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Intensive care medicine in resource-limited settings: a general overview

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Summary

This introductory article gives an overview of intensive care medicine in developing countries and contrasts its development with high-income countries. The second part of this manuscript aims to give the reader a general overview of the basic aspects and requirements of ICUs and intensive care medicine in resource-poor settings.

WHAT IS INTENSIVE CARE MEDICINE?

Intensive or critical care medicine refers to the medical specialty which focuses on the management of critically ill patients. Critical illness describes a general state which may arise from various medical pathologies (e.g. trauma, infection, acute coronary syndrome, stroke etc.) and leads to the impairment of vital (consciousness, circulation or respiration) or single organ functions (e.g. kidney or liver function). Furthermore, intensive care includes the care of patients after major surgery or the observation of patients in whom critical illness may rapidly occur.

INTENSIVE CARE MEDICINE IN RESOURCE-POOR SETTINGS

In Western countries, the first intensive care units (dedicated hospital wards where intensive care medicine is practiced and critically ill patients are cared for) were established in the 1950s and 1960s following the last European polio epidemics.[1] Since then the number of intensive care units (ICUs) has grown steadily and intensive care medicine has gained importance as a medical specialty in its own right. The majority of acute care hospitals in high-income countries now run one or more ICUs. The most frequent pathologies leading to ICU admission in Western countries are cardiovascular diseases, major surgery, sepsis and respiratory failure.

Although the first ICUs were introduced to select resource-poor settings shortly after intensive care medicine started to develop, the majority of critically ill patients in less developed countries, harboring around two thirds of the world population, still do not have access to intensive care.[2] Few data exist on the current state of intensive care medicine in less developed countries, but there seems to be wide variability in the availability of ICUs in these countries, ranging from non-existent to sophisticated centres in selected private hospitals catering for a few privileged patients. Recent data from the Republic of Zambia revealed that only 29 ICU beds exist for the entire country of 12.9 million people and only 7% of hospitals providing surgical services run an ICU. Even in those hospitals with ICUs, basic equipment is lacking and an oxygen supply is only inconsistently available.[3] Similar data were reported from other African or Asian regions.

In countries like Bangladesh, India and Nepal, there has recently been an important increase in the availability of intensive care units, although shortage in staffing, lack of basic equipment, poor maintenance of equipment and interrupted supplies often pose major challenges. In addition, the medical profession in less developed countries is, in general, not set up to provide formal training in intensive care medicine. Knowledge about important recent progress in the field is frequently absent. These factors inevitably result in a lack of recognition of intensive care medicine as a medical specialty in resource-poor settings. As a consequence, disproportionately high mortality rates have been reported for selected critical illnesses in developing countries.[4]

DIFFERENCES IN INTENSIVE CARE MEDICINE BETWEEN HIGH INCOME AND RESOURCE-POOR SETTINGS

Intensive care medicine between Western and less developed countries not only differs in equipment and material availability, but also in the patient populations treated in the ICU.[5] In less developed countries critically ill patients admitted to the ICU are characteristically younger, suffering from less premorbid conditions. The underlying diseases leading to ICU admission in resource-poor areas differ geographically from those seen in high income countries. While in Northern developing countries (e.g. central Asian countries) ICU admission diagnoses are similar to those reported from high income countries, tropical and infectious diseases are among the leading causes of critical illness in developing countries in South Asia, South America and Africa. Trauma and sepsis are far more common in ICUs of developing than Western countries. Disease severity at ICU admission is typically higher in resource-poor settings, while the number of interventions and procedures performed is smaller compared to critically ill patients admitted to ICUs in high income countries. Irrespective of the ICU admission diagnosis, mortality rates of critically ill patients are consistently higher in less developed than in high income countries.[5]

ICU STAFFING

An ICU needs the presence of well trained and

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experienced ICU workers 24-hours-a-day, 7-days-a-week. An ideal ICU team consists of nurses, specially trained in intensive care medicine, one or more intensivists (physicians specialized in providing intensive care medicine) and a variable number of nurse assistants, technicians and cleaners. In many resource-poor settings, the role of the intensivist is taken over by a nurse anaesthetist or an anaesthetic clinical officer. This is a practicable and legitimate policy since maintenance and restoration of vital functions is one of the key fields of anaesthesia. If the intensivist is not a medical doctor, it is advisable that a physician is available to assist in the care of the critically ill patient's underlying disease. Ideally, the intensivist in charge should be a physician specially trained in intensive care medicine. In some Western countries (e.g. the United Kingdom), specialized postgraduate training programs for intensive care medicine exist. In addition, diplomas in intensive care medicine can be taken from international intensive care societies (e.g. the European Society of Intensive Care Medicine).

Due to the wide-ranging lack of health care personnel and qualified staff in many resource-poor settings, the anaesthetist/physician caring for the ICU often has to fulfill additional medical duties in the operation theatre or hospital, particularly at night and during weekends. This frequently leaves the ICU unattended by an intensivist and places more responsibility on the ICU nurses, making them the key players of the ICU team. Trust and good communication with the intensivist in charge, as well as continuous education, adequate training and a strong team spirit, are of outstanding importance for ICU nurses in resource-poor settings.

ORGANIZATIONAL ASPECTS OF AN ICU

An ICU can be organized in different ways. Larger hospitals in particular often run specialized ICUs caring for critically ill patients with selected diseases; for example surgical, pediatric, neurosurgical, cardiac, medical or burns ICUs. Although this may have some benefits for certain patient populations, recent data indicate that multidisciplinary ICUs caring for patients with different pathologies may result in better care. In any case, it is important to understand that caring for a critically ill patient, irrespective of the underlying disease, must include an interdisciplinary approach, involving integration of physicians from other medical specialties such as neurologists, surgeons or pediatricians. Mutual respect is a prerequisite for fruitful interdisciplinary communication.

In a *closed ICU* one or more intensivist is principally responsible for the care of all patients admitted to the ICU. This organizational structure is in contrast to the *open ICU* where different physicians, who are not continuously present in the ICU, care for single critically ill patients. Organization of ICUs as closed units, including the presence of a an intensivist, has been shown to result in lower mortality, less complications, a reduced length of ICU stay and lower costs, when compared to open ICUs.[6] If hospitals are too small to implement a 24-hour intensivist service, telemedical assistance by external intensivists may be used to support decision making and patient care.[7] Although most reports on intensive care telemedicine originate from high-income countries (the United States and Australia), personal experience of the author suggests that regular (e.g. weekly) telemedical counseling by experienced intensivists can be a valuable tool to improve patient care in ICUs in resource-limited areas.

CONSTRUCTIONAL ASPECTS OF AN ICU

Even though intensive care medicine can be supplied under several circumstances and at various locations, an ICU in a resource-poor setting has certain constructional requirements. Non-leaking roofs, closable windows/doors, solid walls and, whenever necessary, a functional heating system must be available to protect patients and staff from adverse climate influences. Floors and walls should be easily washable to allow effective cleaning. Light and a stable electricity supply are further indispensable prerequisites to run an ICU. Stable electricity supply, on the one hand, includes the availability of a power generator (e.g. driven by gasoline or diesel), providing electricity in case of power cuts. On the other hand, in many resource-poor settings, voltage stabilizers need to be placed in the main electrical line supplying the ICU, in order to prevent voltage peaks that may damage delicate medical apparatus such as mechanical ventilators or patient monitors.

Figure 1. *Intensive care unit in a rural African hospital - 1, patient monitor; 2, suction machine; 3, oxygen concentrator; 4, mechanical ventilator; 5, mosquito net.*

Running water with a constant supply of soap is essential to reduce cross-infection between critically ill patients. In areas where malaria and other insect-transmitted infectious diseases are endemic, mosquito nets should be available for each ICU bed to protect patients from insect bites during evening and night times (Figure 1). Air filtering and room climatization are not essential, but can greatly help to maintain clean air and adjust room temperatures and air pressure to patient needs. Although no scientific data have so far proven that isolation of patients with resistant bacteria, such as methicillin-resistant *Staphylococcus aureus*, can reduce transmission of these bacteria to other patients, an ICU should include a room to isolate patients. For certain infectious diseases, such as open pulmonary tuberculosis or certain viral haemorrhagic fevers, isolation is obligatory. When spatial isolation is required, the patient should not be in isolation from medical and nursing care. The nurse base, an integral part of the ICU, should be placed centrally and allow full sight on as many ICU beds as possible (Figure 2).

OXYGEN, PRESSURIZED AIR AND SUCTION

One of the most important drugs required in the ICU is oxygen. Oxygen can be stored and supplied in various ways. Oxygen

Figure 2. *View from the nurse base of a Mongolian ICU.*

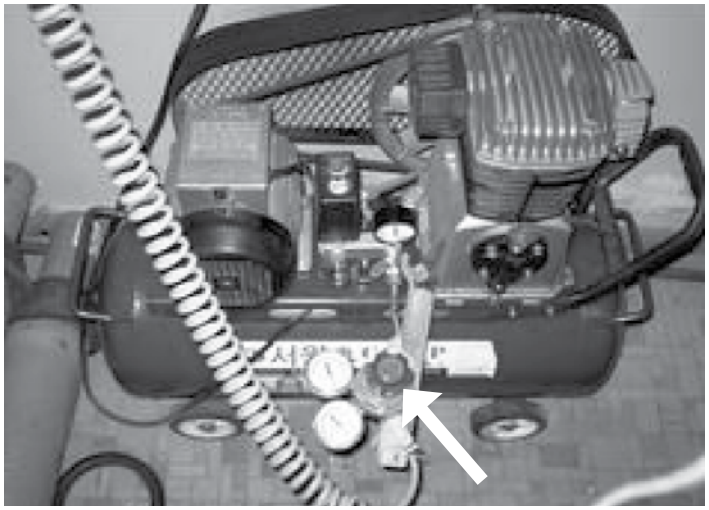

Figure 3. *Air compressor supplying the pressurized air system of a Mongolian ICU, with the pressure regulator indicated by the white arrow.*

concentrators provide 90-100% oxygen but rely on a constant electricity supply and usually do not provide oxygen flows higher than 4-6L.min^{-1}. While this is sufficient to treat neonates and infants with respiratory insufficiency, in many cases it is inadequate to oxygenate larger children or adults with respiratory failure. In contrast, oxygen cylinders can provide pure oxygen at high flow rates and are independent of electricity supply, but need to be replenished at regular intervals. This must be addressed in advance before the last cylinder has emptied, leaving the patient with respiratory distress without oxygen. Central oxygen systems are the most efficient and convenient way to store and supply ICUs with oxygen. The source of oxygen of a central oxygen system can either be a special oxygen tank storing oxygen at low temperatures, or a bank of oxygen cylinders. Both of these require regular maintenance and replenishment. The tubing of the pressurized oxygen system must consist of a non-oxidizing material, typically copper. In countries where no professional companies offer installation of medical air systems, refrigeration engineers usually have sufficient experience in installing copper/pressurized gas lines.

Pressurized air, used to run mechanical ventilators, can similarly be administered either by direct connection of a compressor to the mechanical ventilator or preferably by connecting a compressor to a central air system, providing pressurized air through single outlets at each ICU bed. Although specific medical air compressors exist, oil-free industrial compressors, with a pressure regulator as well as additional air filters, provide comparable air qualities. These are more easily affordable in resource-poor settings (Figure 3). Where oil-free compressors are available air filters need to be placed in the air lines and before air enters the ventilator. Although oil spilling into the patient's respiratory system is the by far most relevant danger, more frequent complications are acute blockade of line or air filters in the ventilators. Central suction units may be connected to the pressurized air system, but usually depend on special suction generators, which can be cumbersome to find and install in resource-limited areas.

BASIC RESOURCE REQUIREMENTS OF AN ICU

Although intensive care medicine, above most other medical specialties, relies on technical devices and material resources, it is crucial to consider that no apparatus can replace an alert ICU worker at the bedside. Nonetheless, certain technical devices are required to support the work of the ICU staff. These typically include patient monitors, suction machines and mechanical ventilators. While patient monitors measuring ECG, respiratory rate, arterial blood pressure and oxygen saturation should be available at each bed, suction machines and mechanical ventilators can be used specifically for patients in need of these devices. The technical aspects of mechanical ventilators must be considered, because the majority of available ventilators depend on a dual supply of pressurized oxygen and air. In ICUs where neither pressurized air nor adequate stores of pressurized oxygen are available, only ventilators with internal air compressors together with an external oxygen source (e.g. from an oxygen concentrator or an oxygen cylinder) can be used.

Infusion and syringe pumps allow drugs and fluids to be administered at exact rates and dosages, but, in the clinical practice of resource-poor settings, may well be replaced by mechanical drop regulators or close clinical surveillance by a nurse. Any device not depending on electricity increases patient safety during power cuts, particularly when vital drugs (e.g. catecholamines) are infused. Despite being a life-saving intervention, renal replacement therapy in patients with acute kidney failure is usually unavailable in resource-poor settings. Given that neither intermittent hemodialysis nor continuous hemofiltration is superior in terms of patient survival, and that hemofiltration is more time and resource-consuming, intermittent hemodialysis is the technique of choice to treat patients with acute kidney failure in resource-poor settings. Although data on the use of peritoneal dialysis in critically ill patients with acute kidney failure are conflicting, peritoneal dialysis may be an option if local experience is available.

Similarly, a basic set of essential disposable materials, drugs and laboratory tests need to be available to adequately and safely care for critically ill patients. These sets usually do not need to include high-end materials or a large variety of drugs or tests, but should focus on the basic needs of critically ill patients treated in the respective ICU. Furthermore, small numbers of essential materials, drugs and tests warrants expert use by the ICU staff and facilitates stock maintenance.

THE ICU'S PLACE IN A RESOURCE-POOR HOSPITAL

Intensive care medicine is an integrative medical specialty, requiring close cooperation with several other medical disciplines and technical services (e.g. laboratory services, blood bank etc.) in the hospital. Therefore, to assure adequate and efficient care of critically ill patients, other medical departments and hospital services need to be prepared and trained to manage the needs of critically ill patients.[2,4]

Since ICUs in resource-poor settings are either non-existent or have only recently been established, acceptance of ICU services among colleagues from other medical specialties (who have so far cared for critically ill patients on the hospital ward) is a frequent problem. After establishing an ICU in a resource-poor hospital, referral and admission rates are often low. If patients are admitted this typically occurs at a pre-terminal stage, where ICU interventions may fail to safe the patient's life. This can lead to a perception amongst ward staff and relatives that patients are transferred to the ICU to die. Integration of ward physicians into ICU care (e.g. during daily rounds or regular discussions at the bedside), together with education of the hospital staff about when to admit patients to the ICU are ways to increase acceptance of newly established ICU services in resource-poor hospitals.

When ICU services are well-established and accepted, unavailability of ICU beds is a far greater problem. ICU bed capacities need to be coordinated with the emergency department and the operation theatre at regular intervals each day. From a practical standpoint, ICUs should always have the capacity to admit unplanned critically ill patients. This can be organized by leaving one ICU bed in the hospital unoccupied or having the facility to discharge one patient rapidly to an appropriate hospital ward.

INTENSIVE CARE MEDICINE 'WITHOUT WALLS'

Provision of intensive care medicine is not only restricted to the ICU. In order to prevent patients being admitted too late, after they have developed irreversible shock or organ failure, the intensivist can play a valuable role in assessing patients before ICU admission (e.g. in the operation theatre or the emergency department) or after ICU discharge (post-ICU review). In several hospitals, intensivists play a key role in resuscitation teams or medical emergency teams. The function of these teams within a hospital is described in a later article. Implementation of medical emergency teams in hospitals of high-income countries reduced the rates of unexpected cardiac arrests on non-ICU wards.[8] In addition to providing resuscitation and emergency care, intensivists may further assist physicians from other medical specialties with certain clinical problems (e.g. prescription of parenteral/enteral nutrition, provision of palliative care, cannulation of central vessels or assessment of surgical and anaesthetic risks).

CONCLUSION

Intensive care medicine is a comparatively young medical specialty which has grown rapidly to become an essential component of modern hospitals. Many hospitals in resource-poor settings do not run ICUs and critically ill patients frequently receive suboptimal care with unacceptable levels of mortality. When implementing intensive care medicine in resource-poor settings several staff, constructional, organizational and resource aspects need to be considered.

Table 1. *Ten basic principles of intensive care medicine.*

1	No medical apparatus can replace the presence of an ICU worker at the bedside.
2	No diagnostic test can replace a thorough patient history, chart review or systematic clinical examination.
3	Supportive therapy is life-saving, challenging and may distract the intensivist's attention from searching for the underlying cause of critical illness. Always try to identify why a critically ill patient is sick and do everything to treat this condition.
4	Always ask why a patient is deteriorating or fails to improve. Never accept or explain treatment failures simply by disease severity.
5	Do not over-sedate. Only sedate agitated patients or those with certain diseases (intracranial hypertension, acute lung or circulatory failure).
6	Do not overhydrate patients. Although fluid resuscitation can safe lives in the acute phase, indiscriminate infusion of fluids at later stages leads to complications (e.g. sepsis), prolongs ICU stay and increases mortality.
7	Do no harm! Be aware that every intervention and drug applied in the ICU carries the potential to harm the patient.
8	As soon as the patient has stabilized do everything to reduce invasive support.
9	Always consider the therapeutic consequence before performing diagnostic tests (e.g. imaging studies).
10	Do not indiscriminately order laboratory tests but only measure these values where relevant and pathologic information can be expected.

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