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Outcome of mechanical ventilation in Central Africa

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Summary

The outcome of mechanical ventilation is reported in a prospective series of 200 patients managed in an intensive care unit in Zambia. Fifty two patients survived (26%), and 46 patients were subsequently discharged from hospital (23%). Ten patients died in whom a complication of ventilation was a factor. Patients not expected to survive by the authors had a 96.3% mortality whereas patients with a chance of survival had a mortality rate of 58.8%. Two diagnostic groups were found to have a high mortality: head injury (85.1%) and non-traumatic coma (76.4%). This series is compared with similar series from developed countries and recommendations are made for the institution of mechanical ventilation in the developing world.

Introduction

A number of studies have demonstrated that ventilation saves lives *(1–4)* in up to 50% of cases in the developed world. In these countries, the cost-effectiveness of intensive care units and their technologies has been questioned *(5,6,7)* and the need to reserve intensive care for those who are likely to benefit has been stressed *(8)*. In the developing world where the largest numbers stand to benefit from safe water, vaccination programmes and access to primary surgery *(9)* the appropriateness of intensive care must be carefully evaluated. The aim of this study has been to evaluate prospectively the effectiveness of mechanical ventilation in Zambia.

Methods

THE INTENSIVE CARE UNIT

All the patients in the series were ventilated on the intensive care unit of the University Teaching Hospital. The unit has ten beds and is staffed by 21 nurses, with no formal ICU training. As the bed occupancy was just over 5 patients per day, a nursing ratio of one nurse per patient was not possible.

There was no resident ICU medical staff, the on-call medical and surgical teams and clinical officer anaesthetists providing cover at night. One surgeon and one anaesthetist performed an administrative role conducting daily ward rounds and frequent visits to the unit.

EQUIPMENT

Patients were ventilated with one of four ventilators: an East Radcliffe with a respiratory rate fixed at 20 cycles per minute due to a mechanical problem with the gear system; a Blease Pulmoflator; a Bennett MA1 and an Oxford Ventilator Mk II (Penlon) driven by an electrical compressor (Gast). As the supply of pressurised gas was unreliable, and power cuts were frequent in the rainy season, an Ambu bag was at each bed and oxygen cylinders and an oxygen concentrator (Rimmer Alco) were available for backup.

Airway humidification was provided by either condenser or kettle humidifiers and all the patients in this series were ventilated via Portex® implant tested, high volume, low pressure cuffed endotracheal tubes. Suction was provided either by electrical units or from wall outlets.

MONITORING

No blood gas analysis or pH estimations were available. Patients on ventilators were monitored clinically by the nursing staff who charted standard respiratory parameters up to ¼ hourly. Four ECG monitors were available, 1 Wright respirometer and 1 ventilator alarm. Standard haematology, biochemistry and microbiology investigations were available during the day. Invasive cardiovascular monitoring was limited in this series to measurement of central venous pressure and X-rays were not available for the final two months of the study.

PATIENT MANAGEMENT

The decision to ventilate ICU admissions was made on clinical criteria often by the admitting doctors rather than the authors and no admission policy was practised.

Standard nursing procedures were performed, including hourly sterile endotracheal toilet and a trained physiotherapist was available each weekday morning. Nasal

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intubation was preferred and sedation was kept to a minimum with combinations of diazepam and pethidine. Ventilation was usually instituted without paralysis.

Patients were ventilated with tidal volumes of 12 ml/kg body weight and respiratory frequencies of 12/min, unless otherwise indicated clinically. Oxygen concentrations were maintained between 21% and 60%.

There was an ongoing programme of nurse training on the unit and an additional anaesthetist and surgeon were involved in the management of the unit for the last 4 months of the study. Satisfactory humidification was not introduced until 6 months into the study and at this time the Oxford ventilator with alarms was also introduced.

DATA COLLECTION

Information was kept prospectively on all ventilated patients in the form of detailed summaries hand written by the authors from the ICU patient notes. Patients were recorded as either not expected to survive or as having a chance of survival by JRS or DAKW, and this subjective assessment was documented but not used in management decisions. Ward follow-up was conducted on all survivors.

Statistical analysis was performed using the χ^2 and Fischer's Exact tests.

Results

During the 16 months of the study there were 855 admissions to the intensive care unit. Two hundred of these patients were treated with mechanical ventilation (23.2%). Of these patients 148 died in ICU (74%) and 52 patients survived (26%). A further 6 patients died in the ward giving a hospital mortality of 77%.

There were 3 survivors in the 81 patients not expected to survive (98.6% mortality). Two of these were ventilated after cardiac arrest and the other was a head injury who was ventilated for aspiration pneumonitis. There were 70 deaths in the 119 patients with some chance of survival (58.8% mortality). Sixty three per cent of head injury patients, 70% of patients with hypertensive encephalopathy or CVA and 85.7% of patients with medical coma were not expected to survive.

There was a significant reduction in the mortality of patients with a chance of survival over the 16 months of the study ($P=<0.05$). Of the first 100 patients ventilated in the series, 66 were expected to survive; 45 of these patients died (68.1%). Out of the second 100 patients ventilated, 53 patients were expected to survive, of whom 25 died (47.8%). There was no significant improvement in the mortality of patients not expected to survive (Table I).

The diagnostic groups chosen are shown in Table II. Head injuries account for the greatest number of patients ventilated (23.5%). Other large groups identified are obstetric (12.5%) which were predominantly complicated puerperal sepsis, and postoperative surgical (14%) none of whom were ventilated electively.

Fifty nine patients (29.5%) were ventilated for non-traumatic coma and these have been divided into 5 diagnostic groups. The mortality was 100% in the patients ventilated for hypertensive encephalopathy or CVA. Patients ventilated in the medical coma group; hepatic encephalopathy (4), undiagnosed coma (4), dia-

TABLE I *Outcome of patients recorded as either not expected to survive or as having a chance of survival*

	*Patients with chance of survival**		*Patients not expected to survive†*	
	Survivors n=49	*Deaths n=70*	*Survivors n=3*	*Deaths n=78*
1st 100	21	45	0	34
2nd 100	28	25	3	44

*$\chi^2=4.526$, $P=<0.05$
†Exact $P=1.24$ NS

TABLE II *Diagnostic groups*

	No. 200	*Not expected to survive* n=81*	*Deaths n=148*	*Survivors n=52*	*Mortality Rate (%) 74*
Head injury	47	30	40	7	85.1
Obstetric	25	4	15	10	60
Surgical postoperative	28	6	18	10	64.2
Surgical miscellaneous	14	7	8	6	54.1
Pulmonary disease	11	2	7	4	63.6
Cardiac/renal failure	7	4	7	0	100
Tetanus	7	0	6	1	85.7
Guillain-Barré syndrome	2	0	2	0	100
Non-traumatic coma					76.4
Cerebral malaria	7	3	6	1	85.7
Hypertension/CVA	17	12	17	0	100
Medical coma	14	12	14	0	100
Organophosphate poison	15	1	7	8	46.6
Eclampsia	6	0	1	5	16.6

*All patients not expected to survive died with exception of:
1. Upper airway obstruction following cardiac arrest.
2. Upper airway obstruction following cardiac arrest.
3. Head injury GCS 4, aspiration pneumonitis.

betic ketoacidosis (2), meningitis (2), pellagra (1), and ethanol poisoning (1), also had 100% mortality. The mortality was lower in those with eclampsia (16.6%), and organophosphorus poisoning (46.6%). The overall mortality for non-traumatic coma was 76.4%.

The surgical miscellaneous group included 5 cases of upper airway obstruction, 3 severe burns and 2 fractured cervical spines, one case of necrotising fasciitis, and 2 patients with abdominal sepsis.

Patients who were ventilated and had either renal or cardiac failure had a mortality of 100%. The mortality for tetanus, cerebral malaria and Guillain-Barré syndrome was high.

The survivors in the pulmonary disease group were all young patients with acute surgical pathology; two patients with fat embolus following fractured femur, one patient with a flail chest and one with empyema following staphylococcal septicaemia.

Of the 47 head injury patients ventilated in this series, 40 died (85.1%). Thirty one (77.5%) of these deaths were in patients with Glasgow Coma Scale (GCS) less than 6. Of the 7 survivors, 3 had a GCS less than 6. Two of these patients were ventilated for reasons other than their head injury and the other died subsequently on the ward.

Mechanical ventilation was identified as having significantly contributed to death in 10 patients (5%). Seven of these were 'ventilator accidents' where the endotracheal tube either became blocked or dislodged, and 3 were multiresistant pseudomonas infections of the respiratory tract. The mortality rate for ventilation was highest in the patients who were ventilated for less than 24 h. (Table III). In the 8 patients ventilated for over 10 days, 4 patients died. In all 4 of these fatalities, 2 tetanus patients and the 2 patients with Guillain-Barré syndrome, a 'ventilator accident' was contributory.

TABLE III *Length of time on ventilator and mortality rate*

Days on ventilator	*No.* *200*	*Survivors* *n=52*	*Mortality Rate (%)* *74*
<1	143	31	78
1–3	33	9	72
3–10	17	8	52
>10	8	4	50

Discussion

The ICU mortality rate of 74% in this series is high compared to series from developed countries in Europe and the USA. In a series of 486 ventilated patients Searle reported an ICU mortality rate of 43.6%, with a mortality after hospital discharge of 52.5% *(1)*. Nunn reported a 33% ICU mortality and 20% mortality on the ward *(2)*, while Cullen reported a 57% mortality after 1 month *(3)*. Bell reported an ICU mortality of 30.4% *(4)*.

The only previous report from an African country is from Nigeria where 10 of 12 patients died (83.3%) *(10)*.

Mortality is dependent upon the spectrum of diagnoses admitted to an ICU for ventilation. In Nunn's series of 100 patients *(2)*, only 7% were ventilated following trauma compared with 23.5% of the patients in this series ventilated for head injury. Differences in illness severity between centres will influence outcome. Nunn's excellent 33% mortality figures were from an ICU where patients 'deemed irrecoverable' were not ventilated *(2)*. Many of the patients admitted to our ICU are *in extremis* often with very little pre-ICU therapy and neglected illness. This is the reason for the high mortality (78%) for patients ventilated for less than one day and the much improved mortality after three days (52%). A large number of patients who died in the first 24 hours were ventilated as a last resort. Nunn excluded all patients ventilated for less than 4 hours from his series. It is of interest that the mortality rate for patients ventilated for less than 24 hours in his series did well by comparison, with an ICU mortality rate of 7%. This may well reflect a population of postoperative patients ventilated electively, who would be expected to do well. No postoperative patients were electively ventilated in our series.

Differences in mortality between ICUs also depend upon differences in admission criteria. Patients in our series were often admitted to the ICU for ventilation by the on-call medical and surgical teams or by non-medically trained clinical officer anaesthetists. The large number of irrecoverable cases ventilated reflects this admission policy, which is responsible for the high mortality rate. A stricter admission policy, which would reduce the number of hopeless cases being ventilated, can only be introduced on the basis of clinical audit.

The mortality rate for ventilation of head injuries in this series was high. This finding is supported by others. Searle reported 23 fatalities out of 36 patients ventilated for head injury *(1)* and Jennett reported that mechanical ventilation was associated with a greater than expected head injury mortality *(11)*.

Other diagnostic groups which did badly in our series were hypertensive patients with encephalopathy or CVA (100% MR), and patients with non-traumatic coma (76.4% MR). These observations have also been made in developed countries; Nunn ventilated 3% of his series for CVA with 100% mortality *(2)*, and Searle reported an 80% mortality rate for non-traumatic coma *(1)*.

In intensive care without resident medical staff, the most important principles for safe management of ventilated patients are: (1) adequate humidification, (2) one nurse by the bedside at all times, (3) reliable ventilators with backup and (4) meticulous endotracheal tube care. Ventilator alarms provide further safety once these principles have been established. The improvement in outcome of the group of patients with a chance of survival over the study period is due to the gradual introduction of these safety measures. It is interesting that this improvement was in spite of non-availability of X-rays for the final 2 months of the study.

In a developing country limited resources must be channelled into areas which will produce greatest benefit. Mechanical ventilation is expensive. There is no doubt, however, that it saved 46 lives in this series and might have saved more with improved standards. We have identified groups of patients who are likely to benefit from mechanical ventilation in the developing world.

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Notes on books

Trauma. Emergency Surgery and Critical Care edited by John H Siegal. 1206 pages, illustrated. Churchill Livingstone, New York. £130.

High velocity blunt trauma associated with motor vehicle injuries is a major cause of death and disability in the United States and an increasing cause in the United Kingdom. In the past, the patient who had sustained such massive trauma was seen as having a collection of injuries each to be dealt with by a specialist in that particular anatomical system. Thus the orthopaedic surgeon dealt with fractures, the neurosurgeon performed burrholes, the general surgeon treated ruptured viscera and the plastic surgeon dealt with extensive lacerations. This view is changing and more so in the United States than in some other countries. It is now recognised that trauma is in reality a set of related pathologies that have a similar aetiology and that induce a similar set of body responses that determine the nature, extent and severity of the injury. Modern trauma care therefore is based on a comprehensive knowledge of the basic mechanisms of cellular and organ injuries and the integrated body response.

This large and authoritative book addresses major trauma and care problems that are seen in adults. Section 1 covers basic science foundations including cell injury and biochemical disorders. Subsequent sections cover hypovolaemic shock, cardiogenic shock, sepsis, the adult respiratory distress syndrome and disordered metabolism. The final section covers specific injuries which may cause specific problems. A volume that should be widely available to all who may be called upon to treat the massively injured patient.

Atlas of Cutaneous Surgery by Neil A Swanson. 177 pages, illustrated, paperback. Little Brown, Boston. £21.50.

This atlas is written as a self-instruction manual for medical students, residents and dermatologists. Each section contains a series of practice tests to be performed using a pig's foot which can be bought at a local meat market or grocery store. The author comments that although there is some lack of elasticity and less sub-cutaneous tissue than contained in normal human skin a fresh pig's foot is adequate for learning basic techniques of cutaneous surgery. After an initial section on instruments and the method of inserting various skin sutures the atlas goes on to discuss and illustrate various skin flaps and skin grafts.

The author is a dermatologist and writes in the preface that it is the goal of his book to help physicians discover the fun of cutaneous surgery no matter what their status in the practice of medicine. Surgeon readers of this notice may care to ponder on this approach to one particular branch of surgery which is gaining increasing momentum on the other side of the Atlantic.

Pathology of the Vulva and Vagina edited by Edward J Wilkinson. 340 pages, illustrated. Churchill Livingstone, New York. £45.

Volume 9 in the series 'Contemporary Issues in Surgical Pathology', this lavishly illustrated book published on glossy paper gives a detailed account of the pathology of the external female genitalia. Although much of the pathology discussed relates to histopathology there is much that will also interest the clinician. The photo-micrographs are of particularly high quality and the book is a handsome addition to the library itself.

Pointers to Cancer Prognosis edited by Basil A Stoll. 368 pages, illustrated. Martinus Nijhoff, Dordrecht. £84.50.

Edited by a well-known author in the field of oncology this volume provides a survey of both clinical and biological indicators of prognosis in patients with cancer. The contributors include physicians, surgeons, radiotherapists and pathologists. The first section is devoted to clinical indicators of prognosis. The second section relates to biological indicators such as tumour markers and histological appearances, while the third section is devoted to the clinical applications of these various matters in specific cancers.

Gastrointestinal Emergencies edited by C W Imrie and A R Moossa. 225 pages, illustrated. Churchill Livingstone, Edinburgh. £25.

This concise volume should interest all general surgeons. Twelve chapters cover the range of gastrointestinal emergencies and each is written in attractive style by well-known names from four different continents. The two editors contribute chapters on acute pancreatitis and inflammatory bowel disease respectively. Each chapter gives references for further reading and the volume is strongly recommended to all those who take their turn at being on call for general emergencies.

Cardiovascular Problems in Pediatric Critical Care edited by D B Swedlow and R C Raphaely. 311 pages, illustrated. Churchill Livingstone, Edinburgh. £35.

The editors write in their preface that this monograph is written with the belief that a solid understanding of the principles behind cardiovascular physiology, pharmacology and monitoring technology is necessary to deliver optimal care to the child with existing or impending failure of the circulation. The contributors, who are almost all anaesthetists, discuss these matters in great detail in the course of nine chapters, each of which is heavily referenced (Chapter 1 has no fewer than 466 cited references taking 18 pages to enumerate!).