a country's GDP used on health care has reached its limits. It is not self-evident that spending more money on health care will necessarily improve public health; it is possible that investment in other areas of the society will pay off more. This will obviously hit intensive care medicine, since this involves an expensive treatment, reported to range from below 1000 € to more than 3000 € per day in the ICU.

To this end, understanding the organizational challenges of intensive care medicine is a key issue in providing more cost-effective intensive care. We hope that this book may provide the reader with in-depth knowledge of important aspects related to how the ICU functions and how it should be managed. We also hope the information here may be of help to shape ICUs for the future, by discussing further important and highly relevant themes which are related as well to the structure, work-flow and outcome after intensive care.

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A. Concepts

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What is an ICU?

Introduction

Intensive care medicine (ICM) is the science and the art of detecting and managing critically ill patients while preventing further deterioration, in order to achieve the best possible outcomes. Delivering high-level quality care to these patients demands the perfect match of two factors:

- An open and holistic approach from the intensivist, looking to detect, evaluate, integrate and develop a set of priorities and objectives of care for the patient, both in the short, medium and long term;
- A dedicated area, in which all monitoring and therapeutic devices required are immediately available, together with a large, multidisciplinary, highly specialised team of professionals, with a high nurse-to-patient and physician-to-patient ratio: the intensive care unit (ICU).

Even today, at a time in which critical care knowledge and skills are increasingly required and used outside the ICU, from pre-hospital care to long-term follow-up clinics (a process that Ken Hillman immortalised with the words "critical care without walls" [1]), the ICU is still needed as an independent unit inside the hospital.

From the concept of high-vigilance bed to the first intensive care units

The nurse Florence Nightingale was best known as 'the lady with the lamp' for her habit of making rounds at night to tend to injured soldiers during the Crimean war (Oct. 1853–Feb. 1856). Perhaps her most important contribution towards the development of intensive care medicine was her recognition of the fact that some patients needed more frequent and careful monitoring than others. As a consequence she started to place these patients closer to the nursing station [2]. This insight also appeared in the late 19th century in other places of the world [3]. Subsequently, as a consequence of the treatment of respiratory failure associated with the 1952 Copenhagen poliomyelitis epidemic [4, 5], hospitals started to create the first spaces specifically designed and adapted to provide this kind of organ support. The introduction of this new branch of medical science (both physiological and technological) quickly required the development of a new setting for these skills and the subsequent creation of a designated area in the hospital, known today as the ICU.

This area of the hospital was conceived to provide continuous monitoring and high-intensity

therapy, as required, for instance, in the case of those patients with poliomyelitis needing artificial ventilation, the replacement of a physiological function (in this case respiration). This represented an organisational revolution for hospitals, as we argue in another chapter of this book (see chapter A "Interfacing the intensive care unit and evaluating it – admission and discharge policies"). What followed in the development of intensive care medicine is well known: Vladimir Negovsky [6], Peter Safar, Max Harry Weil, amongst others, created the science of reanimatology [7] in the late 1950s and early 1960s, of which we are the heirs. These pioneers together with subsequent generations of clinicians and nurses have continued to develop new knowledge and skills as well as the technology required to transform this diverse series of competencies into an integrated package of care, now known as the art and science of intensive care medicine.

The ICU of today

Given the objectives and scope of intensive care, the ICU is critically involved with many areas and specialties within the hospital. The location chosen for the ICU, however, commonly reflects the need for proximity to the more acute areas such as the emergency department and operating theatres, as well as required diagnostic facilities such as the radiology department, minimising the distances that critically ill patients have to be transferred. In addition, the availability of biological tests 24 hours a day, 7 days a week, and easy access to blood transfusion facilities are mandatory. Most ICUs today have facilities and equipment located within the unit to perform immediate analysis of arterial blood gas samples and some basic biochemistry and haematology.

Since most situations in intensive care medicine are critically time-dependent, the successful provision of care is reliant on good relationships and communications between the ICU and the other services and departments of the hospital; this is required both for optimising the timing of referrals and admissions of the patients to the ICU and for the safe and effective discharge of patients to a less intensive area of the hospital, a process in which the monitoring of resolving organ dysfunction/failure is very important [8]. A higher level of vigilance with respect to these recently discharged patients by both ward doctors and nurses is necessary to identify and prevent any deterioration early; failure to do so can compromise all the benefits of the ICU stay [9, 10]. Another risk to the recovering intensive care patient is inappropriate early discharge to the ward, due to lack of beds or time constraints [11], and although this is controversial [12, 13], it has been demonstrated that there is room for improvement [14]. This need for an effective interface between the ICU and the other departments of the hospital not only has physical and architectural implications, it also has a crucial impact on human resource factors, both outside and inside the ICU, on stress management, professionalism in facing and coping with rotating working patterns [15], and fatigue [16, 17]. All these issues are now being addressed and disclosed, an attitude that was virtually unthinkable a couple of decades ago and that will have a major impact on the organisation of our work.

The fact that the last European recommendations on minimal requirements for intensive care departments [18] were published in 1977 (and are just being revised this year), in a field that changes so quickly, indicates how low this has been on the scientific agenda of intensive care professionals as well as the political agenda of regulatory agencies and healthcare managers. Fortunately, in most European countries some recommendations are in place, although usually limited and locally designed, not integrated, and developed using less than optimal consensus techniques.

The concept of levels of care

The concept of levels of care (LOC) was initially proposed by Lockward in 1960 [19] and defined for the first time by a National Institute of Health (NIH) consensus conference on critical care medicine, the Bethesda Conference in 1983 [20]. Based on differences in staffing, available technology and professional organisational structures of the ICUs, the Bethesda Conference proposed the division of intensive care facilities into four groups: intensive care, high care, medium care, and low care (usually no longer considered an ICU).

Two main criteria were used in this classification: the availability of technological resources (type and intensity of use of specific monitoring

and therapeutic interventions) and the availability of human resources (training and coverage by medical leadership and nurse-to-patient ratio). Underlying this classification was the concept of complexity of care: patients were moved around the system according to the complexity of the care they needed at a given point in their hospital stay.

On the European side, also during the 1980s, a task force of the European Society of Intensive Care Medicine chaired by Dinis Miranda considered this classification insufficient for purposes of organisational and policy-making decisions [21]. Arguing that it did not provide sufficient information for comparing ICUs and was inadequate for purposes of effective regionalisation of intensive care, this task force proposed a new classification based entirely on the amount of nursing manpower required by the patients: three LOC were proposed, level I with a patient/nurse (P/N) ratio of 4:1, level II, with a P/N ratio of 2.5:1 and level III with a P/N ratio of 1:1. The rationale behind the choice of this criterion was that the nurses represent the largest part of the fixed resources allocated to ICUs and consequently was the most comparable element of the permanent staff of an ICU. Also, despite the fact that the use of nursing staff is dependent on the various activities provided to each patient in each ICU, these activities depend to a large extent on the number and typology of the admitted patients and on the standing practices and policies of care in each ICU. Consequently, nursing workload can be seen as the most important and quantifiable limiting factor in the provision of care inside the ICU. Several years later, this concept developed to integrate the fact that inside the same ICU co-existed patients requiring different P/N ratios. Thus, ICUs should be classified by the mean level of care they provide and not by the maximum amount of care that can be provided (as is the case if the type and amount of available technology is used to classify ICUs) [22].

This methodology was subsequently tested by Dinis Miranda et al. in a large national study in the Netherlands at the beginning of the 1990s [23]. In this study, three LOCs were identified after determining the P/N ratios for the participating ICUs. These LOCs correlated with the size and type of hospital in which the respective ICUs were operating and discriminated significantly for the different medical activities developed in each LOC. Another interesting finding was that when comparing units under the classical definition of intensive, high and medium care that ICUs classified as 'medium care' could have a larger organisation and provide a greater frequency and intensity of care than other ICUs identified as 'intensive care'. One important implication of this was the inappropriate allocation of staff to some units and the resulting mismatch between available and required resources.

A further development of these concepts was derived from the analysis of the database of the Foundation for Research on Intensive Care in Europe (FRICE) concerning data collected during a Concerted Action of the Biomed 1 Program of the Commission of the European Communities, called EURICUS-I (BMH1-CT93-1340), addressing the effects of organisation and management on the effectiveness and efficiency of ICUs in Europe [24]. This database included data from 89 ICUs in 12 European countries. In this study the evaluation of the use of nursing manpower was done using the Nine Equivalents of Nursing Manpower use Score (NEMS), developed and validated for this specific purpose [25]. Since the Therapeutic Intervention Scoring System (TISS) had been demonstrated to be accurately related to the amount of nursing workload used [26] and NEMS previously shown to be highly related to TISS [25], they share the same limitation: they measure the amount of nursing workload used and not the amount of nursing workload required or the appropriateness of their use. This could be seen as a limitation of all methods of ICU classification and evaluation based on nursing workload use. Based on the available number of nurses, on the amount of work one nurse can perform in each shift (the equivalent of 46 NEMS points in 24 hours) and on the amount of NEMS points used during the study period, the efficiency of nursing manpower use was evaluated by the work utilisation ratio (WUR) [27]. This measure can be defined as the ratio between the produced workload and the available workload in the ICU, and is computed as:

$$\text{Work utilisation ratio} = \frac{\Sigma \text{ NEMS points used during one year}}{\text{Number of nurses} \times 200 \times \frac{46}{3}}$$

in which 200 is the annual number of working days for each nurse, 46 is the maximum number

of NEMS points a nurse can perform in a day and 3 is the usual number of nursing shifts (8 hours) per 24 hours.

During the same study, the planned level of care of the ICUs was computed based on the appointed number of nurses in relation to the number of beds. Briefly, the planned number of beds to be assisted by one nurse (planned patient/nurse ratio) was computed for each ICU according to the formula:

$$\text{Number of beds assisted by one nurse} = \frac{A \times B \times C \times D \times E}{F \times G}$$

Therein:

A: Number of shifts per day (set to 3)
B: Number of beds in the unit
C: Number of days the unit is operating per week (set to 7)
D: Occupancy rate (set to 85%)
E: Extra manpower for holidays, illness, etc. (set to 25%, i.e. E = 1.25)
F: Number of nurses in the ICU
G: Number of days that each professional is working per week

Based on these data, the three LOC proposed by the Bethesda Consensus Conference meeting [20] were computed and compared with the operative level of care of the ICUs, computed for each ICU by dividing the number of NEMS points equivalent to the nursing activities of one nurse per shift (46 daily points) by the mean value of daily NEMS in the ICU during the study period.

This work has the advantage of replacing a subjective classification with a more objective system (to distinguish what is "limited invasive monitoring" from "all necessary invasive and non-invasive monitoring" [20] as proposed by the Bethesda classification?). Moreover, the classification of ICUs according to the complexity of care defines each LOC as an area of "medical competence of care". Accordingly, with this criterion some ICUs should have the competence for the implementation of all techniques and therapies, others only for a limited set of them. This distinction is against the rationale behind the concept of good practice of intensive care regardless of the level of care. The development of intensive care medicine in Europe is based on the concept that intensive care should be practised where and when necessary, by professionals with the right amount of knowledge and skills. In 1998 it was proposed that the limiting factor on the practice of intensive care at ICU level is the amount and not the complexity of the work that can be performed. This concept implies that two ICUs with the same amount of nursing manpower available may treat groups of patients with different severity of illness (requiring care of distinct complexity) if other variables such as occupancy rate and/or length of stay are also taken into account. This is nothing different than what happens in daily practice, when the degree of physiologic derangement and the complexity of the patients usually decrease over time during the ICU stay. Therefore, one ICU operating at a low LOC may be able to treat a newly admitted patient requiring much more nursing care than the average patient on that ICU. It is the overall daily amount of work (which depends on the total number and the relative proportion of patients in each category) that limits the provision of more differentiated (and more nursing workload-consuming) care [22]. The application of this concept also helps managers to address the goal of the classification of ICUs into LOCs: in order to match demand and provision of resources. Finally, being easily quantifiable, it allows for evaluation and comparison of the planned versus the operative levels of the ICUs, which is nothing more than the effectiveness of the use of nursing workload resources in each ICU. In any case, the most adequate patient-to-nurse ratio for each patient and each clinical condition should be found, or we may otherwise end up with unacceptably high rates of nosocomial infections, mortality, postoperative complications, and unplanned extubations [28]. As in all domains of life, the right balance, the optimal match between what is needed and what must be provided is the key, not always identifiable but crucial to the system, defined by Donabedian as the point of optimal balance between cost and effectiveness. It is also important to conceptually separate two important concepts that are unduly mixed in the current classification of ICUs: operative capability and medical competence. Operative capability is a continuous measurement that can be lower or higher than the average for any given ICU. Medical competence is a rather dichotomous question (yes/no), that must be evaluated by the standing professional regulatory