ORGANIZATION OF INTENSIVE CARE UNIT AND PREDICTING OUTCOME OF CRITICAL ILLNESS

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Introduction

Following polio epidemics of 1950s, critical care became a major growth industry in U.S. The availability of funds matched the technological advances, which progressed hand in hand. Over the few decades special care units became commonplace and in 1980 critical care, already a nursing speciality, evolved as a medical discipline.

In 60's it was recognized that an ICU was an economic arrangement for treatment of grave illness. It not only improves the chances of patients with desperate illness but also likes to promote an improvement in general level of medical & nursing care. It has been said that antecedents of the ICU was the postoperative recovery room. Polio epidemic provided the incentive to develop the artificial ventilation and long-term care in specialized areas, which reduced the mortality. 1960s saw the development of coronary care units. The modern intensive care has developed from an amalgam of the lessons learned from respiratory and coronary care with continued momentum provided by the clinical and technological development in cardiopulmonary resuscitation, pharmacological and mechanical circulatory support, advances in renal replacement therapy, respiratory failure, cerebral oedema, multi-organ failure and patient monitoring systems.

The name intensive care rings a bell to any one who practices medicine. It is nothing but specialized and dedicated care given by a team to a patient who is critically ill. The aim of the critical care is to see that one provides a care such that patient improves and survives the acute illness or tides over the acute exacerbation of the chronic illness. Intensive care has developed in the last decade in our country. It is being imparted to both critically as well as to terminally ill patients. Various regional, political factors, and problems associated within our health care delivery are to be overcome to provide an ideal setting as in the western world.

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The 1970s saw great interest in intensive care with research into pathophysiological process, treatment regimens and outcomes of critical illness and founding of the speciality journals, training programmes and qualifications dedicated to intensive care. It has become a separate speciality.[1] Some training is imparted in all specialities but one can no longer regard it as part of anaesthesia, general medicine, chest medicine or general surgery. It must be regarded as a separate speciality with a status of its own. The time has arrived in our country too.

Economics of intensive care

There is a great demand for ICU bed in a hospital, which costs three times more per day than an acute ward bed. The ICU uses 8% of the total hospital budget and in USA it is 14-20%.[2,3] The total ICU costs per patient of US$22,000 in USA (1978) and A$1375 in Australia (1986) have been reported.[4,5] Batra et al have worked out cost per patient per day from a major teaching hospital in India to be Rs.3200 ($167.7).[6] Similar pattern was observed in our own ICU in the year 1997 and the cost worked out in 2000 is around Rs.5000 ($106) per patient per day (personal communication).[7] The costs in our country vary tremendously between the corporate and teaching institutions. The costs are higher in patients requiring parenteral nutrition, sepsis with usage of more antibiotics, requiring imaging modalities for investigations.

ICUs have a definite role and it should be well defined. In general and district hospital the ICU is somewhat like a high dependency are where close observation and monitoring is carried out. When one uses complex management, and all systems are supported, it should be located in a large tertiary hospital. Therefore, ICUs can be classified accordingly:

Level I: This can be referred as high dependency are where close monitoring, resuscitation, and short term ventilation <24hrs has to be performed.

Level II: Can be located in general hospital, undertake more prolonged ventilation. Must have resident doctors, nurses, access to pathology, radiology, etc.

Level III: Located in a major tertiary hospital, which is a referral hospital. It should provide all aspects

of intensive care required. All complex procedures should be undertaken. Specialist intensivist, critical care fellows, nurses, therapists, support of complex investigations and specialists of from other disciplines to be available at all times.[8]

Organization of ICU

It requires intelligent planning. One must keep the need of the hospital and its location. One ICU may not cater to all needs. An institute may plan beds into multiple units under separate management by single discipline specialist viz. medical ICU, surgical ICU, CCU, burns ICU, trauma ICU, etc. It may be useful but experience in Australia has favoured multidisciplinary ICUs, which are managed by specialist intensivists. Duplication of services and equipment is to be avoided. Critically ill patients develop the same pathophysiological process no matter whether they are classified as medical or surgical. They require the same approaches to support the organs. The problems of critically ill patients do not confine to their primary disease and the single discipline doctor lacks the experience and expertise to deal with the complexities of the multi-organ failure.

The number of ICU beds in a hospital ranges from 1 to 10 per 100 total hospital beds. Multidisciplinary requires more beds than single speciality. ICUs with fewer than 4 beds are not cost effective and over 20 beds are unmanageable[8]. ICU should be sited in close proximity to relevant areas viz. operating rooms, imageology, acute wards, emergency department. There should be sufficient number of lifts available to carry these critically ill patients to different areas.

Design of ICU

There should be a single entry and exit. There should not be any through traffic of goods or hospital staff. ICU must have areas and rooms for public reception, patient management and support services. Full commitment must be given from administration and a designated team to work on various tasks.

Patient areas

Each patient requires a floor space 18.5m^2 (200 sq.ft) with single room being larger about 26-30m^2 to accommodate patient, staff, equipment without overcrowding. There should be at least 3 to 3.67 metres between the bed centers. Single rooms are essential for isolation and privacy. The ratio of single room beds to open ward beds depends on the role and type of ICU. Service outlets could conform to local standards (electrical safety, and emergency supply). Three oxygen, two air, four suction and 16 power outlets and bedside lamp are optimum for level III ICU. They can be either wall mounted, or bed pendants. Many of the charts, syringes, sampling tubes pillows should be kept in bed dividers. Lead lining these dividers will help minimize x-ray radiation risk to staff and patients.

There should be source of natural light coming from the windows. Lack of natural light has shown to cause patient disorientation and increased stress to the staff. A central station will have the central monitor, drug cupboard, telephone, refrigerator and patient records. Nursing in ICU is always at the bedside. Sufficient hand wash areas should be provided. X-ray views are needed in multi-bed wards. Proper facilities for haemodialysis such as filtered water should be incorporated at the time of ICU planning.

Storage areas/Service areas

Most ICUs lack storage space. They should have a total of 25-30% of all patient and central station areas for storage. Clean and dirty utility rooms should be separate each with its own access. Disposal of soiled linen and waste must be catered for. A lab, which estimates blood gases, electrolytes, haemoglobin, is a must. Good communication systems, staff lounge, food areas must be marked out. There should be an area to teach and train students. This completes the design.

Equipment

Depends upon the type of ICU. Level II ICUs requirements are necessarily less, may require a two-channel monitor, whereas level III ICU will require multi-channel invasive monitors. Inappropriate or unsuitable equipment is brought by inept or less knowledgeable people. Ventilators, infusion pumps, portable x-ray unit, fluid and bed warmers, portable light, defibrillators, anesthesia machine and difficult airway management equipment are necessary. Dialysis unit is essential. An echo, ultrasound machines are necessary but can be commanded from the respective departments when necessary.

Staffing

Large hospital requires bigger team.

Medical staff

Carrier intensivists are the best senior medical staff to be appointed to the ICU. He/she will be the director. Less preferred are other specialists viz. from anaesthesia, medicine and chest who have clinical commitment elsewhere. Junior staff are intensive care trainees and trainees on deputation from other disciplines.

Nursing staff

The major teaching tertiary care ICU will require trained nurses in critical care. In our setups it may be ideal to have an in house training programme for critical care nursing. The number of nurses ideally required for such units is 1:1 ratio, however, it may not be possible to have such numbers in our setup. 1 nurse for two patients is acceptable. In complex situations they may require two nurses per patient. The number of trained nurses should be also worked out by the type of ICU, the workload and work statistics and type of patient load.

Allied services

Physiotherapy, social workers, dieticians, radiology services, respiratory therapists are a useful work force responsible for patient management and equipment maintenance. Biomedical department services are required on a regular basis to service and repair and develop equipment. Adequate secretarial assistance and reception category makes the functioning smooth. For transport of patients it is ideal if one can have separate teams to lift critically ill patients and transport them to different areas. Trained staff in this area would be very valuable contribution.

Type of ICU

There are two types of ICUs, an open and closed. In the former physicians admit, treat and discharge and in the latter the admission, discharge and referral policies are under the control of intensivists. The patient outcome, cost benefit is noted to be better if intensivists have full clinical responsibility.[9,10] In our country where the specialist intensivist has not evolved completely, specialists interested in the ICU care manage, be it from anaesthesia, chest or intensivist, when there is no provision for intensivists the persons, usually anaesthesiologist looks after on a day-to-day basis. The concerned specialists must spend all their time in the ICU and get totally trained in the area. The director should be a full time intensivist. The lines of management have to be delineated, protocols should be well documented and responsibilities should be shared correctly. The policies should be formulated, periodically reviewed, e.g. antibiotic policies and hand washing. Microbiologist as an additional member of the team is welcome to not only prevent and treat infections and but to involve in infection control, antibiotic policies, etc.

Data collection, Continuing education and Research

Data should be collected and computerized so that it follows the set guidelines and conforms to the policies laid out. It gives idea about the caseload. Audits should be conducted regularly, the results should be discussed, critical incident should be reported from time to time and should be recorded[11]. The various critical incidents are analyzed over a period of time and published from our ICU.[12] A critical incident is an event, which has or would have led to morbidity or mortality.[13] Analyzing these will alter the practices and improve care.

The outcomes can be judged by using APACHE II scores. Its multivariate analysis model has been used to compare performance of actual versus predicted death rates.[14,15] Ongoing academic programmes should be a part of ICU. Journal reviews, mortality conference, teaching programme for nurses, trainees, respiratory therapists must be encouraged to develop their quality assurance programme. Research has to be pursued at all levels.

Critical care in its various form plays a central role in access to medical care. Because of its dramatic display of medical intervention at its best, it is viewed as part of medical system that is expected to contribute its share of service for welfare of entire society. Quality assurance and continuous quality improvement is an important aspect of any critical care unit. The constant thrust for improvement of quality can provide significant for all who care for critically ill.[13]

Ethics in intensive care

These should be scrupulously upheld over enthusiastic treatment. Euthanasia has to be addressed and discussed. These can cause problems due to public misconception, different interpretation of terminology and irresponsible media. There should be strict guidelines on all ethical issues and frequent discussion with hospital administration.

Brain death

Is well accepted in western countries. This should be thoroughly discussed with relatives, for termination of life support systems. A coordinator added to the team may be a useful member particularly for organ donation. Brain death declaration is part of the transplantation of organs act 1995 in our country. Though in other countries, legal or ethical implications are not there for euthanasia, we have no legislation regarding its usage. The only way is the explanation for the relatives and consent from them to terminate the life support, which is withdrawn or withhold

treatment, which sustains or prolongs life. Persistent vegetative state patients should be discharged to ward after establishing the spontaneous respiration and not to be managed in ICU.

Withdrawal of treatment has to be discerned at length with all relatives in our setups. The whole situation should be clearly explained and written consent taken. We should say treatment is not being abandoned but reduced from time to time. Discontinuing oxygen, reducing inotropes, withholding antibiotics are a few steps to name. Sudden disconnection from ventilation should be avoided. Effective communication between ICU team and family is the key to success in difficult circumstances. In our culture, many a times a request is made to continue treatment, which is futile.

Handling relatives

Done in a calm atmosphere, talking to them on a regular basis. Building up rapport, identify one or two persons to talk on a regular basis. Relatives feel comfortable when nurse is also around. Any misinformation or misconception must be cleared in simple clear consistent terms.

The comments made at NIH consensus conference are as follows. Critical care medicine (CCM) is a multidisciplinary and multiprofessional medical/nursing field concerned with patients who have sustained or are at risk of sustaining acutely life threatening single or multiple organ system failure due to disease or injury. These require prolonged minute-to-minute therapy or observation in ICU, which is capable of high level of intensive therapy in terms of quality and care. It includes management at scene of onset of critical illness or injury, transportation in the emergency department, during surgical intervention in operating room and finally in the ICU.[16]

The ability of specially trained critical care physicians to lower mortality in ICU was shown by two studies. Reynolds et al showed that mortality from septic shock decreased from 74% to 23% when specially trained physician supervised care.[14] Mortality decreased by 52% when full time critical care specialist was recruited.[15]

Improvement can be defined as attainment of an unprecedented level of performance. In health care performance can be measured in terms of critical outcome, patient satisfaction, error rates, waste, costs to produce a given product, products, market share and much more continuous improvement requires that we reject the current level of performance the status quo. Grounded in the present, continuous improvement has its eye on the future. It is not a technique that conserves itself simply with putting out fires or solving sporadic problems. Instead goal is, better long-term performance, improving basic design to achieve a superior product.

Conclusions

The level III ICU is an extended operating room where very sick patients are catered. The overall care should be given such that even the most critically ill patients with high risk of death survive. A tremendous commitment, team effort from each and every member, scientifically based and ethically correct practices and regular audits go a long way in establishing an ideal critical care unit.

PREDICTING OUTCOME IN CRITICAL ILLNESS

Clinical outcome is the most important measure of critical care activity. It is the end result of therapeutic interventions applied to the patients. It encompasses the entire range of activities of the ICU forming the basis of performance appraisal in its widest meaning. It can be short term or long term. It can be measured in the perspective of the patients, care takers and various other health care personnel. It is the end point for research, audit benchmark, performance and making comparisons. It helps allocating the funding and demonstrates efficiency, as the resources are scanty in relation to the number of patients.

From the perspective of the staff, the short and long term outcomes are important. As a large quantity of resources are expended on patients who do not survive in intensive care (intensive care given to non-survivors costs twice as much as survivors)[17], attempts to identify potentially ineffective care are constantly under review. Prognostic tools may help physicians in the difficult task of directing ICU resources to those patients who are more likely to benefit with the best chance of long-term survival. The effects of disease and the consequences of medical interventions on mortality are important. New therapeutic options are frequently introduced with the expectation of reduced ICU mortality. Accurate and reliable data helps the health managers, economists and politicians to resolve conflicts concerning areas of health care, not only within the hospital but also establish appropriate balance between the primary and secondary health care as their task involves distributive justice to maximize good for the whole of society.

Measurement of outcome

All outcome measures have limitations, as the results from outcome structures and data concerning outcome could be over interpreted. The most important clinical outcome measures from the patient's perspectives are:

1. ***Survival*** – Long term survival is most important to the patient, but individuals undergoing major surgical procedures will also want to know the risks of intervention and hence the short term mortality.
2. ***Functional outcome*** – Depicts the physical and mental capabilities after recovery. Most patients will want to return to an independent existence to at least their previous level of activity.
3. ***Quality of life*** – Includes patient's sense of well-being and satisfaction, which are the important components of quality of life.

ICU survival

ICU mortality provides a global impression of the ICU performance but is affected by the factors such as case mix, severity of illness, co-morbidity and the age of the patients. Discharge policy whereby no terminal care is given in ICU with hopelessly ill patients being discharged to the general wards or if the ICU workload has a large elective surgical component (low-risk patients) will depress the overall mortality figure.

Hospital survival

Hospital mortality is frequently quoted as an outcome measure following critical illness. However, it is influenced by the care beyond ICU and represents the institutions overall performance.

Prediction of outcome

It is the probabilistic estimation of a binary outcome (death or survival) usually at hospital discharge. Severity scores can be classified according to their aim; (1) to measure the severity by assigning points according to the severity of illness, (2) predict outcome by providing a numerical estimate of probability of outcome (hospital mortality) to a group of similar patients.

Severity of illness scoring systems, are not perfect, have false positive and false negative error rate hence prediction may be erroneous. Given their probabilistic nature they do not predict for a specific individual.

Outcome prediction models

Outcome prediction in ICU can be made using general outcome prediction models. Such models aim to predict clinical status at hospital discharge, based on a given set of variables evaluated at ICU admission or within 24 hours. So the rationale behind the construction is that derangement of homeostasis has an adverse effect on mortality and the magnitude of change from normal for physiological and laboratory variables is proportional to their effects on outcome. Using logistic regression equation these predict outcome in a patient having a particular past medical history and acute clinical condition (defined by the values of predictive variation) and receiving treatment in a (theoretical) reference ICU. Such models were developed in large multi-center databases. Hence these are therapeutic intervention or physiological derangement based. Ideally they should be[18]:

1. Time insensitive, i.e. provide an accurate mortality prediction when used prospectively as well as retrospectively.
2. A true estimate of presenting risk of death, i.e. measure of the severity of illness from data, which is not influenced by therapy, e.g. assessment of severity of illness using data within the first 24 hours (APACHE II) may become a measure of sub-optimal care than severity of illness.
3. Calculated from data collected in the usual care of the patient, i.e. pulse rate, BP, temperature, etc. If weight is given to data, gained from the use of complex and expensive equipment, hospital will be rewarded from using more tests regardless of the appropriateness or the quality of care.
4. Calculated from objective data that cannot be manipulated (unlike subjective data).
5. Accurate at all levels of the scale, i.e. the system must have an accurate calibration. Current mortality systems use regression technique that tend to under predict the likelihood of death for more severely ill patients and over predict for patients with less severe illness.
6. Simple and not add markedly to administrative costs.
7. All components of the system should be open for review, i.e. the systems (particularly the prediction equations) must be able to be scrutinized and tested.

Outcome scoring systems are of three types:

1. ***Anatomical*** – e.g. Injury Severity Score
   - Score 0-5 for each anatomical area involved
   - Final score – sum of three highest squared
   - Useful for trauma audits and research
2. ***Therapeutic*** – e.g. Therapeutic Intervention Scoring System (TISS)
   - Sum of weighted scores of therapeutic interventions
   - Correlates well with outcome
   - Wide applicability
   - Limited by available facilities, illness severity, staff experience

3. ***Physiological*** – e.g. APACHE – Acute physiology and chronic health evaluation
   - Designed for quality review rather than prognosis
   - Extensive - 33 variables and difficult to use clinically
   - Simplification–SAPS (13 variables), APACHE II
   - APACHE II – 12 variables +age+previous health
   - Correlates with hospital mortality
   - Limited by subjective scoring

Numerous intensive care scoring systems have been proposed in an attempt to increase the prognostic accuracy e.g. the multi-variate sickness score (SS),[19] simplified acute physiology scores (SAPS),[20] logistic organ dysfunction scores (LODS),[21] mortality prediction models (MPM),[22] paediatric risk of mortality (PRISM),[23] paediatric index of mortality (PIM)[24] and the single system of disease scoring systems e.g. Glasgow coma scale (GCS),[25] injury severity score (ISS),[25] trauma score,[26] abbreviated burn index,[27] child's hepatic failure grading,[28] artificial neural network.[29] However, the predictive ability of all scoring systems are not accurate enough to make them prognostically useful and continue to show a failure rate of 15-20% in predicting the outcome in individual patients.[30]

The severity of illness/risk stratification models most frequently used for outcome prediction in adult general critically ill patients are:

1. APACHE II or III
2. New simplified acute physiology score, second version – SAPS II
3. The mortality probability model, second version – MPM II

Acute physiology and chronic health evaluation II (APACHE II)[31]

The severity of disease classification, APACHE, was developed to prognostically stratify acutely ill patients and assist researchers to compare the success of new or differing forms of therapy. The score required an assessment of 34 physiological measurements within the first 32 hours of admission, as well as an assessment of the severity of the patient's preadmission status (functional status, productivity, medical treatment) for the 6 months before admission.

The APACHE classification was found to be too cumbersome for clinical use, and APACHE II was developed which required only 12 commonly measured variables along with an evaluation of the patient's previous health. Physiological variables were assigned a value between 0 and 4 for both high and low values about a mean, and points were also assigned for age and chronic health.

Many intensive care units currently use APACHE II to classify the severity of disease of their patients. The initial score is commonly calculated as the worst score during the initial 24 hours after admission to the unit. The 12 parameters are temperature, mean arterial blood pressure, heart rate, respiratory rate, PaO_2 (if the FiO_2 is < 50% or $P(A\text{-}a)O_2$ if the FiO_2 is > 50%), arterial pH, serum potassium, serum creatinine, white blood count and glasgow coma score.

All parameters are required to be entered into the score. In routine postoperative cases, arterial pH and serum creatinine are often assumed to be normal. In sedated, ventilated patients the glasgow coma score is assumed to be 15, when neurological problems are unlikely to be present. Patients who have undergone cardiac surgery or who are less than 16 years of age are excluded from APACHE II analysis. While the maximum APACHE II score is 71, patients rarely exceed a score of 55.

However, APACHE II is not ideal. It has not been found to be an accurate predictor of outcome for the individual patient and is not an accurate enough measure for intensive care unit resource utilization. Moreover, in one study of patients with cardiac failure who required mechanical ventilation, the mean APACHE II score was higher in the survivors than in non-survivors. A wide inter-observe variability scoring has also been reported.

Acute physiology and chronic health evaluation III (APACHE III)[32]

To counter some of the problems associated with APACHE II, APACHE III was developed which records six physiological measurements (i.e. blood urea nitrogen, bilirubin, $PaCO_2$, serum glucose, urine output and serum albumin) in addition to the variables used in APACHE II. The $PaCO_2$ is combined with pH as a single acid-base variable, potassium is no longer used as a variable, and the glasgow coma scale is in an abbreviated form. A minimum of nine physiological values is required to provide a score. The measurements collected are the worst values in the 24-hour period for the first day's and subsequently day's recordings. The chronic health component has six questions regarding haematological malignancies, metastatic cancer, immune suppression, hepatic failure, cirrhosis and AIDS. There are also more than 60 specific disease categories that may be used to classify the patient's disease.

APACHE II SCORING SYSTEM

PHYSIOLOGIC VARIABLE	HIGH ABNORMAL RANGE					LOW ABNORMAL RANGE			
	+ 4	+ 3	+ 2	+ 1	0	+ 1	+ 2	+ 3	+ 4
TEMPERATURE – rectal (°C)	³41°	39-40.9°		38.5-38.9°	36-38.4°	34-35.9°	32-33.9°	30-31.9°	£29.9°
MEAN ARTERIAL PRESSURE – mmHg	³160	130-159	110-129		70-109		50-60		£49
HEART RATE (ventricular response)	³180	140-179	110-139		70-109		55-69	40-54	£39
RESPIRATORY RATE – (non-ventilated or ventilated)	³50	35-49		25-34	12-24	10-11	6-9		£5
OXYGENATION: A-aDO_2 or PaO_2 (mmHg) a. FiO_2 ³ 0.5 record A-aDO_2	³500	350-499	200-349		< 200				
b. FiO2 < 0.5 record only PaO_2					PO_2 > 70	PO_2 51-70		PO_2 55-60	PO_2<55
ARTERIAL pH	³7.7	7.6-7.69		7.5-7.59	7.33-7.49		7.25-7.32	7.15-7.24	< 7.15
SERUM SODIUM ($mmolL^{-1}$)	³180	160-179	155-159	150-154	130-149		120-129	111-119	£110
SERUM POTASSIUM ($mmolL^{-1}$)	³ 7	6-6.9		5.5-5.9	3.5-5.4	3-3.4	2.5-2.9		< 2.5
SERUM CREATININE ($mg100ml^{-1}$) (Double point score for acute renal failure)	³3.5	2-3.4	1.5-1.9		0.6-1.4		< 0.6		
HAEMATOCRIT (%)	³60		50-59.9	46-49.9	30-45.9		20-29.9		< 20
WHITE BLOOD COUNT (total/mm^3) (in 1,000s)	³40		20-39.9	15-19.9	3-14.9		1-2.9		< 1
GLASGOW COMA SCORE (GCS): Score = 15 minus actual GCS									
Total ACUTE PHYSIOLOGY SCORE (APS) Sum of the 12 individual variable points									
Serum HCO_3 ($venous\text{-}mmolL^{-1}$) (Not preferred, use if no ABGs)	³52	41-51.9		32-40.9	22-31.9		18-21.9	15-17.9	< 15

B) AGE POINTS

Assign points to age as follows:

AGE(yrs)	POINTS
£ 44	0
45-54	2
55-64	3
65-74	5
³ 75	6

C) CHRONIC HEALTH POINTS

If the patient has a history severe organ system insufficiency or is immumo-compromised assign points as follows:

a. for nonoperative or emergency postoperative patients – 5 patients

b. for elective postoperative patients – 2 points

DEFINITIONS

Organ insufficiency or immuno-compromised state must have been evident prior to this hospital admission and conform to the following criteria:

LIVER: Biopsy proven cirrhosis and documented postal hypertension; episodes or past upper GI bleeding attributed to portal hypertension or prior episodes of hepatic failure/encephalopathy/coma.

CARDIOVASCULAR: New York Heart Association Class IV.

RESPIRATORY: Chronic restrictive, obstructive, or vascular disease resulting in severe exercise restriction, i.e. unable to climb stairs or perform household duties; or documented chronic hypoxia, hypercapnia, secondary polycythemia, severe pulmonary hypertension (>40mmHg), or respirator deficiency.

RENAL: Receiving chronic dialysis.

IMMUNO-COMPROMISED: The patient has received therapy that suppresses resistance to infection., e.g., term or recent high dose steroids, or has a disease that is insufficiently advanced to suppress resistance to infection, e.g., leukemia, lymphoma, AIDS

APACHE II SCORE

Sum of A + B + C

A. APS points _____

B. Age points _____

C. Chronic health points _____

Total APACHE II _____

New simplified acute physiology score (SAPS) II[33]

The SAPS II system was described in 1993 following a combined European and North American study. It was developed and validated in a large sample of patient data from 110 European and 27 North American hospitals. This model comprised 17 variables:

- 12 physiological variables
- Age
- Type of admission (non-operative, emergency surgery and elective surgery)
- Three prior diagnoses (AIDS, metastatic cancer and haematological cancer).

The SAPS II score varies between 0 and 163 points. All the physiological variables are registered as the worst values during the first 24 hours in the ICU. Calculation of the risk of death does not require selection of a primary admission diagnosis nor further information on chronic health status.

Mortality probability models (MPM) II[34]

The MPM II models were described in 1993 to 1994 and were based on the same data as used for the development of SAPS II with additional data from six other ICUs in North America. In these models, the final result is expressed only as a probability of death and not as a score. It comprised four different models:

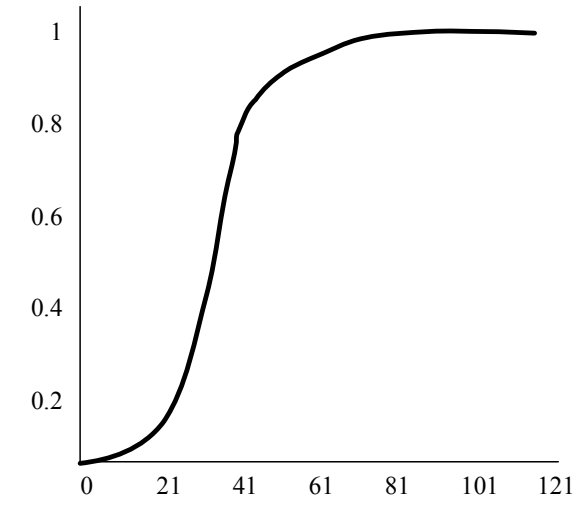
- The MPM II admission (MPM II_o), computed within one hour of the ICU admission. This model contains 15 variables. It is the only general model that is independent of treatment provided in the ICU and therefore can be used for patient stratification at the time of admission to the ICU.
- The MPM II 24 hour model (MPM II_{24}), computed after 24 hours in the ICU. This model comprises 13 variables.
- The MPM II 48 hour model (MPM II_{48}), computed after 48 hours in the ICU.
- The MPM II 72 hour model (MPM II_{72}), computed after 72 hours in the ICU.

All the physiologic variables are evaluated based on the worst values during the first 24 hours in the ICU.

The MPM II_{48} and MPM II_{72} models use the same variables of the MPM II_{24} model, with different weights for risk of death calculation. Both are based on the worst values presented by the patient during previous 24 hours.

Transformation of the severity score to a probability of death[33]

Once the severity score is compiled transformation to probability of death at hospital discharge is done using a logistic regression equation.



Relationship between the SAPS II score and the probability of death in hospital

The sigmoid shape of the curve has important implications for scores in the middle range wherein even small changes in the score are associated with large changes in the probability of death. At extremes of the score (very low or very high values) the associated changes in the probability of death are small.

Evaluating the performance of severity score

All statistical models need validation. This evaluation should be performed at regional or national level, should consist of two measures:

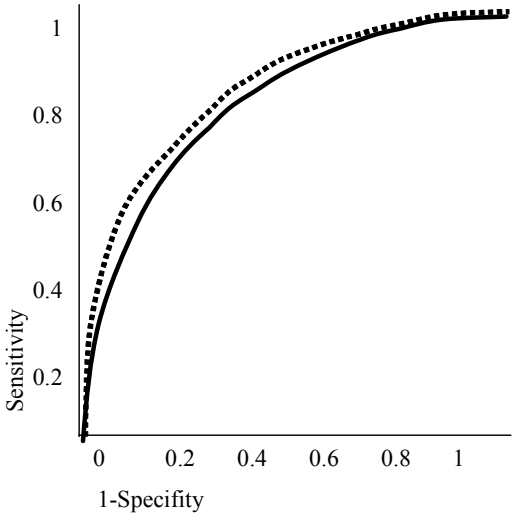
- Overall goodness of fit (discrimination and calibration)
- Uniformity of fit

Overall goodness of fit

Can be subdivided into discrimination and calibration

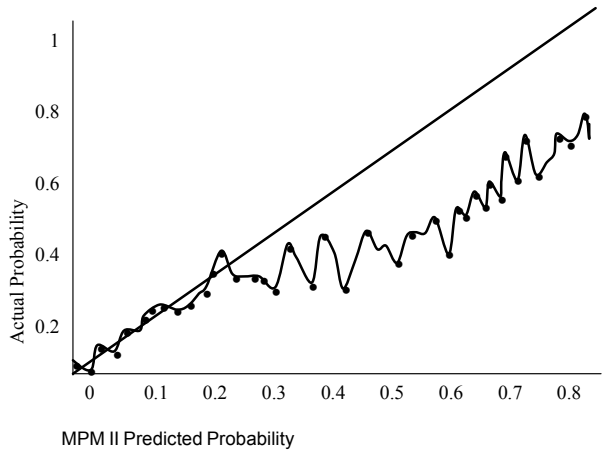
Discrimination[35] : Discrimination is the ability of the model to distinguish survivors from non-survivors and is usually evaluated using the area under receiver operating characteristic (ROC) curve, which plots the sensitivity (proportion of correctly classified non-survivors) against (1 minus) the specificity (proportion of correctly classified survivors) at different cut-off values of the score. The interpretation of discrimination is easy: a perfect model will have an area under the ROC curve of 1.0 and a model whose discriminative capability is no greater than chance

has an area of 0.5. For most models, this value should be greater than 0.8. The greater the under the ROC curve, the better is the discrimination of the model.



Receiver operator curve for SAPS II (·) and MPM II (-) in the EURICUS I study. The curves plots the sensitivity and 1-the specificity for all possible values of the two scores.

Calibration[35] : Calibration is the degree of correspondence between the probabilities assigned by the model and observed mortality. It is usually evaluated by two statistical tests proposed by Hosmer and Lemeshow (the C test and the H test), which divide the population into deciles of risk, and compare the expected with the actual number of survivors (and non-survivors) in each decile. A more intuitive evaluation, although less formal, can be made by the use of calibration curves. Greater the agreement between the observed and predicted mortality, the better the calibration of the model.



Calibration curve for the MPM II_o model in EURICUS I study. The straight line represents the perfect match between predicted and observed mortality. It is evident that for patients with a predicted probability greater than 0.3, observed mortality is significantly lower than predicted mortality.

Uniformity-of-fit

Uniformity-of-fit reflects the model's performance in sub-groups of patients. The rationale of this evaluation is similar to that of general regression, where influential observations that can have an important impact in the overall performance of the model are specifically explored. Although no consensus exists about the best technique for identifying these sub-groups, we can use discrimination and calibration measures in sub-groups of patients. The most influential factors are those related with major case-mix components:

- Location in the hospital before ICU admission
- Patient type (non-operative, emergency surgery, scheduled surgery)
- Degree of physiological dysfunction
- Physiological reserve (age, chronic diagnosis)
- Acute diagnosis

This evaluation is more important when studying highly specialized ICUs with unique patient characteristics. However, it can also be important in general ICUs.

Conclusions

The intensive care units are well established even in India. However, it is an expensive speciality. The outcome of a disease depends largely on the patient's age, previous health status (co-morbidities), current disease (and severity) and treatment. The need to develop an index and quantify severity of illness has arisen from the need to predict the likely outcome of an illness to assess the difference in the treatments between two or more intensive care units and to appropriately assess and administer health funding. Currently, apart from predictors of brain death, outcome predictors are not sufficiently accurate to give 100% assurance of outcome and therefore are not able to decide when to terminate individual patient care.

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