Intensive care in the developing world

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Summary
Appropriate and sustainable intensive care practice is possible even in the resource-limited locations of sub-Saharan Africa. Data from seven sub-Saharan African countries indicates that the majority of patients served are surgical. Comparison between intensive care units is difficult due to lack of laboratory support, which precludes the severity sickness scores used internationally. Hospital mortality can be reduced by increasing nurse/patient ratios, adequate monitoring and initiating postoperative intermittent positive pressure ventilation when required. Equipment should include appropriate technology, for instance using oxygen concentrators and a ventilator not dependent on compressed gases or disposable circuits. The clinical officer anaesthetist has a major role to play in the intensive care team.

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Intensive care in a developing country where resources are limited is extremely challenging. The value of allocating increased nurse/patient ratios, appropriate monitoring and greater medical supervision to a percentage of hospital beds is equally valid in the resource limited location as any other, although the nature of possible therapeutic options and disease spectrum will be different to developed countries. Fenton et al. showed that 80% of peri-operative Caesarean section deaths occur in the postoperative period on the general ward, so it is appropriate to consider how to identify and observe these vulnerable patients at this critical time [1]. The disparity in the quality of care within developing countries is very wide [2], although in some private institutions, often in urban centres, the practice may be much the same as urban centres in the developed world. Twenty-nine of 31 countries lowest in the United Nations human development index are in Africa; in contrast to other developing regions, life expectancy in these countries has been falling in recent years (Fig. 1) [3].

This article will address the ICU provision in sub-Saharan Africa using our experience from St Mary’s Hospital Lacor, Uganda, as the principle example as it reflects the situation for a rural population in one of the most deprived regions of the world. The ICU challenge in this location must take on very different priorities and should not seek to copy the developed world.

General considerations in intensive care provision

Water and electricity
A regular supply of water and electricity cannot be guaranteed even in the capital cities of many developing countries and the situation is often worse in the rural areas, where up to 80% of the population live [4]. An irregular supply of water is not in itself a limitation to the ICU as hospital staff become adept at managing with a system of rationing and storing water on the wards. Cross-infection is no doubt more of a risk, but an acceptable standard of care can be given. An irregular electricity supply is a more serious problem, especially when oxygen concentrators are in use. Back-up generators in many hospitals provide an important source of power when main supplies fail, but this back-up may take a significant time to connect. Nursing staff must remain alert to this possibility if subsequent mortality and morbidity is to be avoided, especially for the ventilated patient. Monitoring equipment and ventilators are at risk of damage from voltage surges, which should be prevented. An irregular supply of water and electricity to a hospital is therefore not a complete bar to developing some ICU facility, but staff need to be trained to deal with the local conditions.

Oxygen
A recent survey showed that only 63% of anaesthetists in Uganda had oxygen available on a regular basis [5].
Providing a regular supply of oxygen cylinders to any hospital in rural Africa is both expensive and logistically difficult. The most important development in the last 15 years in oxygen supply is the oxygen concentrator [6]. Although the concentrator requires an initial capital outlay, the cost of oxygen production is then very low. A regular safe electricity supply is essential as well as technical support for maintenance.

Rational oxygen therapy is most practically guided by pulse oximetry but this technology is in short supply in rural sub-Saharan Africa. In a recent survey the absence of a pulse oximeter was the major reason for unsafe anaesthesia in Uganda [5]. An affordable and rugged pulse oximeter would be a major technical contribution to both monitoring in theatre and rational oxygen therapy in the wards [7].

### Equipment

There is evidence that mortality in ICU is related to the availability of appropriate technical equipment [8]. Any planning for an ICU facility must relate to the economic background of the community the hospital intends to serve. A clinical area where there is a rational use of oxygen, good basic nursing and monitoring may be the entry point and an inexpensive first step. An appropriate ventilator independent of compressed gases and disposable circuits is ideal. The Glostavent has been developed to answer these requirements and, in the authors’ view, the development has been very promising [9]. Invasive arterial monitoring and haemodialysis require a significant cost in disposables that make them beyond the scope of all except private hospitals in the major cities of sub-Saharan Africa, or university hospitals, where there is also a substantial patient cost-sharing input, and is unlikely to be an option in the rural areas of Africa for many decades.

### Staff

Trained nurses are vital for an effective ICU, but clinicians are rarely full time in the unit [10]. The nurse’s role often encompasses duties that may be regarded as medical duties in some countries, although they rarely have any financial reward for increased responsibility and workload. Specific training for ICU nurses in sub-Saharan Africa is very rare. Nurses who remain in these posts may be attracted by the challenge and remain particularly motivated. Identification of such nurses and encouragement for them to remain in post can enhance the general quality of care offered. Often the hospital administration fails to appreciate the specialist nature of ICU nursing and rotates nurses throughout all wards as a routine. This practice can be detrimental to establishing a core of locally trained and experienced ICU nursing staff. In the larger units in sub-Saharan Africa, physician anaesthetists provide the major medical input to ICUs. In the rural areas, where physicians of any speciality are very few, this responsibility often falls on non-physicians such as the anaesthetic clinical officers who may also be committed to a busy workload in the operating theatre [11]. Emphasis on intensive care in the training of anaesthetic clinical officers would be appropriate to prepare them for future developments in ICU for the rural areas.

### Supporting services

The quality of ICU care depends upon supporting laboratory and radiology departments. Haemoglobin, white cell counts, HIV testing, and blood transfusion capabilities are usually available in even remote areas of Africa but even in major cities of sub-Saharan Africa, blood gas, creatinine and serum electrolyte estimations are usually unavailable [12]. This affects clinical care as well as the ability to estimate international severity sickness scores, as will be discussed below.

Blood transfusion services are usually under great strain and fewer than 70 of the 191 member states meet the World Health Organization (WHO) recommendations for a national blood programme [13]. Microbiological services are very rare and often unreliable [14]. While many remote hospitals may have a basic radiology service, few have the ability to offer a portable service to the wards and the same is true of ultrasound imaging [15, 16]. Computerised tomography scans may be available in big urban centres but often require a significant patient cost-sharing contribution even when transfer from a rural area is logistically and financially possible.

### Cost and management

The per capita budget for healthcare in Uganda is £10 per year [5]. As with most developing countries, costs for inpatient treatment easily exceed the government
provision. Some form of formal or informal cost-sharing process or direct subsidy is necessary for standard hospital care, and when the cost of intensive care is added to this burden, then the clinician must consider the overall sustainability of the unit [4].

The limited data comparing ICU care in Africa and Europe show that the overall age of the African patient is younger and the prior health status better. Good outcomes from ICU in Africa are therefore more likely to result in a healthier patient with good economic potential [17, 18]. The HIV status of a patient does not have an effect on outcomes from intensive care if the reason for admission was not related [19, 20]. There are many ethical problems in treating ICU patients in a developing country which must also include the potential of financially impoverishing the patient’s entire extended family, particularly if in the end the result is death or a poor outcome. However, for carefully selected patients, the prospects for survival in ICU are much greater than care on the general ward, where one trained nurse cares for 70 patients or more, many of whom are seriously ill.

Severity scores
As the diagnosis of an illness alone does not necessarily indicate its severity, developed world ICUs now estimate illness severity by scoring several physiological and laboratory indices, producing a illness severity score which can be subjected to statistical analysis. Comparisons of scores between different units or emerging treatments allow useful data to be developed. The financial burden in Africa of expensive but ineffective therapies is even more relevant than in the richer countries and scores can give some approximate indication of outcome would be clinically useful.

The parameters of the current Acute Physiology and Chronic Health Evaluation (APACHE) score include blood gases, creatinine, and electrolytes, estimations which are rarely available outside the main urban centres of Africa [21]. It is therefore very difficult to estimate these scores for most areas in Africa. As a result, research comparing outcomes with the developed world or between different units within Africa, or even comparing different therapies within the same ICU, is not possible as clinical severity cannot be standardised. An alternative scoring system which relies on clinical indices alone has been developed and compared with APACHE 11 [22, 23]. More work needs to be done in this area to allow data from ICU units in Africa to be assessed more accurately.

St Mary’s Hospital Lacor Intensive Care Unit
St Mary’s Hospital Lacor, Gulu, in Uganda is a church-supported general hospital of 476 beds where 87% of patient costs are subsidised. It is in a remote rural area where for the last 20 years there has been a significant security problem. For 10 years it has had a small four-bed ICU near the operating theatre, which was recently upgraded to an eight-bed unit. The nurses and clinical officer anaesthetists are trained in central line placement and its interpretation. The central lines are donated. One Glostavent and one Puritan Bennet ventilator with an internal compressor are available. There are no infusion pumps and inotropes are rarely used. Laboratory results are slow to reach the ward and there is a limited quantity of bedside Glucostix strips. There is no capacity for peritoneal dialysis or haemodialysis as, despite significant overseas assistance, this specialist area has not been sustainable. There is no fresh frozen plasma, platelets, parenteral nutrition, activated protein C and no facility for invasive arterial monitoring.

The nurse-to-patient ratio is approximately one trained nurse to four patients, but assistant nurses who have no formal training are present on each shift. The surgical and medical teams share care with one physician anaesthetist and one non-physician medical clinical officer, both attached to the ICU full time. One non-physician anaesthetic clinical officer shares duties on the ICU with theatre duties.

Disease spectrum and outcomes
Figure 2 is a graph of diagnosis and outcomes from the ICU for an 18-month period of prospective data collection from July 2005 to January 2007 [24].

The overall mortality was 25%. Postoperative surgical patients were the main group benefiting from the ICU so the ICU is in practice a surgical ICU. This surgical emphasis has been noted in other published data from Burkina Faso, Nigeria, Malawi, Zambia, Tanzania and the Democratic Republic of Congo, and includes both urban and rural environments of Africa [10, 25–28]. Patients requiring postoperative surgical stabilisation, trauma, eclampsia, burns and foreign body in bronchi make up the major workload. In planning any new ICU in this environment it is therefore logical to site it close to the operating theatre.

During the period of data collection 56 patients were ventilated with 50% mortality (Figs 3 and 4). The group of postoperative surgical patients benefited most from this facility of intermittent positive pressure ventilation (IPVV), with a 44% mortality rate. The duration of IPPV in this group rarely exceeded 24 h. Most patients in septic shock did not survive.

Due to limited personnel and resources, head-injured patients admitted to ICU were not normally ventilated. Our outcomes compare favourably with published work from urban Zambia [28].
Tetanus remains a major challenge to the practice of intensive care in Africa. In developed countries where full ICU care is available the majority of patients with tetanus under 30 years should survive, although there is a mortality of 52% in patients over 60 years, even in the USA [11, 29]. Many patients require sedation and ventilation during their treatment. However, there are few hospitals in the rural areas of Africa where IPPV can be sustained to permit time for central nervous system recovery (often up to 4 weeks of ventilation required).

Magnesium without IPPV has been used effectively in Sri Lanka with good outcomes [30] and we have developed a regimen using magnesium and diazepam in both children and adults in an effort to avoid IPPV. Our overall mortality in tetanus was 63% in 30 patients; however, all six children in our series survived, four of

S.O., Medical Clinical Officer
A 40-year-old cachectic man was transferred to theatre with a diagnosis of volvulus having been admitted 6 h before. The history was 5 days of abdominal pain, abdominal distension and constipation. In theatre he looked severely dehydrated and had a blood pressure of 85/60 mmHg, pulse 125 beats.min⁻¹ and respiration rate 25 breaths.min⁻¹. Pulse oximetry was 93% on air. A catheter was passed and 400 ml of concentrated urine drained. A nasogastric tube was passed with drainage of 200 ml. He had received 2 l of normal saline while waiting on the ward. In theatre he was given oxygen by facemask and his saturations increased to 98%. A further 4 l of normal saline were given over the next hour in theatre. An internal jugular line was inserted and the central venous pressure measured −1 cm of water. Blood pressure increased to 110/70 mmHg and pulse reduced to 120 beats.min⁻¹. Anaesthesia was then induced using a rapid sequence intubation technique. Ketamine 75 mg and suxamethonium 100 mg were given followed by pancuronium 4 mg and anaesthesia was maintained with ether and air with added oxygen. The surgeon found a large volvulus of the colon and a necrotic segment, which he resected. The patient was given gentamicin and metronidazole as these were the only suitable available agents. During the operation the blood pressure fell to 60/30 mmHg and he was given 10 mg ephedrine without any effect and then 100 µg adrenaline, which returned the blood pressure to 100/60 mmHg. He was estimated to have lost 3 units of blood but only 1 unit was transfused in theatre as the bank was empty. At the end of the procedure, muscle relaxation was reversed using neostigmine and atropine. He appeared to wake from anaesthesia and had a fair tidal volume but was unable to lift his arms or his head from the bed and his oxygen saturation in air was 80% and in oxygen 94%. The anaesthetist was not happy to extubate and asked for advice from a senior colleague, who suggested transferring the patient to ICU for ventilation and to seek more blood. Serum electrolyte measurements were not possible as there were no reagents in the laboratory and there was no facility for blood gas estimations. A third generation cephalosporin antibiotic was stored in ICU and he was given a first dose on admission. Overnight ventilation was uneventful and he was given 2 more units of blood after blood donors had been found and 4 l of Hartmann’s solution. In the morning he had passed 1500 ml of urine and his blood pressure was 115/80 mmHg and pulse 110 beats.min⁻¹ and cardiovascular pressure (CVP) was 5 cm of water. He was alert and breathed well on removal from the ventilator and had warm peripheries. He was extubated after 1 h off the ventilator and another unit of blood given on the first day when his haemoglobin was found to be 7 g. The laboratory was still unable to measure serum electrolytes.
whom had received IPPV (age range 8–13 years). The significance of this good outcome in children is not clear but encourages energetic therapy in children if resources permit. All adult patients who failed to respond to initial magnesium and diazepam treatment and were ventilated died from generalised sepsis and multi-organ failure. Neonatal tetanus is generally thought to have a case fatality of 80%, which is similar to our experience.

Conclusions

The first ICU is reported to have started at the Kommunehospitalet Copenhagen, in 1953 by Dr Bjorn Ibsen, who made a remarkable contribution to the 1952 polio epidemic by realising that the patients were dying from respiratory failure, not overwhelming viral infection [31]. During the epidemic, 27 of the first 31 patients with respiratory problems died from respiratory failure. This mortality was reduced to 25% when Dr Ibsen instituted tracheostomy and manual IPPV using a to-and-fro system with a Waters canister. In 1953, critically ill patients were transferred to the recovery ward for his care from other parts of the hospital and respiratory support was one of the most important therapeutic interventions offered. In present sub-Saharan Africa the practice of intensive care is likewise in an early stage of development and it is possible it will follow this historical route, in which IPPV will be the first more complex therapeutic intervention offered to reduce postoperative surgical mortality. Post-operative surgical stabilisation is the most common group admitted to the ICU in published data from five sub-Saharan Africa countries. The anaesthetic clinical officer will be pivotal in initiating this transformation of care and current teachers must include educational resources to equip them for this challenge. As with many medical advances, appropriate technology will facilitate intensive care development. Affordable oxygen concentrators, oximeters and a ventilator that is not reliant on compressed gases or significant disposable circuits are the three technological tools upon which this transformation is possible. Nursing care at a better nurse/patient ratio, improved intravenous fluid management, rational use of oxygen, better pain management, blood product replacement, renal output monitoring in the early postoperative period, and respiratory support when required will be the foundation of ICU practice in rural sub-Saharan Africa. This model of primary ICU practice is sustainable with support from the surgeon and hospital management, and the anaesthetic clinical officer will play a key role.

References

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**Further reading**