A STUDY ON APACHE II SEVERITY SCORING SYSTEM IN INTENSIVE CARE UNIT HOSPITAL UNIVERSITY SAINS MALAYSIA

by

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ABSTRAK

KAJIAN KE ATAS APACHE II SISTEM PENILAIAN KETERUKAN DI UNIT RAWATAN RAPI HOSPITAL UNIVERSITI SAINS MALAYSIA

Sistem penilaian keterukan pesakit telah digunakan secara meluas untuk mengkaji keadaan pesakit yang dimasukkan ke unit rawatan rapi samada untuk melihat perubahan fisiologi atau keberkesanan rawatan dan menilik kadar kematian. APACHE II merupakan system penilaian yang selalu digunakan kerana ia adalah senang dikendalikan dan mudah diperolehi. Selama 12 bulan, dari Januari 2000 ke Disember 2000, seramai 180 pesakit telah dimasukkan ke unit rawatan rapi, hospital Universiti Sains Malaysia. Kemasukkan adalah berdasarkan criteria yang telah ditetapkan di dalam kajian ini.

Kemasukkan samada dari wad medical/surgeri, unit kemalangan dan kecemasan atau selepas pembedahan. Kebanyakkan pesakit adalah selepas pembedahan kecemasan, 52.8%. Majoriti pesakit adalah berumur kurang dari 44 tahun , 55.0% dan 91.9% adalah melayu. Memandangkan hospital Universiti Sains Malaysia merupakan pusat rujukan bagi kes-kes neurosurgeri bagi kawasan Pantai Timur, 43.3% pesakit adalah pesakit neurosurgeri.

Skor minimum bagi APACHE II adalah 0 dan maksimum adalah 39, dengan kebanyakkan pesakit yang memperolehi markah APACHE II diantara 6-10 (25.6%). Bagi pesakit yang mendapat markah APACHE II lebih dari 25, kadar kematian adalah 100%. Terdapat perbezaan yang ketara diantara kadar kematian sebenar dan kadar kematian yang ditilik dengan $p< 0.0001$. Kuasa penilikan kadar kematian yang betul adalah 70.9%.

ABSTRACT

A STUDY ON APACHE II SEVERITY SCORING SYSTEM IN INTENSIVE CARE UNIT HOSPITAL UNIVERSITY SAINS MALAYSIA

Severity scoring system have been widely used for assessment of patients admitted to intensive care unit whether to see the physiological derangement or the effectiveness of the treatment and prediction of mortality rate. APACHE II is the most commonly used severity scoring system because it is user friendly and easily available. For the past 12 months between January 2000 to December 2000, a total of 180 patients were admitted to the intensive care unit, Hospital University Sains Malaysia. Admission was based upon the criteria that have been tailored towards the study.

Admission was either from general medical/surgical wards, accident and emergency unit or postoperatively. Post emergency operation patients contribute the most admission, 52.8%. Majority of patients were less than 44 years old, 55.0% and 91.1% were Malays. Since Hospital University Sains Malaysia is a referral center for Neurosurgical cases in the East Coast, 43.3% of patients were neurosurgical patients. The minimum APACHE II score was 0 and the maximum was 39, with most patients with APACHE II scores range in between 6-10 (25.6%). All patients with APACHE II score more than 25 had 100% mortality rate .

There was statistically significant different between the observed mortality and predicted mortality with $p < 0.0001$. The power of correct prediction of mortality was 70.9%.

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CHAPTER 1. INTRODUCTION

Critical Care Medicine (CCM) has evolved considerably since its inception during the 1960's. As levels of sophistication continue to climb, critical care has reflected admiration and controversy at the same time. No one disagrees with the need for critical care. But disagreement surfaces concerning the best model for delivery of critical care, and philosophical issues such as which patients should or should not receive critical care. Infused with these issues is the concern over the cost of critical care.

Severity scoring systems in critical care have been developed in part to address issues such as these. Severity scoring systems are systems, which predict patient outcome based on specific physiologic parameters that are considered to be correlated with outcome (based on statistical analysis or expert opinion). These scoring systems have been historically developed to predict outcome for populations of patients as opposed to individual patients. They essentially allow physicians to compare observed outcome, such as mortality, with a predicted mortality for the population of patients admitted to their intensive care units (ICU).

In 1981, Knaus and his co-worker developed a severity scoring system, Acute Physiological and Chronic Health Evaluation (APACHE). 4 years later, APACHE II was developed to simplify the collection of data from APACHE. In 1991, Knaus et al. reevaluated and improved the physiological parameters of APACHE II to produce APACHE III.

Beside APACHE scoring system, there are also other severity scoring systems such as Simplified Acute Physiological Score (SAPS), Therapeutic Intervention Scoring System (TISS), Mortality Prediction Models (MPMs) and others.

APACHE II severity scoring system is chosen for this study because it is more clinically practical than APACHE. In APACHE II, the physiologic variables are reduced from 34 to 12, and are easily measured values. Also APACHE II is also freely available whereas APACHE III is a commercial programme, with more complex calculation. Furthermore comparing with other prognostic and severity scoring systems, APACHE II is extensively validated and less complex and has wider application and available to selected groups of critically ill patients.

This study is done in Intensive Care Unit (ICU), Hospital University Science Malaysia. The ICU is located in the new hospital building near the Coronary Care Unit and Operation Theatre. It is a level III ICU, well equipped with central monitoring, staff and doctors and emergency facilities. It is a 10-bedded ICU and can accommodate 10 ventilated patients at one time. Total patient admission per year is about 400-450 patients. This ICU receives post-operative surgical patients, medical and paediatric patients that required ICU care.

This study is a cross-sectional study whereby admission before 1st. June 2000 were obtained retrospectively and the consecutive data after 1st. June were done prospectively.

1.1 OBJECTIVES

The objectives of this study are to use APACHE II scoring system, to assess the severity of the patients admitted to the intensive care unit and to predict their outcome based upon the score.

Other objectives are:

1. To assess patient in order to determine the level and degree of diagnostic and therapeutic intervention.
2. To record the severity scoring system in ICU

CHAPTER 2: LITERATURE REVIEW

2.1 HISTORY

The development of intensive care signifies that for the first time, anaesthetist stepped out of operating theatres and developed their own ward for the care of their patients. This was obtained after hard battles with fellow colleagues for space, equipment and staff for the intensive care of critically ill patients. It was their knowledge and skills in the area of mechanical ventilation and circulatory support, which were of life-saving benefit to the seriously ill patients of that time. Against this background, a chronological view in which intensive care has developed is presented here (Rushmann et al., 1996).

1801: Five two-bedded rooms, reserved for patients who were critically ill or who had undergone a major operation, were planned for the renovation of the Forth Banks Infirmary, Newcastle-upon-Tyne, United Kingdom (Clark, 1801)

1885: Joseph O'Dwyer (1841-98), a physician in New York, invented a short metal endotracheal tube as a life-saving alternative to tracheostomy in diphtheria. The upper flange prevented the endotracheal tube from falling through the larynx.

1888: O'Dwyer combined his tube with George Fell's (1850-1918) (from Buffalo, New York) resuscitation bellows for intermittent positive pressure ventilation (IPPV). He later added a cuff to his tube. The apparatus was used for treating respiratory

arrest and for relief of upper airway obstruction as caused by diphtheria, and later for thoracic anaesthesia.

1929: Drinker developed the tank ventilator in which the patient's body (usually those paralyzed by poliomyelitis) was intermittently subjected to negative pressure, causing respiration. The patient's head was outside the tank (Drinker & McKhann, 1929). These were large, awkward devices, which severely restricted nursing access. An attempt was made to solve some of the problems with the 'see-saw' rocking-bed respirators.

1940: The respiratory care unit was founded at Oxford, England (Smith, 1963).

1942: The development of non-depolarizing neuromuscular blocking agents by Griffith produced the need for new ventilators for anaesthesia, which could be combined with the new endotracheal techniques of Magill and Macintosh. This was more convenient for the operating theatre environment and also solving the problem of oropharyngeal and gastric secretions entering trachea (Griffith and Johnson, 1942).

1950s: This decade saw the appearance of intensive care units. 'The concept of intensive therapy was founded and formulated when the patient was brought to the anaesthesiologist for treatment and not vice versa (Ibsen, 1968).

1952: The poliomyelitis epidemic, which occurs in Copenhagen in 1952, had enormous influence on the development of care of patients with respiratory failure.

Bjorn Ibsen (1951-) developed the method of hand ventilation through tracheostomy tube and an understanding on the importance of carbon dioxide levels in the blood. The Copenhagen experience resulted in the development of ventilators in many European countries and in the United State of America. It also stimulated interest in blood-gas measurement. Astrup has described the early development of blood gas and blood acid-base measurement.

1953: The Seldinger technique of guide wires to aid insertion of central venous lines was introduced.

1961: Roger Manley described Manley Ventilator, which did much to enable widespread and easy intermittent positive pressure ventilation (IPPV). The ventilator was relatively cheap, extremely reliable and was reasonably flexible. It was designed to minimize the cardiovascular effects of IPPV on the anaesthetized patient (Manley, 1961).

Other examples of early ventilators include the Beaver (Beaver, 1953) and the Radcliffe (Russel et al., 1956) in Britain, the Bang in Denmark in 1953, the Engstrom in Sweden in 1954, the Morch Piston ventilator in United State of America in 1954 and the Drager Poliomat in Germany in 1955.

1967: The introduction of positive end-expiratory pressure, which often improved oxygenation during IPPV of sick patients, although at the expense of reduced cardiac output.

The end of 1960s saw the rising popularity of parenteral nutrition for the sick patients who were unable to feed themselves.

1970: The Intensive Care Society in the United Kingdom was founded by Dr. Alan Gilston. It was a forum for sharing and debating difficult issues of this subspeciality. The European Society of Intensive Care was formed later by Dr. J. L. Vincent

1975: Cullen and associates presented Therapeutic Intervention Scoring System (TISS) for quantitating categories of ICU patients (Cullen et al., 1975).

1981: Knaus and co-workers invented and later developed APACHE (Acute Physiological and Chronic Health Evaluation) scoring (Knaus et al., 1981).

1983: The simplified Acute Physiological Score (SAP) was described (Le Gall et al., 1984). Sepsis Score was introduced (Elebute & Stoner, 1983).

1985: Knaus later simplified the APACHE score into APACHE II score, which reduced physiological variables from 34 to 12 (Knaus et al., 1985).

1991: Knaus et al. reevaluate and improved explanatory power APACHE II to produce APACHE III.

1999 : William A. Knaus had alert APACHE II user that the severity scoring system had significant limitations when used today for estimating group death rates among patients currently being treated in the United States critical care units.

2.2 INTENSIVE CARE UNIT

The term **intensive care** has been defined by the Intensive Care Society (ICS) (Intensive Care Society, 1997) as:

> *a service for patients who have potentially recoverable conditions, who can benefit from more detailed observation and invasive treatment than can be provided safely in an ordinary ward or high-dependency area. It is usually reserved for patients with threatened or established organ failure, often arising as a result or complication of an acute illness or trauma, or as a predictable phase in a planned treatment programme*

An intensive care unit (ICU) is a specially staffed and equipped hospital ward dedicated to the management of patient's with life threatening illnesses, injuries or complications. It is mentioned in history how ICU developed from postoperative recovery room or the poliomyelitis epidemics in the early 1950s. Nowadays modern ICU is not limited to postoperative care or mechanical ventilation. It is a speciality, which evolved from the experience of respiratory and cardiac care, physiological organ support and coronary care units.

Intensive care today is a separate speciality, it can no longer be regarded as part of anaesthesia, chest medicine, general surgery or any acute discipline.
In general, 3 levels of ICUs can be classified. This is based upon the requirements and the facilities that are available at the respective hospital.

1. Level I - District hospital

It may also be called a high-dependency unit (HDU), rather than ICU. Such a unit allows for a close nursing observation and electrocardiogram (ECG) monitoring. Immediate resuscitation is possible, but only short-term ventilation should be undertaken (less than 24 h). A level 1 ICU has a role in a small district hospital.

2. Level II - General Hospital

A level II ICU is located in larger general hospitals. It is capable of undertaking more prolonged ventilation, and has a resident doctor and access to physiotherapy, pathology and radiological facilities at all times. It should support the role of its hospital (e.g. area trauma centre).

3. Level III – Tertiary hospital

A level III ICU is located in a major tertiary referral hospital. It should provide all aspects of intensive care required by its referral role. The unit is staffed by specialist intensivists with trainees, critical care nurses, allied health professionals and clerical and scientific staff. The support of complex investigations and imaging, and by specialist of all disciplines required by the referral role of the hospital, is available at all times.

2.2.1 DESIGN OF AN INTENSIVE CARE UNITS

There is no fixed formula for the number of critical care beds needed by a trust, and it is important that the number is tailored to the workload and case-mix that the hospital treats. The following have been put forward as factors to be considered when estimating the size of an ICU:

a) Number of acute beds in hospital or catchment area

b) Type of acute bed

c) Previously calculated occupancies of wards, HDUs and ICUs

d) History of refusals

e) Location of other high-care areas

f) Number of operating theatres

g) Surgical specialities services and case-mix

h) Medical specialities

i) A&E department

j) Sub-regional or regional services

k) Ability to transfer patients to an off-site ICU

l) Paediatric care location.

There is no firm guidance as to the optimum size for an ICU. An ICU should have a single entry and exit point. Also areas and rooms for public reception, patient management and support service.

a) Patient areas

Each patient bed area requires a minimum floor space of 18.5 m^2 (200 ft^2), with single rooms being larger to accommodate patient, staff and equipment without overcrowding. Single rooms are essential for isolation cases and privacy for conscious long-stay patient.

Bedside service outlets should conform to local standards and requirements (including electrical safety and emergency supply). 3 oxygen, 2 air, 4 suction and 16 power outlets are optimal for level III ICU. There also should be room to place additional portable monitoring equipment. All central staff and patient areas must have large clear windows as lack of natural light and windowless ICUs give rise to patient disorientation and increase stress to all.

Central nursing station should be positioned so that all patients can be observed. The station usually has a central monitor that monitors each patient's vital signs, drug cupboards and refrigerator, telephones, computer and patient's records.
Sufficient numbers of non-splash hand-wash basins should be built close to all beds and one each for the single room. At least one multi-display X-ray viewer is needed in each multi-bed ward. Proper facilities for haemodialysis, such as filtered water, should be incorporated.

b) Equipment

The quantity and type of equipment will depend on the role and type of ICU. Level II and level I ICUs will require less equipment than that of level III. (Table 1)

Experienced intensivists should choose equipment, as inept or less knowledgeable people often buy expensive but inappropriate or unsuitable equipment, for ICU use.

c) Staffing (Table 2)

The level of staffing also depends upon the level of the ICU.

Table 1: Level III ICU equipment

a) Monitoring

- Bedside and central monitors
- 12-lead ECG recorder
- Intravascular and intracranial pressure monitoring devices
- Pulse oximeter
- Pulmonary function devices
- Expired carbon dioxide analysers
- Cerebral function /EEG monitor
- Temperature monitor
- Patient/bed weighter

b) Radiology

- X-ray viewer
- Portable X-ray machine
- Image intensifier

c) Respiratory therapy

- Ventilators – bedside and portable
- Humidifiers
- Oxygen therapy devices and airway circuits
- Airway devices
- Intubation trolley (airway control equipment)
- Manual self-inflating resuscitators
- Fibreoptic bronchoscope
- Anaesthetic machine

d) Cardiovascular therapy

- Cardiopulmonary resuscitation trolley
- Defibrillators
- Temporary transvenous pacemaker
- Infusion pumps and syringes

Table 1 continue

e) Dialytic therapy

- Haemodialysis machine
- Peritoneal dialysis equipment
- Continuous haemofiltration sets

f) Laboratory

- Blood-gas analyser
- Selective ion (electrolyte) analyser
- Haemotocrit centrifuge
- Microscope

g) Hardware

- Dressing trolleys
- Drip stands
- Bed restraints
- Heating/cooling blankets
- Pressure distribution mattress
- Sterilizing equipment (e.g. autoclave and glutaraldehyde bath.

Table 2: Level III ICU staff

i) Medical

- Director
- Staff specialist intensivists
- Doctors

ii) Nurses

- Nurse managers
- Nurse specialist
- Nurse educators
- Critical care nurse

iii) Allied health

- Physiotherapist
- Pharmacist
- Dietician
- Social worker
- Respiratory therapist

iv) Technicians

v) Radiographers

vi) Support staff

- Orderliness
- Cleaners

2.2.2 ECONOMICS OF INTENSIVE CARE UNITS

Utilization of ICUs had increased markedly in developed countries in the 1970s and early 1980s. This increase inevitably necessitates economic considerations. An ICU bed cost 3 times more per day than an acute ward bed, and the ICU uses 8% of the total hospital budget. Monetary support of ICUs comes from government, private fees and insurance payment. However the cost of treatment for patients who are admitted to government hospital is being burden on the government. This, along with the increasing demand on ICU beds, has led to critically ill patients being denied or having delayed access to ICU. This is occurring not just for the group of patients least likely to benefit from ICU care, who may be given reduced priority, but also from an appropriately referred group of critically ill patients (Bion, 1995, Metcalfe et al., 1997). Failure to admit or an improper referral for transfer for ICU admissions has been demonstrably associated with an increased morbidity and mortality (Bion et al., 1988 Purdie et al., 1990, Henao et al., 1991). This, along with inappropriate early discharge from ICUs, means that British ICUs contain more severely ill patients, refuse to admit or transfer more appropriately referred patients and have a higher post-ICU discharge mortality than those of many comparable countries (Rowan et al., 1993, Bion, 1995, Metcalfe et al., 1997).

This situation leads to a call for higher ICU funding in an already financially restrained health system. Perhaps a more cost-effective approach would be to determine accurate admission and discharge criteria that could reduce resource wastage on patients who are too sick to benefit from intensive care and in those that are too well to show cost-benefit. In other words, concentrating provision on those

most likely to benefit from the resource. This is where severity-scoring system comes into use.

2.2.3 CRITERIA FOR INTENSIVE CARE ADMISSION

Attempts have been made to apply specific standardized admission criteria to the breadth of patients referred for ICU admissions (Bone et al., 1993, Metcalf et al., 1997). Scoring systems, such as the Acute Physiological and Chronic Health Evaluation II (APACHE) and Mortality Prediction Model II (MPM), have been widely used to determine probability of ICU survival in populations of ICU admissions (Knaus et al., 1985, Teres et al., 1987, Lemeshow et al., 1993, Gallimore et al., 1997). It has been suggested that these scoring systems could be adaptable for use in predicting ICU survival in specific cases and, thus, be used to determine admission criteria for individual patients (Rogers & Fuller, 1994, Lim et al., 1996). However, they are designed and evaluated only for the determination of probability of survival in ICU populations and have limited applicability to individual cases (Knaus et al., 1985, Rogers & Fuller, 1994, Bion, 1995, Dept. Of Health, 1996). Also, the data collection and interpretation required for APACHE II is complex and time consuming, and the raw data needed is often not available in the ward setting. There has been suggestion that it is unethical to apply systems for predicting ICU survival for patients to whom ICU admission may be refused (Metcalfe et al., 1997).

The correlation of number of organ system failures and ICU mortality has lead to a crude count of that number being applied in an ad hoc fashion to justify refusal of admission to ICU (Knaus et al., 1985, Zimmerman et al., 1996). Such practice is

inappropriate, although this concept has been formalised in the System for Organ Failure Assessment. In this system, the severity of organ system failures is scored on each organ system and a cumulative score is attained which relates to ICU survival. Once again this has not been verified as being applicable for ICU admission criteria (Vincent et al., 1996) and the application of this relatively simple score to ward patients with deteriorating condition on a daily basis, although appealing requires to be tested as a system to determine ICU admission.

Other familiar scoring systems are the American Society of Anesthesiologists (ASA) score and the Physiological and Operative Severity Score for Enumeration of Mortality and Morbidity (POSSUM) (Copeland et al. 1993, Keats, 1978). Although ASA score predicts surgical risk, it is not very sensitive for the prediction of requirement for ICU admission. However, it has been shown to correlate closely with early post-operative emergencies which often lead to ICU admission (Lee et al., 1998) POSSUM, like APACHE II, predicts probability of surgical mortality for a range of surgical sub-populations, but not the need for ICU or HDU support (Copeland et al., 1991, Copeland et al., 1993, Sagar et al., 1994).

Some have suggested that the patient's age should be used as a means to ration scarce health care resources, including ICU services, though many feel that this is inappropriate and, indeed, unethical. The APACHE II data does demonstrate that increasing age is related to increased ICU mortality and indeed the score is weighted for age. The importance of age has been shown to vary in different countries and it has been suggested that biological, rather than chronological, age may be more important (Ridley et al., 1990, Wu et al., 1990, Zaren and Bergstrom, 1989, Bion , 1995). There is evidence that critical care patients are mostly males and that a high

proportion are elderly. Intensive Care National Audit and Research Centre (ICNARC) in United Kingdom data showed that 4.8% of admissions were in the age range 0-17, and that 46.5% of admissions were of people aged 65 years or over. The mean age of patients is 57.3 years .

The inability of admission criteria and scoring systems to guide ICU admission in a general cohort of ICU admissions contrast with the successful use of attempts with criteria in patients with specific conditions such as gastrointestinal haemorrhage (Kollef et al., 1995, Kollef et al., 1997). The great diversity of diagnoses, and severity of illnesses seen in ICU admissions make the current broad criteria for admission inappropriate to apply. Indeed, the statement that ICU should be available to anyone who has reversible pathology and has a reasonable chance of returning to an acceptable quality of life is just as appropriate and almost as specific a guideline. So, we return to the rather poor definition of who should be admitted to ICU. The answer, at this time, is anyone who could benefit.

When should the critically ill surgical patient be admitted to ICU? . One study reported that over 70% of admissions to ICUs were in the cardiovascular or respiratory categories. Other data from Intensive Care National Audit and Research Centre (ICNARC) in United Kingdom had shown that the ten most frequent reasons for admissions are:

a) Aortic or iliac dissection or aneurysm - surgical

b) Acute myocardial infarction - non-surgical

c) Pneumonia, with no organism isolated - non-surgical

d) Bacterial pneumonia - non-surgical

e) Septic shock - non-surgical

f) Primary brain injury - non-surgical

g) Large bowel tumour - surgical

h) Left ventricular failure - non-surgical

i) Asthma attack in a new or known asthmatic - non-surgical

j) Non-traumatic large bowel perforation or rupture - surgical

The most common condition admitted made up only 6.5% of admissions, and the top ten conditions made up only 26.8% of admissions. The ten conditions that use the greatest number of bed-days are as follows:

a) Bacterial pneumonia - non-surgical

b) Pneumonia, with no organism isolated - non-surgical

c) Aortic or iliac dissection or aneurysm - surgical

d) Septic shock - non-surgical

e) Primary brain injury - non-surgical

f) Non-traumatic large bowel perforation or rupture - surgical

g) Acute myocardial infarction - non-surgical

h) Exacerbation of chronic obstructive airways disease - non-surgical

i) Inhalation pneumonitis (gastrointestinal contents) - non-surgical

j) Non-cardiogenic pulmonary oedema (ARDS) - non-surgical

These conditions made up 32.8% of bed-days. The lack of ICU and HDU beds in the UK leads to appropriate admissions to ICU being delayed and, thus, patients are admitted to ICU later and with higher severity of illness scored (Purdie et al., 1990, Henao et al., 1991, Bion, 1995). Although standardisation for case mix and severity of illness shows that British ICUs achieve similar outcomes to elsewhere (Le Gall et al., 1994), this hides the fact that for individual patients this worsening of clinical

condition caused by delayed ICU admission does have adverse effects on outcome. Thus, ICU in the UK is probably associated with an unnecessary excess morbidity and mortality (Purdie et al., 1990, Henao et al., 1991, Bion, 1995). It has also been pointed out that the quality of care before admission to ICU is frequently sub-optimal (Garrard & Young, 1998)(McQuillan et al., 1998). In a cohort of 100 consecutive ICU admissions, it was found that care was deemed sub-optimal in 54 of these cases. Care was said to be inadequate at the most basic levels, including airway, breathing, and circulatory management. There are three main ways in which this situation may be remedied:

1) Pre-operative admission and optimisation in ICU
2) Early recognition and rapid interventions for the critically ill
3) Better staff training in critical care.

1) Pre-Operative Admission

It seems logical that early admission and timely discharge of appropriately chosen patients to ICU is desirable. The timing of admission for surgical patients is usually with regard to operative care. In a large-scale study, only 5% of surgical patients were admitted to ICU pre-operatively, and this was thought to be due, in part, to pressure on ICU beds (Rowan et al., 1993). Most of the deaths related to surgery are at least three days into the postoperative period, but it has been suggested that pre-operative admission to ICU and cardiovascular optimisation may reduce this post-operative mortality (Gallimore et al., 1997).

In 1987, Shoemaker et al published the results of a prospective trial of supra-normalisation of cardiovascular indices in the management of high-risk surgical

patients (Table 3). Patients were admitted pre-operatively to a critical care area for pulmonary artery catheterisation and supra-normalisation of cardiac index (>4.5l/min/m^2) and oxygen delivery (>600ml/min/m^2) using fluids and inotropes. Results suggested that there was a major benefit in terms of morbidity and mortality (Shoemaker et al., 1988). These results were supported by the work of Boyd et al in the UK. These workers also demonstrated a significant reduction in mortality in a prospective randomised trial of pre-operative supra-normalisation, continuing for up to 24 hours post-operatively, in the same high risk patients (Table 3)(Boyd et al., 1993). A further study of pre-operative optimisation in vascular surgery patients using a different protocol also demonstrated reduction in cardiovascular morbidity and mortality (Berlauk et al., 1991). The situation was made less clear by more recent studies. In orthopaedic patients, non-invasively monitored fluid filling did not seem to reduce mortality but the authors claimed it had a beneficial effect on recovery (Sinclair et al., 1997) and in major vascular surgery patients, two trials have failed to show favourable effects (Ziegler et al., 1997, Valentine et al., 1998). However, none of these studies actually "supranormalised" the cardiovascular indices as described by Shoemaker. A further recent report has again clearly demonstrated a marked improvement in mortality in high risk surgical patients undergoing pre-operative optimisation and supranormalisation (Wilson et al., 1999). These positive results are seen to contrast with the failure of trials of supranormalisation in the already critically ill patients who show no benefit (Hayes et al., 1994, Gattinoni et al., 1995). This would suggest that such strategies must be implemented before the insult occurs in order to show some improvement in mortality. This has lead to suggestions that aggressive pre-operative interventions may be the way forward in the management of a group of patients, whose mortality could be reduced from the quoted 17-28% down

to 3-6%) (Shoemaker et al., 1988, Boyd et al., 1993, Treasure & Bennet, 1999, Wilson et al., 1999).

Patients with severe cardiac disease for major non-cardiac surgery are a subgroup of the above-mentioned high-risk group with a particularly poor outcome. Goldman et al were first to attach specific multi-factorial risks in this group pointing out the very high mortality associated with cardiac failure and recent myocardial infarction (Goldman et al., 1977). Later work by Rao et al suggested that invasive monitoring and aggressive therapy throughout the operative period, including pre- and post-operative admission to ICU, could bring about very significant reductions in mortality (Rao et al., 1983). Detailed guidelines for the perioperative care of such patients now exist (Eagle et al., 1996).

The National Confidential Enquiry into Perioperative Deaths (NCEPOD), in 1994-95, and the Scottish Audit of Surgical Mortality, in 1996, highlighted the importance in terms of poor outcome due to the under-provision of ICU and HDU beds. These two large audits questioned whether major surgery on high-risk patients should be performed in hospitals lacking appropriate 24-hour ICU facilities (Gallimore et al., 1997, Scottish Audit of Surgical Mortality, 1997). NCEPOD tells us that 20 000 patients per year die within 30 days of surgery. Many of these patients will be true emergency patients who will not be able to benefit from extensive pre-operative optimisation. However, many are elective or urgent cases in which a few hours of pre-operative manipulation would be feasible. If these results are generally applicable the potential lives saved could be very significant.

Table 3: Criteria for high risk patients

- Previous severe cardio-respiratory illness (acute myocardial infarction, stroke, COAD)
- Extensive ablative surgery planned for carcinoma (i.e. oesophagectomy, gastrectomy, prolonged surgery)
- Severe multi-trauma (i.e.> 2 organs or 3 systems, or opening 2 body cavities)
- Massive acute blood loss (> 8 units), blood volume < 1.5 l/ m2, haematocrit < 0.2
- Age > 70 or evidence of limited physiological reserve of one of more organs
- Septicaemia, positive blood cultures or septic focus, WCC >13 000/ml, spiking fever to > 38.3oC for 48 hours
- Shock, MAP < 60mmHg, CVP < 15cmH2O and urine output < 20ml/hr
- Respiratory failure, PaO2 < 8mmHg on FIO2 > 0.4, intrapulmonary shunt fraction > 30%, mechanical ventilation needed > 48 hours
- Acute abdominal catastrophe with haemodynamic instability (i.e. pancreatitis, gangrenous bowel, perforated viscus, GI bleeding)
- Acute renal failure: serum urea > 17.9 mmol/l, creatinine > 265mmol/l
- Late stage vascular disease involving aortic disease

Reference: Shoemaker WC, Appel PL, Kram HB, Waxman K, Lee TS. Prospective trial of supranormal values of survivors as therapeutic goals in high-risk surgical patients. Chest 1988; **94(6):** 1176-86