ICU Outcome Scoring Systems

- ***Specific***

  a. head injury → Glasgow coma score

  b. burns → % + age ~ mortality

  c. trauma → injury severity score (ISS)
  trauma score

  d. IHD → NYHA / AHA classification

  e. pancreatitis → Ranson's scoring criteria

  f. liver failure → Child's classification

- ***General***

  a. TISS = therapeutic intervention scoring system
  - rough indicator of severity
  - useful for costing & staffing assessments
  - influenced by available equipment, staff & enthusiasm

  b. APACHE II = 12 variables + age + chronic health
  - objective, easy
  - uses available hospital data
  - valid for many diagnoses
  - indicative of illness severity
  - independent of treatment

  c. APACHE III → boarder base, taking into account,
  - referral patterns
  - time delay from diagnosis to admission
  - daily score
  - more individual use
  - board cost-benefit analysis

  d. APS, SAPS = sickness score, mortality prediction models
  - comparable specificity ~ 90-95%
  - poor sensitivity ~ 50-60%

  e. Knaus' = mortality vs. organ failure prediction table

- ***Why Predict Outcome ?***

  a. prognosis
  b. cost-benefit analysis
  c. withdrawal of treatment
  d. comparison between different centres
  e. monitoring/assessment of new therapies
  f. population sample comparison in studies

- ***Requirements for a Good Scoring System***

  a. simple, reliable, easily obtainable
  b. wide patient applicability - different diagnoses
     - all age groups
     - all levels / types of ICU's
  c. high sensitivity/specificity - ie. should be a good ***discriminator***
  d. stimulates improvement in outcomes
  e. independent of treatment
  f. physiological parameters
  g. optimal time is unclear
  h. number of criteria is unclear

- ***Potential Problems***

  NB: should not,

  i. limit treatment of individuals
  ii. result in nihilistic therapy
  iii. outweigh clinical judgement
  iv. depersonalise therapy

- ***Baldock ICW 1987***

NB: → three groups of scoring systems

1. ***anatomical*** - eg. Injury Severity Score
   - score 0-5 for each anatomical area involved
   - final score → sum of 3 highest squared
   - useful for trauma audits & research
2. ***therapeutic*** - eg. Therapeutic Intervention Scoring System, TISS
   - sum of weighted scores of 70 therapeutic interventions
   - correlates well with ***outcome***
   - wide applicability
   - limited by available facilities, illness severity, staff enthusiasm and experience
3. ***physiological***
   - eg. "acute physiology and chronic health evaluation", APACHE
   - designed for quality review rather than prognosis
   - extensive, 33 variables & difficult to use clinically
   - simplifications → SAPS (13 var) & APACHE II
   - APACHE II = 12 var + age + previous health
   - correlates with ***hospital mortality***
   - limited by subjective scoring

■ ***Knaus CCM 1985***

- point score based on 12 physiological variables
- variable selection & weighting was based on 'expert' physician determination

APACHE II									
	+ 4	+ 3	+ 2	+ 1		+ 1	+ 2	+ 3	+ 4
Temperature	≥ 41	39-40.9		38.5-38.9	**36-38.4**	34-35.9	32-33.9	30-31.9	≤ 29.9
MAP	≥ 160	130-159	110-129		**70-109**		50-69		≤ 49
HR	≥ 180	140-179	110-139		**70-109**		55-69	40-54	≤ 39
RR	≥ 50	35-49		25-34	**12-24**	10-11	6-9		≤ 5
Oxygenation[1]	≥ 500	350-499	200-349		**< 200** $\mathbf{P_{aO2} > 70}$	61-70		55-60	< 55
pH	≥ 7.7	7.6-7.69		7.5-7.59	**7.33-7.49**		7.25-7.32	7.15-7.24	< 7.15
Na^+	≥ 180	160-179	155-159	150-154	**130-149**		120-129	111-119	≤ 110
K^+	≥ 7	6.6-6.9		5.5-5.9	**3.5-5.4**	3-3.4	2.5-2.9		< 2.5
Creat	≥								
Hct	≥ 60		50-59.9	46-49.9	**30-45.9**		20-29.9		< 20
WCC	≥ 40		20-39.9	15-19.9	**3-14.9**		1-2.9		< 1
15-GCS									

[1] $F_IO_2 > 0.5$ record $\delta A\text{-}aO_2$ $F_IO_2 < 0.5$ record P_{aO2}

- plus points for,
    1. age > 44 years
    2. chronic health status

- 5815 ICU patients from multicentre study,
    a. increased score correlated with ***mortality***
    b. high specificity (> 98%) but low sensitivity (< 30%)
    c. correct prediction only **~ 80%**

■ ***Chang Anaesthesia 1987***

- prospective study of APACHE II for 12 months in Saudi Arabia, 210 patients
- increased score associated with increased mortality,
    a. sensitivity < 42%
    b. specificity > 95%

- ***Knaus Ann Surg 1985***

- prospective multicentre study of 5677 ICU patients
- comparing number of organ systems failing (OSF) and mortality
- where the organ systems were,

1. CVS
2. respiratory
3. renal
4. CNS
5. haematological

No. of OSF	**Mortality**			
	Age < 65		Age > 65	
	day 1	day 7	day 1	day 7
1	16%	30%	32%	60%
2	46%	55%	61%	90%
3	76%	100%	85%	100%

- predictive value limited
- not stratified for disease types nor previous health
- indicative of mortality during study period only

- ***Lemeshow CCM 1985***

- multiple regression analysis of 775 adult medical & surgical ICU patients
- measured condition and treatment variables on admission and at 24 hours
- univariate significant factors

a. significant factors ***on admission***
   i. age
   ii. BP & HR
   iii. number of OSF
   iv. presence of infection
   v. if CPR used
   vi. conscious level
   vii. elective or emergency
   viii. type of admission ($p < 0.001$)

b. significant factors at ***24 hours*** = above plus,
   i. mechanical ventilation
   ii. number of "lines"
   iii. use of vasoactive drugs
   iv. high levels of PEEP
   v. oliguria
   vi. use of a S-G catheter
   vii. PaO_2, F_IO_2, arterial pH, creatinine
   viii. infection
   ix. shock
   x. type of admission ($p < 0.001$)

Multivariate Significant Factors		
	On admission	At 24 hours
	level of consciousness	level of consciousness
	infection	infection
	number of OSF	number of OSF
	age	age
	admission type (med/surg)	admission type
	systolic BP	shock
	cancer	F_IO_2
Sensitivity	~ 50%	~ 55%
Specificity	~ 96%	~ 95%
Prediction	~ 87%	~ 85%

- ***Lemeshow CCM 1987***

• comparison of APS, SAPS, MPM → all performed comparibly with 2000 ICU patients

- ***Teres CCM 1987***

• previously developed weighted scoring system, MPM, mortality predictive model
• tested on ~ 2000 patients with some modifications
• admission score better than 24 hour score in mortality prediction
• with the number of OSF added to criteria,

a. sensitivity ~ 50%
b. specificity ~ 95%

- ***Chang CCM 1988***

• once only APACHE II versus daily APACHE II in 212 patients
• later more accurate predictor of mortality,

a. sensitivity ~ 42%
b. specificity ~ 97%
c. prediction ~ 83%

- ***Shoemaker CCM 1985***

• used empirically derived numeric ***severity index***, developed from 220 surgical patients, intensively monitored perioperatively
• recommends many new "normal ranges" for many vital signs etc. in post-operative patients
• limited by,

a. small study group
b. all elective patients
c. unusual statistical "fiddling"
d. involves invasive monitoring

- ***Nicholas ICM 1985***

• multicentre study, 792 ICU admissions to 8 institutions,

a. mortality increased with ***age*** → < 45 yrs ~ 15%
> 65 yrs ~ 37%
b. mortality similar for all elderly age groups,
→ **> 55 yrs** there is little increase in mortality from age difference alone
c. high APS score associated with high mortality in all age groups,
ie. less difference between ages
d. increased age associated with increased treatment (TISS score)
e. increased age not associated with longer duration in ICU

- ***Jacobs ICM 1988***

• followed 313 ICU patients, looking at ***survival***,

a. at discharge ~ 76%
b. at 6 months ~ 61%
c. at 12 months ~ 58%

• of those discharged,

a. 21% → developed decreased physical status and function
b. 2% → improved from time of discharge
c. 76% → unchanged from time of discharge

NB: ***health status*** prior to admission best indicator of "quality of life" after discharge from ICU;
age and SAPS scores showed ***less*** correlation

■ ***Definitions of Organ System Failure (OSF) Knaus et al***

• if patient has one of more of the following during a 24 hour period, regardless of other values, OSF existed on that day:

1. CVS *presence of one or more of the following
   - i. MAP ≤ 49 mmHg
   - ii. HR ≤ 54 bpm
   - iii. VF or VT
   - iv. AGA pH ≤ 7.24 with $PaCO_2$ ≤ 49 mmHg
2. Respiratory *presence of one or more of the following
   - i. RR < 5/min or ≥ 49/min.
   - ii. $PaCO_2$ ≥ 50 mmHg
   - iii. $AaDO_2$ ≥ 350 mmHg
   - iv. ventilator dependence on the ***fourth day*** of OSF
     - ie. not applicable for the initial 72 hr of OSF
3. Renal
   - excluding patients on chronic dialysis before hospital admission
   - presence of one or more of the following,
   - i. urine output ≤ 479 ml/24 hr or ≤ 158 ml/8 hr
   - ii. urea ≥ 36 mmol/l
   - iii. creatinine ≥ 270 µmol/l
4. Haematological failure
   - presence of one or more of the following,
   - i. WBC ≤ 1 x 10^9/l
   - ii. platelet count ≤ 20 x 10^9/l
   - iii. haematocrit ≤ 20%.
5. Neurological failure
   - GCS £ **6** *in absence of sedation at any point of the day
   - if intubated, use clinical judgement for ***verbal responses*** as follows,
   - i. patient unresponsive 1
   - ii. patient's ability to converse in question 3
   - iii. patient appears able to converse 5

- ***Multiple Organ Dysfunction Score Marshall Et Al***

1. Respiratory → P_{aO2} / F_IO_2
   - without reference to mode of mechanical ventilation and use or level of PEEP
2. Renal → creatinine µmol/l
   - without reference to use of dialysis
3. Hepatic → bilirubin µmol/l
4. Pressure adjusted HR → PAR = HR × RAP/MAP
   - normal, 2.5 to 10 beats/min
   - record the three component variables simultaneously
5. Haematological → platelet count (platelets/m 10-3)
6. Neurologic → Glasgow Coma Score

- ***Scored***

a. once per day in the morning 0900; missing values entered as normal

b. as worst value, if such is available, after the approach of Knaus et al

- this will allow a comparison between the approach of Marshall et al
- "We chose to record these variables at a constant time point (usually the first morning values) to minimize aritifactual variability and to reflect a model of organ dysfunction as a sustained rather than a transient, process. The effect of other approaches merits study as the score evolves".

- ***Consensus Conference***

NB: Bone *et al.*, American College of Chest Physicians / Society of Critical Care, 1992

Def'n: ***Infection***: a microbial phenomenon characterised by an inflammatory response to the presence of microorganisms, or the invasion of normally sterile host tissue by these organisms

Bacteremia: the presence of viable bacteria in the blood

Systemic Inflammatory Response Syndrome **:** a characteristic clinical response, manifested by ***two or more*** of the following,

1.	***temperature***	> 38ºC		
		< 36ºC	(rectal)	
2.	***WCC***	> 12,000	/mm^3	
		< 4,000	/mm^3	
		> 10%	immature band forms	
3.	***tachycardia***	**> 90**	adults	
		> 150	children	
		> 160	infants	
4.	***tachypnoea***	**> 20**	adults	or P_{aCO2} < 32 mmHg
		> 50	children	
		> 60	infants	

Def'n: ***Sepsis*** **:** SIRS secondary to ***infection***

Severe SIRS / Severe Sepsis **:**
SIRS / sepsis with associated organ dysfunction, hypoperfusion, or hypotension

SIRS with Shock / Septic Shock **:**
SIRS / sepsis with associated organ dysfunction or hypoperfusion,
with hypotension ***not responsive*** to fluid resuscitation

Multiple Organ Dysfunction Syndrome **:**
state characterised by physiologic derrangements in which organ function is not capable of maintaining homeostasis

Def'n: ***Hypotension*** in the absence of other causes for hypotension,

1. systolic blood pressure < 90 mmHg, or
2. a reduction from baseline > 40 mmHg

Def'n: ***Hypoperfusion*** and perfusion abnormalities may include, but are not limited to,

1. lactic acidosis
2. oliguria
3. an acute alteration in mental status

- patients who are on inotropes / vasopressors need not be hypotensive to fulfill criteria
- in paediatrics, hypotension is ***not*** necessary for diagnosis, as it is a late & ominous sign

Def'n: ***paediatric shock*** **:** a clinical state characterised by inadequate delivery of oxygen and substrates to meet the metabolic demands of the tissues

- at present there are no graded definitions for paediatric sepsis
- septic shock ***mortality*** ranges from 25% to 75%
- average **~ 40%** and has not altered significantly in last 2 decades
    a. 75% of deaths occur early 2º to ***refractory hypotension***
    b. 25% occur late 2º to ***MODS***

- incidence of sepsis syndrome (US) ~ 176 per 100,000
- this has increased 140% from 1979 to 1987

- ***McCabe and Jackson Disease Severity Classification***

1. Rapidly fatal → not expected to survive more than ***1 year***
2. Ultimately fatal → not expected to survive more than ***5 years***
3. Nonfatal → 5 year survival not affected by underlying disease

- ***Comorbidity Score Gross Et Al***

• the number of conditions is restricted to nine,

1. smoking habit
   - active smoking of 10 cigarettes/day with 10 UPY-unit pack years
2. alcoholism
   - regular intake > 80g of alcohol per day
   - history of alcoholic pancreatitis or hepatitis
   - portal hypertension and varices
   - cirrhosis at surgery or by biopsy
3. non-cured malignancy
4. diabetes mellitus requiring treatment
5. splenectomy before ICU admission
6. major surgery within 2 months prior to admission
7. previous antibiotic therapy within 2 months prior to admission and for at least 2 months
8. previous cardiogenic shock or cardiopulmonary resuscitation before admission to the ICU

- ***Sedation Score After Ramsay Levels***

1. anxious and agitated, or restless, or both
2. cooperative, oriented and tranquil
3. respond to commands only
4. asleep but brisk response to glabellar tap or loud auditory stimulus
5. asleep, sluggish response to glabellar tap or loud auditory stimulus
6. no response

SAPS

- LeGall *et al.* 1984, CCM
- 679 patients from 8 ICU's, 40% surgical patients
- 14 physiological variables
- divided scores, 4 to > 21 and associated risks of death,
    a. 5-6 ~ 10%
    b. > 21 ~ 81%

- ROC area ~ 0.8

- SAPSII introduced by LeGall & Lemeshow, JAMA 1993, 17 variables
    a. ROC ~ 0.86
    b. correlation SAPS / SAPSII ~ 0.79

TQEH Data

	Mean	Median	StDev	Min	Max
Age	61.445	66	18.707	15	90
APACHE2	20.8	20	9.288	2	51[1]
ROD[2]	0.3529	0.294	0.2848	0.002	0.983
SAPS	14.501	14	5.572	1	35
SAPS2	41.186	38	18.98	0	97
RODSAPS2	0.3279	0.213	0.2918	0	0.98

[1] highest survivor APACHEII = 41
ROD = 98%

[2] SMR = actual deaths / ROD
~ 29% / 35%
~ 0.82 ($p < 0.05$)

ICU DESIGN

- ***Levels of ICU***

a. level I = small district hospital
   - ~ high dependency unit
   - ~ 24 hour ventilation facilities

b. level II = general hospital
   - prolonged ventilation facilities
   - pathology, radiology, biochem., haematol., etc.

c. level III = tertiary referral centre

- ***Generalised Requirements***

a. 1-2% of hospital beds

b. patient area ~ 18.2 m^2, larger for isolation rooms

c. electrical
   i. "cardiac protected" electrical area
   ii. emergency power for ventilators, lighting and equipment
   iii. 16 power outlets - 8 on emergency circuit

d. required "outlets" per bed,
   i. 3 oxygen, 2 air, 4 suction
   ii. 1 non-splash hand washing basin

e. central nurses station with all beds visible

f. adequate storage area

g. adequate equipment with backups and facility for service

h. staff offices, relative waiting area(s)

i. staffing
   - medical
   - nursing
   - physiotherapy
   - administrative

j. facility access
   - operating theatres
   - imaging
   - laboratories
   - accident & emergency