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30.01 APACHE Score

Overview:
The APACHE (acute physiology and chronic health evaluation) is a system for classifying patients in the intensive care unit. Patients are evaluated by physiologic scores and evaluation of chronic health status. Physiologic scores correlate with severity of illness. Results of the evaluation can be used to estimate the mortality rate for patients in the ICU and during the hospitalization.

Physiologic classes of variables (total 8 classes with 34 variables)
• cardiovascular: 7 variables
• respiratory: 3 variables
• renal: 3 variables
• gastrointestinal: 6 variables
• hematologic: 4 variables
• septic: 4 variables
• metabolic: 6 variables
• neurologic: 1 variable

Scoring
• physiologic data is evaluated during the first 32 hours after admission to the ICU
• each variable is assigned a value of 0 to 4, based on significance of deviation from normal, with more severe deviations given higher values

Cardiovascular

	+4	**+3**	**+2**	**+1**	**0**	**+1**	**+2**	**+3**	**+4**
heart rate ventricular response	>= 180	141-179	111-140		70-110		56-69	41-55	<= 40
mean arterial pressure in mm Hg	>= 160	131-159	111-130		70-110		51-69		<= 50

((S+2D)/3)									
R atrial pressure or CVP in mm Hg			>= 26	16 - 25	1 - 15	< 1			
evidence of acute MI (CPK-MB, ECG, other)	Yes				No				
ECG arrhythmias		A	B					C	D
serum lactate mg/dL	> 72	30.7 - 72			0 - 30.6				
arterial pH	>= 7.7	7.6 - 7.69		7.51-7.59	7.33-7.50		7.25-7.32	7.15-7.24	< 7.15

where
- serum lactate expressed in mEq/L, which is no longer used routinely. This was assumed to be equivalent to mmol/L, which is converted to mg/dL by multiplying by 9
- A: atrial arrhythmias and hemodynamic instability
- B: atrial arrhythmias alone
- C: > 6 PVCs per minute
- D: ventricular tachycardia or fibrillation

Respiratory

	+4	**+3**	**+2**	**+1**	**0**	**+1**	**+2**	**+3**	**+4**
respiratory rate nonventilated	>=50	35 - 49		26 - 34	12 - 25	10 - 11	7 - 9		<= 6
P(A-a)O2 (FIO2 1.0)	>= 500	351-499		200-350	< 200				
PaCO2	>= 70	61 - 69	50 - 60		30 - 49		25 - 29	20 - 24	< 20

where:
- the P(A-a)O2 for FIO2 is given as ((FIO2 as fraction from 0.21 to 1.00) * 713) - PaCO2 - PaO2); however, the decision points for lower FIO2s are not given. These are unlikely to be comparable to those of an FIO2 of 1.00.

Renal

	+4	**+3**	**+2**	**+1**	**0**	**+1**	**+2**	**+3**	**+4**
urine output in L per day			>= 5	> 3.5 - <5	0.7 - 3.5		0.48-< 0.7	0.12-0.47	< 0.12
serum BUN in mg/dL	> 150	101 - 150	81 - 100	21 - 80	10 - 20		< 10		
serum creatinine in mg/dL	> 7.0	3.6 - 7.0	2.1 - 3.5	1.6 - 2.0	0.6 - 1.5	< 0.6			

Gastrointestinal

	+4	**+3**	**+2**	**+1**	**0**	**+1**	**+2**	**+3**	**+4**

serum amylase in IU	>= 2000	501-1999			<= 500				
serum albumin in g/dL	> 8				3.5 - 8.0	2.5 - 3.4	< 2.5		
total bilirubin in mg/dL		>= 15		5.1 - 14.9	0 - 5				
alkaline phosphatase in IU				> 160	0 - 160				
SGOT			>= 1500	101 - 1499	0 - 100				
anergy by skin test	total		rela-tive		none				

where
• total anergy = no response to all provocative skin tests including mumps and fungal
• relative anergy = reduced response to skin tests indicative of compromised cellular immunity

Hematological

	+4	**+3**	**+2**	**+1**	**0**	**+1**	**+2**	**+3**	**+4**
hematocrit	> 60		51 - 60	47 - 50	30 - 46		20 - 29		< 20
WBC in thousands/µL	> 40		> 20 - 40	> 15 - 20	> 3 - 15		1 - 3		< 1
platelet count in thousands/µL			> 1K	>600 - 1K	80 - 600		20 - < 80		< 20
prothrombin time in seconds > control	> 12	5.1 - 12	3.1 - 5.0		0 - 3				

where
• prothrombin testing is done without patient anticoagulation

Septic

	+4	**+3**	**+2**	**+1**	**0**	**+1**	**+2**	**+3**	**+4**
CSF positive culture	Yes				No				
blood culture positive	Yes				No				
fungal culture positive	A	B		C	No				
rectal temp in C°	> 41	39.1-41.0		38.6-39.0	36 - 38.5	34 - 35.9	32 - 33.9	30 - 31.9	<= 29.9

where
• A: blood and/or CSF positive for fungi

• B: 2 sites other than blood or CSF positive for fungi
• C: 1 site other than blood or CSF positive for fungi

Metabolic

	+4	+3	+2	+1	0	+1	+2	+3	+4
serum calcium in mg/dL	>= 16		14 - 15.9	11.1- 13.9	8.0 - 11.0		5.0 - 7.9		< 5.0
serum glucose in mg/dL	> 800	500 - 800		251 - 499	70 - 250		50 - 69	30 - 49	< 30
serum sodium in mEq/L	> 180	161 - 180	156 - 160	151 - 155	130 - 150		120 - 129	110 - 119	< 110
serum potassium in mEq/L	> 7	6.1 - 7.0		5.6 - 6.0	3.5 - 5.5	3.0 - 3.4	2.5 - 2.9		< 2.5
serum bicarbonate in mEq/L		> 40		31 - 40	20 - 30	10 - 19		5 - 9	< 5
serum osmolarity	> 350	321 - 350		301 - 320	260 - 300		240 - 259	220 - 239	< 220

Neurological

	+4	+3	+2	+1	0	+1	+2	+3	+4
Glasgow Coma Score	3	4 - 6	7 - 9	10 - 12	13 - 15				

APACHE score =
= (points for cardiovascular status) + (points for respiratory status) + (points for renal status) + (points for gastrointestinal status) + (points for hematological status) + (points for septic status) + (points for metabolic status) + (points for neurological status)

Preadmission Health Status

Qualifying Questions, based on health status 3-6 months before admission	**Group**	**Description**
Did the patient have weekly visits to a physician? Was the patient unable to work because of illness? Was the patient bedridden or institutionalized because of illness? Had the patient suffered a relapse after systemic treatment for carcinoma?	D	Severe restriction of activity due to disease; includes patients bedridden or institutionalized due to illness
Was the patient's usual daily activity limited? Did symptoms occur with mild exercise? Had the patient received treatment for neoplasm with remission? Had the patient received uncomplicated	C	chronic disease producing serious but not incapacitating restriction of activity

hemodialysis?		
Did the patient see a physician monthly? Did the patient take medication chronically? Was the patient mildly limited in activity level due to illness? Did the patient have diabetes mellitus, chronic renal failure, a bleeding disorder, or chronic anemia?	B	mild to moderate limitation in activity because of chronic health problem
negative responses to all of the above questions	A	prior good health with no functional limitations

Interpretation
- minimum score: 0
- maximum score: 129 (cardiovascular 27; respiratory 12; renal 12; gastrointestinal 18; hematological 16; septic 16; metabolic 24; neurological 4)

Probability of Death in Hospital based on APACHE score

Score	Mortality Rate
0 - 5	2.3%
6 - 10	4.3%
11 - 15	8.6%
16 - 20	16.4%
21 - 25	28.6%
26 - 30	56.4%
31+	70%

data extrapolated from Figure 1, page 595

Relationship between chronic health status and patient outcome

Overall

Preadmission Health Status	Probability of Dying in the ICU	Probability of Dying in the Hospital
A	7.3%	12%
B	5.9%	12%
C	10.5%	16.5%
D	11.7%	25%

Nonoperative

Preadmission Health Status	Probability of Dying in the ICU	Probability of Dying in the Hospital
A	14%	20.9%
B	10.1%	20.2%
C	12.8%	21.7%
D	22.2%	50%

Operative

Preadmission Health Status	Probability of Dying in the ICU	Probability of Dying in the Hospital
A	3%	6.2%
B	2.2%	7.2%
C	8.6%	12.3%
D	3%	6%

References:

Knaus WA, Zimmerman JE, et al. APACHE - acute physiology and chronic health evaluation: a physiologically based classification system. Crit Care Med. 1981; 9: 591-597.

30.02 APACHE II Score

30.02.01 Generating the APACHE II Score

Overview:
The APACHE II score is a general measure of disease severity, based on current physiologic measurements, age and previous health condition. Scores range from 0-71, with an increasing score associated with an increasing risk of hospital death. The score can help in the assessment of patients to determine the level and degree of diagnostic and therapeutic intervention.

APACHE II score =
= (acute physiology score) + (age points) + (chronic health points)

Acute Physiology Score

	+4	+3	+2	+1	0	+1	+2	+3	+4
rectal temp in C°	>= 41	39-40.9		38.5-38.9	36-38.4	34-35.9	32-33.9	30-31.9	<= 29.9
mean arterial pressure mm Hg	>= 160	130-159	110-129		70-109		50-69		<= 49
heart rate in beats/minute	>= 180	140-179	110-139		70-109		55-69	40-54	<= 39
respiratory rate in breaths/min	>=50	35-49		25-34	12-24	10-11	6-9		<= 5
oxygen: A-aDO2 (FIO2 >= 0.5)	>= 500	350-499	200-349		< 200				
oxygen: PO2 (FIO2 < 0.5)					> 70	61-70		55-60	< 55
arterial 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
serum sodium	>=	160-	155-	150-	130-		120-	111-	<=

	180	179	159	154	149		129	119	110
serum potassium	>= 7	6-6.9		5.5-5.9	3.5-5.4	3-3.4	2.5-2.9		<2.5
serum creatinine in mg/dL	>= 3.5	2-3.4	1.5-1.9		0.6-1.4		< 0.6		
hematocrit in percent	>= 60		50-59.9	46-49.9	30-45.9		20-29.9		< 20
WBC in thousands	>= 40		20-39.9	15-19.9	3-14.9		1-2.9		< 1
15 - (Glasgow Coma Score)									

where
• The score for serum creatinine is doubled if the patient has acute renal failure.
• mean arterial pressure =
((systolic blood pressure)+ (2 * (diastolic pressure))) / 2

Age Points

Age	**Points**
<= 44	0
45-54	2
55-64	3
65-74	5
>= 75	6

Chronic Health Points

history of severe organ insufficiency or immunocompromised	**Points**
nonoperative patients	5
emergency postoperative patients	5
elective postoperative patients	2

where
• organ insufficiency or immunocompromised state must have preceded the current admission
• immunocompromised if: (1) receiving therapy reducing host defenses (immunosuppression, chemotherapy, radiation therapy, long term steroid use, high dose steroid therapy), or (2) has a disease severe enough to interfere with immune function such as malignant lymphoma, leukemia or AIDS
• liver insufficiency if: (1) biopsy proven cirrhosis, (2) portal hypertension, (3) episodes of upper GI bleeding due to portal hypertension, (4) prior episodes of hepatic failure, coma or encephalopathy
• cardiovascular insufficiency if: New York Heart Association Class IV
• respiratory insufficiency if: (1) severe exercise restriction due to chronic restrictive, obstructive or vascular disease, (2) documented chronic hypoxia, hypercapnia, secondary polycythemia, severe pulmonary hypertension, (3) respirator dependency

• renal insufficiency if: on chronic dialysis

Interpretation:
• score range: 0 - 71

References:
Knaus WA, Draper EA, et al. APACHE II: A severity of disease classification system. Critical Care Medicine. 1985; 13:818-829.

30.02.02 Computing the Predicted Death Rate for Acutely Ill Patients with APACHE II

Overview:
From the APACHE II score and knowledge of primary clinical diagnoses, an estimated risk of death in the hospital can be calculated.

ln ((estimated risk of hospital death) / (1 - (estimated risk of hospital death))) =
= (-3.517) + (0.146 * (APACHE II score)) + (0.603 if post-emergency surgery, 0 if not) + (diagnostic category weight)

Diagnostic Category - Nonoperative

Group	Disorder	Weight
respiratory failure or insufficiency	asthma or allergy	-2.108
	COPD	-0.367
	pulmonary edema, noncardiogenic	-0.251
	post-respiratory arrest	-0.168
	aspiration	-0.142
	poisoning or toxic	-0.142
	pulmonary embolus	-0.128
	infection	0
	neoplasm	0.891
cardiovascular failure or insufficency	hypertension	-1.798
	rhythm disturbance	-1.368
	congestive heart failure	-0.424
	hemorrhagic shock or hypovolemia	0.493
	coronary artery disease	-0.191
	sepsis	0.113
	postcardiac arrest	0.393
	cardiogenic shock	-0.259
	dissecting aortic aneurysm	0.731
trauma	multiple trauma	-1.228

	head trauma	-0.517
neurologic	seizure disorder	-0.584
	ICH/SDH/SAH	0.723
other	drug overdose	-3.353
	diabetic ketoacidosis	-1.507
	GI bleeding	0.334
vital organ affected	metabolic or renal	-0.885
	respiratory	-0.890
	neurologic	-0.759
	cardiovascular	0.470
	gastrointestinal	0.501

Diagnostic Category - Operative

Group	**Disorder**	**Weight**
Operation	multiple trauma	-1.684
	chronic cardiovascular disease	-1.376
	peripheral vascular disease	-1.315
	heart valve surgery	-1.261
	craniotomy for neoplasm	-1.245
	renal surgery for neoplasm	-1.204
	renal transplant	-1.042
	head trauma	-0.955
	thoracic surgery for neoplasm	-0.802
	craniotomy for ICH/SDH/SAH	-0.788
	laminectomy or other spinal cord surgery	-0.699
	hemorrhagic shock	-0.682
	GI bleeding	-0.617
	GI surgery for neoplasm	-0.248
	respiratory insufficiency after surgery	-0.140
	GI perforation or obstruction	0.060
postoperative complications	sepsis	0.113
	postcardiac arrest	0.393
	postrespiratory arrest	-0.168
NOS	neurologic	-1.150
	cardiovascular	-0.797
	respiratory	-0.610
	gastrointestinal	-0.613

	metabolic renal	-0.196

References:
Knaus WA, Draper EA, et al. APACHE II: A severity of disease classification system. Critical Care Medicine. 1985; 13:818-829. (Appendix pages 828-829)

30.02.03 Sickness Score

Overview
The Sickness Scale is based closely upon the Apache II score and is intended to assess critically ill patients transported between hospitals.

Assessments performed
• before and after resuscitation
• on return to base
• after 24 hours of intensive care

Differences from Apache II
• Measurements are in SIU.
• The FIO2 to PaO2 ratio is calculated rather than A-aDO2 or PaO2 as a measure of oxygenation (FIO2 as percent inspired oxygen, PaO2 in kPa).
• The hemoglobin is used rather than hematocrit, and the breakpoints for each score are slightly different when units are adjusted for, where hemoglobin = ((hematocrit) / 2.94).
• The breakpoints for creatinine differ when units are adjusted for. (1 mg/dL = 88.4 µmol/L).
• A chronic disease must be sufficiently severe to prevent independent self-care.
• In Apache II, the more extreme (maximum or minimum) value for temperature, mean arterial pressure, heart rate and respiratory rate are used, as opposed to single values in the Sickness Score.

	+4	**+3**	**+2**	**+1**	**0**	**+1**	**+2**	**+3**	**+4**
FIO2/PaO2	>= 5.0	4.0-4.99	2.1-3.99		< 2.09				
hemoglobin in g/dL	>= 18.0		15.0-17.9	14.0-14.9	9.0-13.9		6.1-8.9		<= 6.0
creatinine in µmol/L	>= 600	300-599	180-299	130-179	50-129		<= 49		

Interpretation:
• The higher the score the worse the prognosis.
• Scores > 19 are usually associated with subsequent death.
• While the scores for non-survivors may fall after resuscitation, the subsequent outcome is unaffected.

References:
Bion JF, Edlin SA, et al. Validation of a prognostic score in critically ill patients undergoing transport. Br Med J. 1985; 291: 432-434.
Bion JF, Logan BK, et al. Sedation in intensive care: morphine and renal function. Intensive Care Med. 1986; 12: 359-365.
Bion JF, Aitchison TC, et al. Sickness scoring and response to treatment as predictors of outcome from critical illness. Intensive Care Med. 1988; 14: 167-172.

30.03 Modification of the APACHE II Score for Organ System Failures

30.03.01 Organ Failure Score

Overview:
The presence of major organ failures is associated with increased patient mortality. Adjustment of the APACHE II score to reflect the number and duration of major organ failures can allow more accurate prediction of patient mortality in the ICU.

Organ System	Criteria for Failure
cardiovascular	**heart rate <= 54 beats per minute**
	mean arterial blood pressure <= 49 mm Hg
	occurrence of ventricular tachycardia and/or ventricular fibrillation
	serum pH <= 7.24 with PaCO2 <= 49 mm Hg
respiratory	**respiratory rate <= 5 per minute, or >= 49 per minute**
	PaCO2 > 50 mm Hg
	AaDO2 > 350 mm Hg
	dependent on ventilator on 4th day of organ system failure (do not apply for first 72 hours of organ system failure)
renal	**(urine output <= 479 mL per day, OR <= 159 mL during an 8 hour period) AND serum urea >= 214 mg/dL**
	(urine output <= 479 mL per day, OR <= 159 mL during an 8 hour period) AND serum creatinine >= 3.5 mg/dL
hematological	**WBC count <= 1000 per µL**
	platelet count <= 20000 per µL
	hematocrit <= 20% AND not chronic renal failure
neurological	**Glasgow coma score <= 6, in absence of sedation, at any one point in day**
liver	**clinical acute liver failure and P < 0.66 (see below)**

where:
- **mean arterial blood pressure = ((systolic blood pressure) + (2 * (diastolic blood pressure))) / 3**
- **AaDO2 = ((713 * FIO2) - PaCO2 - PaO2)**

liver failure

- **LN (P / (1-P)) = X = 10 - (4.3 * (prothrombin ratio)) - (0.03 * (creatinine in mg/dL) * 88.4) - (0.85 * (1 if hepatic encephalopathy present, -1 if hepatic encephalopathy absent))**
- **prothrombin ratio = (patient's prothrombin time in seconds) / (mean prothrombin time for normal plasma)**
- **88.4 is conversion for creatinine in mg/dL to SI units**
- **P = (EXP(X)) / (1 + (EXP(X)))**

Organ Failure Coefficients

day of failure	1 OFs	2 OFs	3+ OFs
1	0.022	0.052	0.08
2	0.031	0.067	0.095
3	0.034	0.066	0.093
4	0.035	0.062	0.096
5	0.04	0.056	0.1
6	0.042	0.064	0.1
7	0.041	0.068	0.1

organ failure score =
= ((APACHE II score) * (1 + (organ failure coefficient)))

References

Chang RWS, Jacobs S, Lee B. Predicting outcome among intensive care unit patients using computerised trend analysis of daily Apache II scores corrected for organ system failure. Intensive Care Med. 1988; 14: 558-566.

Garden OJ, Motyl H, et al. Prediction of outcome following acute variceal hemorrhage. Br J Surg. 1985; 72: 91.

Thomson JN. Chapter 9: Laboratory control of anticoagulant therapy. pages 279-329. (page 318). IN: Thomson JN (editor). Blood Coagulation and Haemostasis, Second Edition. Churchill-Livingstone. 1980.

30.03.02 Organ Failure Score Algorithm to Predict Mortality in the ICU

Overview:
The pattern of organ failure scores for patients in the ICU can be used to predict mortality.

Patterns of Change in Organ Failure Score (OFS) Associated with Patient Death

Day in ICU	Findings	Pattern
Day 1	OFS > 35	high scorer
Day 2	AND	fuzzy bander

	((OFS day 1 > 27), (OFS day 1 <=35), ((OFS day 1) - (OFS day 2) < 2.5))	
Subsequent Day n	**AND ((OFS day n > 27) ((OFS day n) - (OFS day n-1) > 2.5))**	**leaper**
	gradual increase in OFS to > 35	**creeper**

where:
• increases in OFS are unexplained by surgery or major iatrogenic complications

Performance analysis at the Riyadh Intensive Care Program (Western Infirmary, Glasgow) showed that the mortality prediction algorithm has the a sensitivity equivalent to APACHE II (68%), but provides better specificity (95% vs 85%).

References

Chang RWS, Jacobs S, Lee B. Predicting outcome among intensive care unit patients using computerised trend analysis of daily Apache II scores corrected for organ system failure. Intensive Care Med. 1988; 14: 558-566.

Hope AT, Plenderleith JL. The Riyadh Intensive Care Program mortality prediction algorithm assessed in 617 intensive care patients in Glasgow. Anaesthesia. 1995; 50: 103-107.

Jacobs S, Arnold A, et al. The Riyadh Intensive Care Program applied to a mortality analysis of a teaching hospital intensive care unit. Anaesthesia. 1992; 47: 775-780.

30.04 APACHE III

30.04.01 Introduction to APACHE III

Overview:
APACHE III is a further refinement to the APACHE (Acute Physiology, Age, Chronic Health Evaluation) system intended to provide more accurate predictions of hospital mortality risk for the critically-ill hospitalized adult.

The calculations required for the prediction are somewhat complex, involving the combination of the following into a risk equation:
• the APACHE III score, composed of several subscores for age, chronic health, physiologic, acid-base and neurologic status
• a value reflecting admission status
• a value reflecting the major disease category.

From the risk equation, the risk of hospital mortality is calculated.

References:

Knaus WA, Wagner DP, et al. The APACHE III prognostic system: Risk prediction of hospital mortality for critically ill hospitalized adults. Chest. 1991; 100: 1619-1636.

Lemeshow S, Le Gall J-R. Modeling the severity of illness of ICU patients. JAMA 1994; 272: 1049-1055.

Wagner DP, Knaus WA, et al. Daily prognostic estimates for critically ill adults in intensive care units: Results from a prospective, multicenter, inception cohort analysis. Crit Care Med. 1994; 22: 1359-1372.

30.04.02 APACHE III Age and Chronic Health Subscore

Overview:
The APACHE III subscore for age and chronic health gives points based on age and comorbid conditions.

Age in years	Points
<= 44	0
45 - 59	5
60 - 64	11
65 - 69	13
70 - 74	16
75 - 84	17
>= 85	24

Comorbid Condition	Points
AIDS	23
hepatic failure	16
malignant lymphoma	13
metastatic cancer	11
leukemia or multiple myeloma	10
immunosuppression	10
cirrhosis	4

where:
- **points for the comorbid condition are excluded if the surgery is elective**
- **if 2 or more comorbid conditions are present, then the condition with the higher/highest point assignment is used**

Interpretation
- **minimum subscore for age: 0**
- **minimum subscore for comorbid condition: 0**
- **maximum subscore for age: 24**
- **maximum subscore for comorbid condition: 23**

References:

Knaus WA, Wagner DP, et al. The APACHE III prognostic system: Risk prediction of hospital mortality for critically ill hospitalized adults. Chest. 1991; 100: 1619-1636.

Lemeshow S, Le Gall J-R. Modeling the severity of illness of ICU patients. JAMA 1994; 272: 1049-1055.

Wagner DP, Knaus WA, et al. Daily prognostic estimates for critically ill adults in intensive care units: Results from a prospective, multicenter, inception cohort analysis. Crit Care Med. 1994; 22: 1359-1372.

30.04.03 APACHE III Physiologic Subscore

Overview:
The physiologic subscore is based a number of physiologic and biochemical parameters, with points awarded according to the severity of any abnormality present.

Scoring
- **the points are assigned for the most abnormal (worst) value in a 24 hour period**
- **if a value is not available, then score as if normal**

Pulse in beats/minute	Points
<= 39	8
40 - 49	5
50 - 99	0
100 - 109	1
110 - 119	5
120 - 139	7
140 - 154	13
>= 155	17

Mean blood pressure	Points
<= 39	23
40 - 59	15
60 - 69	7
70 - 79	6
80 - 99	0
100 - 119	4
120- 129	7
130 - 139	9
>= 140	10

where
- **mean blood pressure = ((systolic blood pressure) + (2 * (diastolic blood pressure))) / 3**

temperature in °C	Points

<= 32.9	**20**
33 - 33.4	**16**
33.5 - 33.9	**13**
34 - 34.9	**8**
35 - 35.9	**2**
36 - 39.9	**0**
>= 40	**4**

respiratory rate in breaths per minute	**Points**
<= 5	**17**
6 - 11	**8 if not on mechanical ventilation; 0 if on mechanical ventilation**
12- 13	**7 (0 points if rate 12 and patient on mechanical ventilation)**
14 - 24	**0**
25 - 34	**6**
35 - 39	**9**
40 - 49	**11**
>= 50	**18**

PaO2 in mm Hg	**Points**
<= 49	**15**
50 - 69	**5**
70 - 79	**2**
>= 80	**0**

where
• points for PaO2 not given for intubated patients with FIO2 >= 0.5 (see A-a DO2)

A-a DO2	**Points**
< 100	**0**
100 - 249	**7**
250 - 349	**9**
350 - 499	**11**
>= 500	**14**

where:
• A-a DO2 only used for intubated patients with FIO2 >= 0.5

Hematocrit as percent	**Points**
<= 40.9	**3**
41 - 49	**0**

>= 50	**3**

WBC per microliter	**Points**
< 1000	**19**
1000 - 2900	**5**
3000 - 19900	**0**
20000 - 24999	**1**
>= 25000	**5**

Creatinine in mg/dL, without acute renal failure	**Points**
<= 0.4 mg/dL	**3**
0.5 - 1.4	**0**
1.5 - 1.94	**4**
>= 1.95	**7**

Creatinine in mg/dL, with acute renal failure	**Points**
0 - 1.4	**0**
>= 1.5	**10**

where

- **acute renal failure = creatinine >= 1.5 mg/dL, urine output < 410 mL/day and no chronic dialysis**

urine output in mL per day	**Points**
<= 399	**15**
400 - 599	**8**
600 - 899	**7**
900 - 1499	**5**
1500 - 1999	**4**
2000 - 3999	**0**
>= 4000	**1**

BUN in mg/dL	**Points**
<= 16.9	**0**
17 - 19	**2**
20 - 39	**7**
40 - 79	**11**
>= 80	**12**

sodium in mEq/L	**Points**
<= 119	**3**

120 - 134	2
135 - 154	0
>= 155	4

albumin in g/dL	Points
<= 1.9	11
2.0 - 2.4	6
2.5 - 4.4	0
>= 4.5	4

bilirubin in mg/dL	Points
<= 1.9	0
2.0 - 2.9	5
3.0 - 4.9	6
5.0 - 7.9	8
>= 8.0	16

glucose in mg/dL	Points
<= 39	8
40 - 59	9
60 - 199	0
200 - 349	3
>= 350	5

physiologic score =
= (points for pulse) + (points for mean blood pressure) + (points for temperature) + (points for respiratory rate) + (points for PaO2 or A-a DO2) + (points for hematocrit) + (points for WBC count) + (points for creatinine +/- renal failure) + (points for urine output) + (points for BUN) + (points for sodium) + (points for albumin) + (points for bilirubin) + (points for glucose)

Interpretation
• minimum score: 0
• maximum score: 192 (due to PaO2 & A-aDO2, creatinine restrictions)

References:
Knaus WA, Wagner DP, et al. The APACHE III prognostic system: Risk prediction of hospital mortality for critically ill hospitalized adults. Chest. 1991; 100: 1619-1636.
Lemeshow S, Le Gall J-R. Modeling the severity of illness of ICU patients. JAMA 1994; 272: 1049-1055.
Wagner DP, Knaus WA, et al. Daily prognostic estimates for critically ill adults in intensive care units: Results from a prospective, multicenter, inception cohort analysis. Crit Care Med. 1994; 22: 1359-1372.

30.04.04 APACHE III Acid-Base Subscore

Overview:
The acid-base abnormality subscore is based on the patient's arterial pCO2 and pH.

Scoring
• the points are assigned for the most abnormal (worst) value in a 24 hour period
• if a value is not available, then score as if normal

pH	pCO2								
	< 25	25 - < 30	30 - < 35	35 - < 40	40 - < 45	45 - < 50	50 - < 55	55 - < 60	>= 60
< 7.15	12	12	12	12	12	12	4	4	4
7.15 - < 7.2	12	12	12	12	12	12	4	4	4
7.20 - < 7.25	9	9	6	6	3	3	2	2	2
7.25 - < 7.30	9	9	6	6	3	3	2	2	2
7.30 - < 7.35	9	9	0	0	0	1	1	1	1
7.35 - < 7.40	5	5	0	0	0	1	1	1	1
7.40- < 7.45	5	5	0	0	0	1	1	1	1
7.45 - < 7.50	5	5	0	2	2	12	12	12	12
7.50 - < 7.55	3	3	3	3	12	12	12	12	12
7.55 - < 7.60	3	3	3	3	12	12	12	12	12
7.60 - < 7.65	0	3	3	3	12	12	12	12	12
>= 7.65	0	3	3	3	12	12	12	12	12

Interpretation
• minimum subscore 0
• maximum subscore 12

References:
Knaus WA, Wagner DP, et al. The APACHE III prognostic system: Risk prediction of hospital mortality for critically ill hospitalized adults. Chest. 1991; 100: 1619-1636.
Lemeshow S, Le Gall J-R. Modeling the severity of illness of ICU patients. JAMA 1994; 272: 1049-1055.

Wagner DP, Knaus WA, et al. Daily prognostic estimates for critically ill adults in intensive care units: Results from a prospective, multicenter, inception cohort analysis. Crit Care Med. 1994; 22: 1359-1372.

30.04.05 APACHE III Neurologic Subscore

Overview:
The neurologic subscore is based on whether the patient's eyes open or not, the verbal response and the motor response.

Scoring
• the points are assigned for the most abnormal (worst) value in a 24 hour period
• if a value is not available, then score as if normal

Eyes open spontaneously or to painful/verbal stimuli

	verbal response			
motor response	**oriented and converses**	**confused conversation**	**inappropriate words and incomprehen-sible sounds**	**no response**
obeys verbal command	**0**	**3**	**10**	**15**
localizes pain	**3**	**8**	**13**	**15**
flexion withdrawal or decorticate rigidity	**3**	**13**	**24**	**24**
decerebrate rigidity or no response	**3**	**13**	**29**	**29**

Eyes do not open spontaneously or to painful/verbal stimuli

	verbal response			
motor response	**oriented and converses**	**confused conversation**	**inappropriate words and incomprehen-sible sounds**	**no response**
obeys verbal command	**unlikely**	**unlikely**	**unlikely**	**16**
localizes pain	**unlikely**	**unlikely**	**unlikely**	**16**
flexion withdrawal or decorticate	**unlikely**	**unlikely**	**24**	**33**

rigidity				
decerebrate rigidity or no response	**unlikely**	**unlikely**	**29**	**48**

where:
- **unlikely indicates the combination of findings would not be expected to occur clinically**

Interpretation
- **minimum subscore: 0**
- **maximum subscore: 48**

References:

Knaus WA, Wagner DP, et al. The APACHE III prognostic system: Risk prediction of hospital mortality for critically ill hospitalized adults. Chest. 1991; 100: 1619-1636.

Lemeshow S, Le Gall J-R. Modeling the severity of illness of ICU patients. JAMA 1994; 272: 1049-1055.

Wagner DP, Knaus WA, et al. Daily prognostic estimates for critically ill adults in intensive care units: Results from a prospective, multicenter, inception cohort analysis. Crit Care Med. 1994; 22: 1359-1372.

30.04.06 Computing the Predicted Death Rate for Acutely Ill Patients with APACHE III

Overview:
Once the APACHE III points are tabulated, the risk equation can be calculated and the risk of hospital mortality estimated.

Data Requirements
(1) beta value for admission status to ICU
- **if nonoperative patient, select location prior to admission to ICU**
- **if operative patient, select emergency or non-emergency surgery**

(2) beta value for major disease category
- **if nonoperative patient, the major nonoperative disorder at admission to ICU**
- **if operative patient, the major noperative disorder at admission to ICU**

(3) total APACHE III points

total APACHE III points =
= (age subscore) + (chronic health subscore) + (physiologic subscore) + (acid-base subscore) + (neurologic subscore)

where
- **minimum total APACHE III score = 0**
- **maximum total APACHE III score = 299 (24 + 23 + 192 + 12 + 48)**

APACHE III risk equation =
= (beta value for admission status) + (beta value for major disease category) + (0.0537 * (total APACHE III points))

risk of hospital mortality =
= (EXP(APACHE III risk equation)) / ((EXP(APACHE III risk equation)) + 1)

NOTE: Since APACHE III is a proprietary system, the beta values for admission status and disease categories listed below are not published in the literature and are available by subscribing to the commercial system.

Admission - Nonoperative

Location prior to Current ICU Admission	beta
emergency room	
hospital floor	0.2744
transfer from another hospital	
other ICU	
readmission to same ICU	
operating or recovery room	

Admission - Operative

Surgery Prior to Current ICU Admission	beta
emergency surgery	0.0752
nonemergency surgery	

Major Disease Categories - Nonoperative

Class	Operation	beta
Cardiovascular or vascular	cardiogenic shock	
	cardiac arrest	
	aortic aneurysm	
	congestive heart failure	
	peripheral vascular disease	
	rhythm disturbance	
	acute myocardial infarction	
	hypertension	
	other cardiovascular disease	
Respiratory	parasitic pneumonia	
	aspiration pneumonia	-4.5575
	respiratory neoplasm, including larynx and trachea	

	respiratory arrest	
	pulmonary edema, non-cardiogenic	
	bacterial or viral pneumonia	
	chronic obstructive pulmonary disease	
	pulmonary embolism	
	mechanical airway obstruction	
	asthma	
	other respiratory diseases	
Gastrointestinal	**hepatic failure**	
	GI perforation or obstruction	
	GI bleeding due to varices	
	GI inflammatory disease (ulcerative colitis, Crohn's, pancreatitis, etc)	
	GI bleeding due to ulcer or laceration	
	GI bledding due to diverticulosis	
	other GI disease	
Neurologic	**intracerebral hemorrhage**	
	subarachnoid hemorrhage	
	stroke	
	neurologic infection	
	neurologic neoplasm	
	neuromuscular disease	
	seizure	
	other neurologic disease	
Sepsis	**sepsis (other than urinary tract)**	
	sepsis of urinary tract origin	
Trauma	**head trauma with or without multiple trauma**	
	Multiple trauma without head trauma	
Metabolic	**metabolic coma**	
	diabetic ketoacidosis	
	drug overdose	
	other metabolic diseases	
Hematologic	**coagulopathy, neutropenia or thrombocytopenia**	
	other hemtologic diseases	
Renal diseases		
Other medical diseases		

Major Disease Categories - Postoperative

Class	**Operation**	**beta**
Vascular or	**dissecting or ruptured aorta**	

Cardiovascular		
	peripheral vascular disease (no bypass graft)	
	valvular heart surgery	
	elective abdomnal aneurysm repair	
	peripheral artery bypass graft	
	carotid endarterectomy	
Respiratory	**respiratory infection**	
	lung neoplasm	
	upper respiratory neoplasm (mouth, sinus, larynx, trachea)	
	other respiratory disease	
Gastrointestinal	**GI perforation or rupture**	
	GI inflammatory disease	
	GI obstruction	**-4.6974**
	GI bleeding	
	liver transplant	
	GI neoplasm	
	GI cholecystitis or cholangitis	
	other GI disease	
Neurologic	**intracerebral hemorrhage**	
	subdural or epidural hematoma	
	subarachnoid hemorrhage	
	laminectomy or other spinal cord surgery	
	craniotomy for neoplasm	
	other neurologic diseases	
Trauma	**head trauma (with or without multiple trauma)**	
	multiple trauma without head trauma	
Renal	**renal neoplasm**	
	other renal diseases	
Gynecologic	**hysterectomy**	
Orthopedic	**hip or extremity fracture**	

References:

Knaus WA, Wagner DP, et al. The APACHE III prognostic system: Risk prediction of hospital mortality for critically ill hospitalized adults. Chest. 1991; 100: 1619-1636.

Lemeshow S, Le Gall J-R. Modeling the severity of illness of ICU patients. JAMA 1994; 272: 1049-1055.

Wagner DP, Knaus WA, et al. Daily prognostic estimates for critically ill adults in intensive care units: Results from a prospective, multicenter, inception cohort analysis. Crit Care Med. 1994; 22: 1359-1372.

30.04.07 Daily APACHE III Scores in the Intensive Care Unit

Overview:
APACHE III scores for a patient in the Intensive Care Unit (ICU) can be used during the course of the hospitalization to predict the patient's mortality risk.

Protocol
- **For every day in the ICU an APACHE III score is recorded.**
- **Multivariate equations were developed to use these daily APACHE III scores to generate a daily risk prediction.**

daily risk =
= (acute physiology score from day 1) + (acute physiology score for current day) + (change in acute physiology score since day before)

The multivariate equations are copyrighted. They are not published in the literature but are available to subscribers of the commercial system.

References:
Knaus WA, Wagner DP, et al. The APACHE III prognostic system: Risk prediction of hospital mortality for critically ill hospitalized adults. Chest. 1991; 100: 1619-1636.
Lemeshow S, Le Gall J-R. Modeling the severity of illness of ICU patients. JAMA 1994; 272: 1049-1055.
Wagner DP, Knaus WA, et al. Daily prognostic estimates for critically ill adults in intensive care units: Results from a prospective, multicenter, inception cohort analysis. Crit Care Med. 1994; 22: 1359-1372.

30.05 Logistic Organ Dysfunction System

Overview:
The Logistic Organ Dysfunction (LOD) System provides a means to assess patients in the intensive care unit (ICU) for severity of critical organ dysfunction. From this information it is possible to predict the probability of death for the patient.

Data Collection:
All data elements ideally should be collected at least once during the first 24 hours in the ICU.
- **If an element is not measured, then it is assumed to be normal for scoring purposes.**
- **If an element is tested more than once during the first 24 hours, then the most severe value is used.**

LOD score = (neurologic score) + (cardiovascular score) + (renal score) + (pulmonary score) + (hematologic score) + (hepatic score)

Neurologic Score

Glasgow Coma Score	Points
14-15	0
9-13	1
6-8	3
< 6	5

Note: Use the lowest value. If the patient is sedated, estimate the score prior to sedation.

Cardiovascular Score

heart rate per minute	operator	systolic blood pressure in mm Hg	Points
30-139	AND	90-239	0
>=140	OR	240-269	1
		70-89	1
		>= 270	3
		40-69	3
<30	OR	< 40	5

Note: Use the most abnormal value for heart rate or systolic blood pressure, either minimum or maximum.

Renal Score

serum urea nitrogen in mg/dL	oper-ator	creatinine in mg/dL	oper-ator	urine output in liters per day	Points
< 17	AND	< 1.20	AND	0.75 - 9.99	0
17 - 27.99	OR	1.2 - 1.59			1
28 - 55.99	OR	>= 1.60	OR	>= 10	3
				0.5 - 0.74	3
>= 56					5
				< 0.5	5

Notes:

- **Use the highest value for SUN and for creatinine.**
- **If the only data for urine output is for a period less than 24 hour period, adjust that value to 24 hours assuming the same rate of excretion.**

• If the patient is on hemodialysis, use the value of urine output prior to initiating hemodialysis.

Pulmonary Score

On ventilation or CPAP?	operator	ratio (PaO2 in mm Hg) / (FIO2)	Points
No			0
Yes	AND	>= 150	1
Yes	AND	< 150	3

Note: If the patient is receiving respiratory support, use the lowest ratio of PaO2 to FIO2.

Hematologic Score

white blood cell count	operator	platelet count	Points
2,500 to 49,900 /µL	AND	>= 50,000 /µL	0
>= 50,000 /µL			1
1,000 to 2,499 /µL	OR	< 50,000 /µL	1
< 1,000 /µL			3

Note:
• Use the most abnormal value for the white cell count, either minimum or maximum.
• Use the minimum platelet count if several values are available.
• In applying the rules, the OR for the platelet count < 50,000 per µL can be problematic if the WBC is < 1,000 per µL.

Hepatic Score

bilirubin	operator	prothrombin time	Points
< 2.0 mg/dL (< 34.2 µmol/L)	AND	<= 3 seconds above standard (>= 25% of standard)	0
>= 2.0 mg/dL (>= 34.2 µmol/L)	OR	> 3 seconds above standard (< 25% of standard)	1

Note:
• Use the highest value for bilirubin available.
• Use the highest value for prothrombin time in seconds.

Calculating the Probability of Mortality

probability of mortality =
= ((EXP(-3.4043 + (0.4173 * (LOD score)))) / (1 + (EXP (-3.4043 + (0.4173 * (LOD score))))))

where:
- **lowest LOD score is 0, associated with a 3.2% chance of mortality**
- **highest LOD score is 22, associated with 99.7% chance of mortality**

References:
Le Gall J, Klar J, et al. The Logistic Organ Dysfunction System. JAMA. 1996; 276: 802-810.

30.06 Multiple Organ Failure Score of Goris et al

Overview:
Multi-organ failure is associated with the sepsis syndrome. Goris et al developed a simple system for quantifying multi-organ failure. This score is related to the scoring systems used for the sepsis syndrome (below).

Organ systems
(1) pulmonary
(2) cardiac
(3) renal
(4) hepatic
(5) hematologic
(6) gastrointestinal
(7) central nervous system

Organ	Findings	Points
pulmonary	no mechanical ventilation	0
	mechanical ventilation with a positive end expiratory pressure (PEEP) of <= 10 cm H2O and an FIO2 <= 0.4	1
	mechanical ventilation with PEEP > 10 cm H2O and/or FIO2 > 0.4	2
cardiac	normal blood pressure with no vasoactive substances necessary	0
	periods with hypotension necessitating manipulations such as volume loading to keep blood pressure above 100 mm Hg, dopamine HCl infusion <= 10 µg/kg/min, or nitroglycerin <= 20 µg/min	1
	periods with hypotension below 100 mm Hg, dopamine HCl infusion > 10 µg/kg/min, or nitroglycerin > 20 µg/min	2
renal	serum creatinine < 2 mg/dL	0

	serum creatinine >= 2 mg/dL	**1**
	hemodialysis or peritoneal dialysis required	**2**
hepatic	**SGOT < 25 U/L and total bilirubin < 2 mg/dL**	**0**
	SGOT >= 25 U/L and < 50 U/L, and/or total bilirubin >= 2 mg/dL and < 6 mg/dL	**1**
	SGOT >= 50 U/L and/or bilirubin >= 6 mg/dL	**2**
hematologic	**normal WBC and platelet counts**	**0**
	platelet count <= 50,000 per µL and/or WBC count >=30,000 and < 60,000 per µL	**1**
	hemorrhagic diathesis and/or a WBC count < 2,500 per µL or >= 60,000 per µL	**2**
gastrointestinal tract	**normal functioning**	**0**
	acalculous cholecystitis or stress ulcer	**1**
	bleeding from stress ulcer necessitating transfusion of more than 2 units of blood per 24 hours, necrotizing enterocolitis, pancreatitis, and/or spontaneous perforation of the gallbladder	**2**
central nervous system	**normal functioning**	**0**
	clearly diminished responsiveness	**1**
	severely disturbed responsiveness and/or diffuse neuropathy	**2**

multiple organ failure score =
= SUM(points for all 7 organ systems)

Interpretation
- **minimum score 0**
- **maximum score 14**
- **The higher the score the more serious the patient's condition.**

References:
Goris RJA, te Boekhorst TPA, et al. Multiple-organ failure. Arch Surg. 1985; 120" 1109-1115.

30.07 Multiple Organ Dysfunction Score

Overview:
Multiple Organ Dysfunction Score is intended to offer an objective measure for the severity of multiple organ disorders. Six key organ systems commonly affected in systemic disorders are assessed. A cumulative score correlates with mortality rate seen for the seriously ill patient.

Organ System	Measure	Finding	Score

Respiratory	**PO2/FIO2 ratio**	**> 300**	**0**
		226-300	**1**
		151-225	**2**
		76-150	**3**
		<= 75	**4**
Renal	**serum creatinine**	**<= 100 µmol/L (<=1.1 mg/dL)**	**0**
		101-200 µmol/L (1.1-2.3 mg/dL)	**1**
		201-350 µmol/L (2.3-4.0 mg/dL)	**2**
		351-500 µmol/L (4.0-5.7 mg/dL)	**3**
		> 500 µmol/L (>5.7 mg/dL)	**4**
Hepatic	**serum bilirbuin**	**<= 20 µmol/L (<= 1.2 mg/dL)**	**0**
		21-60 µmol/L (1.2-3.5 mg/dL)	**1**
		61-120 µmol/L (3.5-7.0 mg/dL)	**2**
		121-240 µmol/L (7.0-14.0 mg/dL)	**3**
		> 240 µmol/L (> 14.0 mg/dL)	**4**
Cardiovascular	**pressure adjusted heart rate (see below)**	**<= 10.0**	**0**
		10.1-15.0	**1**
		15.1-20.0	**2**
		20.1-30.0	**3**
		> 30.0	**4**
Hematologic	**platelet count**	**> 120,000 /µL**	**0**
		81,000-120,000 /µL	**1**
		51,000-80,000 /µL	**2**
		21,000-50,000 /µL	**3**
		<= 20,000 /µL	**4**
Neurologic	**Glasgow coma score**	**15**	**0**
		13-14	**1**
		10-12	**2**
		7-9	**3**
		<=6	**4**

where:
• conversion factor for creatinine µmol/L to mg/dL is 0.011312
• conversion factor for bilirubin µmol/L to mg/dL is 0.05848

Cardiovascular Calculations

pressure adjusted heart rate =
= (heart rate in beats per minute) * (right atrial pressure in mm Hg) / (mean arterial pressure in mm Hg)

mean arterial pressure =
= ((systolic arterial pressure in mm Hg) + (2 * (diastolic arterial pressure in mm Hg))) / 3

Calculation and Interpretation

Multiple Organ Dysfunction Score =
= (respiratory points) + (renal points) + (hepatic points) + (cardiovascular points) + (hematologic points) + (neurologic points)

Interpretation:
- **minimum score: 0**
- **maximum score: 24**

Score	ICU Mortality	Hospital Mortality
0	0%	0%
1-4	1-2%	7%
5-8	3-5%	16%
9-12	25%	50%
13-16	50%	70%
17-20	75%	82%
21-24	100%	100%

References:
Marshall JC, Cook DJ, et al. Multiple Organ Dysfunction Score: A reliable descriptor of a complex clinical outcome. Crit Care Med. 1995; 23: 1638-1652.

30.08 Scores for the Sepsis Syndrome

30.08.01 Systemic Inflammatory Response Syndrome

Overview:
The Systemic Inflammatory Response Syndrome (SIRS) is the biologic host response to real or perceived infection which may occur in response to several severe clinical conditions.

Definitions

• infection: Microbial phenomenon characterized by an inflammatory response to the presence of microorganisms or the invasion of normally sterile host tissue by those organisms.
• bacteremia: The presence of viable bacteria in the blood.
• septicemia: It is recommended that the term not be used to clinically describe patients.

The stages in response to infection may be viewed as a continuum
• SIRS
• sepsis
• severe sepsis
• septic shock
• end-organ dysfunction, often manifested as the multiple organ dysfunction syndrome
• death

Criteria for diagnosis of SIRS:
Two or more of the following conditions
• temperature > 38° C or < 36° C
• heart rate > 90 beats per minute
• respiratory rate > 20 breaths per minute OR PaCO2 < 32 mm Hg
• WBC > 12,000 per µL OR < 4,000 per µL OR > 10% immature forms

where
• factor for converting PaCO2 to kPa is 0.133

Syndrome	Cultures	Features
sepsis	• positive	• SIRS
severe sepsis	• positive	• SIRS • organ dysfunction, hypoperfusion abnormalities, or hypotension
septic shock	• positive	• SIRS • sepsis-induced hypotension despite fluid resuscitation • hypoperfusion abnormalities
culture negative sepsis	• negative • empirical antibiotic therapy for a clinically suspected infection	• SIRS
culture negative severe sepsis	• negative • empirical antibiotic therapy for a clinically suspected infection	• SIRS • organ dysfunction, hypoperfusion abnormalities, or hypotension
culture negative septic shock	• negative • empirical antibiotic	• SIRS • sepsis-induced hypotension

	therapy for a clinically suspected infection	despite fluid resuscitation • hypoperfusion abnormalities

where:
- **Hypoperfusion abnormalities may include lactic acidosis, oliguria, or an acute alteration in mental status.**
- **Hypotension indicates a systolic blood pressure of < 90 mm Hg or a reduction of > 40 mm Hg from baseline in the absence of other causes for hypotension.**
- **Patients with septic shock receiving inotropic or vasopressor agents may not be hypotensive at the time that perfusion abnormalities are measured.**

Mortality rates shows a stepwise increase paralleling the increased severity of the reaction:
- **SIRS: 7%**
- **sepsis: 16%**
- **severe sepsis: 20%**
- **septic shock: 46%**

References

Members of the American College of Chest Physicians/Society of Critical Care Medicine Consensus Conference Committee. American College of Chest Physicians/Society of Critical Care Medicine consensus conference: Definitions of sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. Crit Care Med. 1992; 20: 864-874.

Nightingale P, Edwards JD. Chapter 66: Critical Care. pages 1309-1345. IN: Healy TEJ, Cohen PJ (editors). Wylie and Churchill-Davidson's A Practice of Anaesthesia, Sixth Edition. Edward Arnold. 1995.

Rangel-Frausto MS, Pittet D, et al. The natural history of the systemic inflammatory response (SIRS). JAMA. 1995; 273: 117-123.

30.08.02 Septic Shock Score

Overview:

Patients with septic shock have an increased mortality rate. The Simplified and Complete Septic Shock Scores are derived from clinical variables and correlate with the mortality rates seen. The Simplified Score can be derived early in the patient course. The Complete Score is more specific but requires culture results, which may take a day or more to collect. This system can be used for septic shock patients in lieu of the APACHE or SAPS scoring systems.

Score Basics

Variables having prognostic significance are identified and graded 0, 1 or 2, with higher points indicating a more significant abnormality.

Simplified Septic Shock Score

Points for Calculating the Simplified Septic Shock Score

Variable	Finding	Points
age in years	< 65	0
	65-69	1
	>= 70	2
sex (male or female)	female	0
	male	1
mechanical ventilation	no	0
	yes	1
Glasgow Coma Scale	>= 13	0
	< 13	2
diuresis (mL/hr)	>= 20	0
	< 20	1
body temperature °C	< 37	2
	37 - 39.5	0
	>= 39.5	1
hematocrit as a percent	>= 25	0
	< 25	2
WBC count per µL, in thousands	< 1.5	1
	1.5 - 24.9	0
	25-39.9	1
	>= 40	2
pH	< 7.10	2
	7.10-7.24	1
	7.25-7.49	0
	>= 7.50	2
prothrombin time in seconds	>= 23	0
	< 23	1
heart rate in beats per minute	< 80	2
	80 - 169	0
	>= 170	2
mean arterial pressure	>= 70	0
	50 - 69	1
	< 50	2
mean pulmonary artery pressure	< 35	0
	>= 35	1
cardiac index in L/min per meter squared	< 3.5	2
	3.5 - 6.4	0
	6.5 - 7.4	1
	>= 7.5	2

where:

• prothrombin time is measured with a thromboplastin having an ISI (International Sensitivity Index) of 1.16.

Simplified Septic Shock Score =
= SUM (points for each of the 14 variables)

Complete Septic Shock Score

Additional Points for Calculating the Complete Septic Shock Score

Type	Condition	Points
Underlying Disease	liver cirrhosis	2
	pre-existing heart failure NYHA functional class III or IV	2
	chronic pulmonary failure	2
	chronic renal failure	2
	immunocompromising condition	1
Type of Infection	polymicrobic blood culture	2
	infection due to Pseudomonas aeruginosa	2
	pneumonia as primary focus of infection	1

Immunocomprising condition involves either
• the patient has received therapy that suppresses resistance to infection, such as immunosuppression, chemotherapy, radiation, long-term or recent high dose steroids
• the patient has an underlying disease that is sufficiently advanced to suppress resistance to infection such as leukemia, lymphoma, or acquired immunodeficiency syndrome

additional point score =
= SUM (points for each of the 8 variables)

Complete Septic Shock Score =
= (simplified septic shock score) + (sum of additional points)

Interpretation

Scores
• maximum simplified septic shock score: 23
• maximum complete septic shock score: 23 + 14 = 37
• minimum scores: 0

Mortality rate from Scores

Score	Simplified	Complete
0	0	0
1	4	1

2	10	4
3	22	9
4	42	21
5	66	42
6	82	65
7	92	85
8	97	93
9	99	97
10	100	99
11	100	100

extrapolated from Figure 1, page 958 (Baumgartner, 1992)

According to the data Figure 1, mortality rate can be determined from the score by use of the following equation:

mortality rate for simplified score =
= EXP(a + (b * (score))) / (1 + EXP(a + (b * (score))))

	a	b
simplified score	1.01	-5.33
complete score	0.94	-4.01

Unfortunately, when these equations are used, the output does not correlate with the data shown in Figure 1. Reversing the assignments for a and b give more credible results, but do not match the data in Figure 1.

References:
Baumgartner JD, Bula C, et al. A novel score for predicting mortality of septic shock patients. Crit Care Med. 1992; 20: 953-960.

30.08.03 Sepsis Syndrome

Overview:
The Sepsis Syndrome is a systemic response to infection resulting in altered organ perfusion. It is a common condition in hospitalized patients and is associated with a high morbidity and mortality. This is viewed as a stage in the continuum of the Systemic Inflammatory Response Syndrome (SIRS, discussed under "Critical Care".)

Screening Criteria: at least one of the following
(1) all 4 of the following
- **temperature > 38.3 ° C or < 35.6° C rectally**
- **respirations > 20 per minute or on mechanical ventilation**
- **heart rate > 90 beats per minute**
- **clinical evidence of infection**

(2) one or more positive blood cultures positive for pathogen at 48 hours.

Confirmatory Criteria: at least one of the following, without alternative explanation

- **PaO2/FIO2 < 280 (intubated) or 40% face mask in use (nonintubated)**
- **arterial pH < 7.30**
- **urine output < 30 mL/h**
- **systolic blood pressure < 90 mm Hg or fall in systolic blood pressure > 40 mm Hg sustained for 2 hours despite fluid challenge**
- **systemic vascular resistance < 800 dynes•s•cm(-5)**
- **prothrombin time or partial thromboplastin time greater than normal or platelet count < 100,000 per µL or platelets decreased to < 50% of most recent measurement before current day**
- **documentation of deterioration in mental status within 24 hours**

Mortality rate

- **34% at 28 days**
- **45% at 5 months**

References:

Sands KE, Bates DW, et al. Epidemiology of Sepsis Syndrome in 8 academic medical centers. JAMA. 1997; 278: 234-240.

30.08.04 Multiple System Organ Failure Score

Overview:

The multiple organ dysfunction syndrome is defined as the presence of altered organ function in an acutely ill patient such that homeostasis cannot be maintained without intervention.The Multiple System Organ Failure Scoring system assesses seven key organ systems for failure on the first day of the sepsis syndrome. From the number of severely affected organs it is possible to predict the mortality of patients with the sepsis syndrome.

Diagnostic Criteria for Sepsis Syndrome

Patient must have a suspected or known site of infection.
Patient must have all 3 of the following: **(1) a core temperature > 101 °F (38.3°C) or < 96°F (35.5°C)** **(2) a heart rate of 90 beats per minute in the absence of beta blockers** **(3) respiratory rate of > 20 breaths per minute, or a minute ventilation > 10 L/min**
Patient must have at least 1 of the following: **(1) cardiovascular system: hypotension <= 90 mm Hg or a fall in systolic blood pressure > 40 mm Hg for more than 1 hour, with filling pressures adequate or the patient unresponsive to at least 500 mL of saline solution infused over 1 hour** **(2) renal system: urine output <= 0.5 mL/kg/hr for at least 1 hour** **(3) pulmonary system: PaO2 <= 70 mm Hg on room air, or a PaO2/FIO2 ratio <= 333. If the primary diagnosis is pneumonia and if the lung is the only one of**

these 4 systems to fail, then the patient must meet established ARDS criteria: (a) PaO2/FIO2 < 200; (b) diffuse bilateral infiltrates on chest X-ray; (c) pulmonary atery wedge pressure < 19 mm Hg.

(4) central nervous system: significant alteration in mental status, with at least a decrease of 2 points in the Glasgow Coma Score

Multiple Organ Failure Scoring System

Organ System	Finding on the 1st day of sepsis syndrome
Respiratory	ventilation dependent with an A-a gradient of > 250 mm Hg, or a pulmonary shunt > 20%
Cardiovascular	adrenergic agents required to maintain the mean arterial pressure above 55 mm Hg in the absence of hypovolemia (pulmonary artery wedge pressure > 6 mm Hg)
Renal	creatinine > 300 µmol/L (3.4 mg/dL)
Hepatic	bilirubin > 60 µmol/L (3.4 mg/dL), or alkaline phosphatase > 350 U/L
Gastrointestinal	fresh blood from nasogastric tube, or melena or fresh blood per rectum, and a fall of hemoglobin of at least 2 g/dL and requiring transfusion of at least 2 units of packed red cells in 24 hours
Hematologic	WBC < 2000/µL or platelet count < 40,000 /µL or evidence of DIC (INR > 2 plus PTT more than 2 times normal control plus fibrin degradation products > 10 mg/L)
Central nervous system	Glasgow coma score < 10, or a decrease in GCS of 3 or more if primary CNS injury is present

where:

- conversion factor for creatinine µmol/L to mg/dL is 0.011312
- conversion factor for bilirubin µmol/L to mg/dL is 0.05848

Interpretation:

- minimum score 0
- maximum score 7

Score	Estimated Mortality
0	< 10%
1-2	25%
3-4	60-70%
>=5	100%

References:

Fry DE, Pearlstein L, et al. Multiple system organ failure. Arch Surg. 1980; 115: 136-140.

Hebert PC, Drummond AJ, et al. A simple Multiple System Organ Failure Scoring System predicts mortality of patients who have sepsis syndrome. Chest. 1993; 104: 230-235.

Members of the American College of Chest Physicians/Society of Critical Care Medicine Consensus Conference Committee. American College of Chest Physicians/Society of Critical Care Medicine consensus conference: Definitions of sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. Crit Care Med. 1992; 20: 864-874.

30.08.05 Prediction of Mortality from Bacteremic Sepsis in ICU Patients

Overview"

The risk of death during hospitalization can be 5-fold higher in septic Intensive Care Unit (ICU) patients as compared to nonseptic ICU patients. The prognosis for patients in the ICU with sepsis and positive blood cultures can be assessed from the severity of the acute illness, complications secondary to the infection, and underlying chronic disease.

Definitions

- **sepsis: systemic inflammatory response syndrome associated with positive blood cultures with either viable bacteria or Candida species**
- **septic shock: sepsis with prolonged hypotension (2 or more hours) despite adequate fluid resuscitation, together with presence of perfusion abnormalities such as lactic acidosis, oliguria or acute alteration in mental status**
- **hypotension is systolic blood pressure < 90 mm Hg in the absence of other causes for hypotension**
- **initial organ dysfunction: presence of one or more organ dysfunction at the time of sepsis**
- **evolving organ dysfunction: either the persistence of an initial organ dysfunction, or the development of a new organ dysfunction more than 24 hours after the onset of sepsis and persisting for at least 24 hours.**

Independent predictors of mortality if present at the onset of sepsis

- **previous antibiotic therapy (odds ratio 2.40)**
- **hypothermia with temperature <= 36.5°C (odds ratio 1.43)**
- **requirement for mechanical ventilation (odds ratio 2.97)**
- **APACHE II score at the onset of sepsis >= 20 (odds ratio 1.21)**

The best 2 independent prognostic factors

- **APACHE II score at the onset of sepsis**
- **number of organ dysfunction developing after onset of sepsis**

Organ Dysfunction	Defining Criteria
acute cardiac dysfunction	elevated right (>= 15 mm Hg) or left (>= 18 mm Hg) ventricular filling pressure with a low cardiac index (< 2.2 L/min/m^2) in the absence

	of cardiac tamponade or pulmonary embolism
	left or right ventricular failure
	myocardial infarction
	severe arrhythmias
pulmonary dysfunction	**mechanical ventilation with an inspired oxygen fraction (FIO2) > 0.4**
adult respiratory distress syndrome	**severe pulmonary failure requiring ventilatory support with PEEP of at least 5 cm H2O and a lung injury score > 2.5**
acute renal dysfunction	**serum creatinine > 2 mg/dL (175 mmol/L)**
	doubling of admission creatinine level in the case of pre-existing renal disease
acute gastrointestinal dysfunction	**bleeding from the upper gastrointestinal tract confirmed by endoscopy or surgical exploration and requiring transfusion of at least 2 blood units**
	perforated stress ulcer
	acalculous cholecystitis
hepatic dysfunction	**total bilirubin > 2 mg/dL (34 mmol/L) with LDH, AST and ALT values at least twice the upper limit of normal**
disseminated intra-vascular coagulation (DIC)	**spontaneous bleeding from 2 or more sites associated with a platelet count < 50,000 per µL, elevated FDP, and fibrinogen < 200 mg/dL**
central nervous system dysfunction	**coma with Glasgow coma scale < 7**

Mortality rate and APACHE II score at onset of sepsis

- **score 0-9: 0%**
- **10-19: 22%**
- **20-29: 58%**
- **>= 30: 90%**

Number of Organ Dysfunction	Mortality within 30 days	Mortality during Hospitalization
0	2%	5%
1	6%	13%
2	18%	31%
3	59%	67%
>= 4	80%	90%

(from Figure 3, page 691, Pittet 1996)

References

Pittet D, Thievent B, et al. Bedside prediction of mortality from bacteremic sepsis. Am J Respir Crit Care Med. 1996; 153: 684-693.

30.08.06 Septic Severity Score (SSS) of Stevens

Overview:
The Septic Severity Score was developed by Stevens at the University of Utah in 1983. It is intended to gauge the severity of the multi-organ involvement in a patient with the sepsis syndrome.

Organ systems evaluated
(1) lung
(2) kidney
(3) coagulation
(4) cardiovascular
(5) liver
(6) gastrointestinal tract
(7) neurologic

Point scoring
• Abnormal findings assigned a score from 1 to 5 accodring to the severity of the dysfunction.

Organ System	Finding	Points
lung	breathing room air	0
	oxygen by mask	1
	intubated. no PEEP	2
	PEEP, 0-10%	3
	PEEP > 10% with PaO2 > 50 mm Hg	4
	maximal PEEP, with PaO2 <= 50 mm Hg	5
kidney	serum creatinine < 1.5 mg/dL	0
	serum creatinine 1.5 - 2.5 mg/dL	1
	serum creatinine 2.6 - 3.5 mg/dL	2
	serum creatinine > 3.6 mg/dl with good urine output (> 50 mL per hour)	3
	serum creatinine > 3.6 mg/dL with urine volume 20-50 mL per hour	4
	serum creatinine > 3.6 mg/dL with urine volume < 20 mL per hour	5
coagulation	no ecchymoses and normal coagulation tests	0
	ecchymoses and normal coagulation tests	1
	PT 12-14 seconds or PTT 45-65 seconds	2
	platelet count 20,000 - 100,000 per µL, PT > 14 seconds, PTT > 50 seconds	3

	platelet count < 20,000 per µL with PT > 14 seconds and PTT > 50 seconds	4
	evidence of DIC, bleeding	5
cardiovascular	normal	0
	slight hypotension	1
	livedo, moderate hypertension	2
	vasopressors required at moderate doses	3
	vasopressors required at large doses	4
	profound hypotension despite maximal vasopressor doses	5
liver	normal liver function tests	0
	LDH and SGOT increased, bilirubin normal	1
	bilitrubin 1.5 - 2.5 mg/dL	2
	bilirubin 2.6 - 4.0 mg/dL	3
	bilirubin 4.1 - 8.0 mg/dL	4
	precoma with bilirubin > 8.0 mg/dL	5
GI tract	normal	0
	mild ileus	1
	moderate ileus	2
	severe ileus	3
	bleeding due to erosive gastritis	4
	mesenteric venous thrombosis	5
neurologic	normal	0
	obtunded	1
	disoriented	2
	irrational	3
	hyporeactive	4
	coma	5

after Table page 1191

where:

- **In Table page 1191, the specifications for the coagulation ratings are a bit vague for ratings 2 and 3 (should these be OR or AND). Also the variability between laboratories for normal ranges of PT and aPTT may not be easily accounted for with the absolute values given for PT and PTT.**
- **In Table page 1191, the bilirubin for liver rating 3 has an upper limit of 4; for liver rating 4 the lower limit is 4.9.**

septic severity score =
= ((points for organ with highest score) ^ 2) + ((points for organ with second highest score) ^ 2) + ((points for organ with third highest score) ^ 2)

estimated length of stay in survivors in days =
= (0.61 * (septic severity score)) + 12

Interpretation:
- **minimum score: 0**
- **maximum score: 75**
- **The higher the septic severity score, the more severe the sepsis.**
- **The mean SSS for nonsurvivors was 49, while the mean SSS for survivors was 29. While survivors showed scores from 0 to 60, nonsurvivors had scores > 30.**
- **Improvement in the score usually correlates with clinical improvement of the patient.**

References:

Stevens LE. Gauging the severity of surgical sepsis. Arch Surg. 1983; 118: 1190-1192.

30.08.07 Prognostic Classification of Patients with Septic Shock Based on Cortisol Levels and Cortisol Response to Corticotropin

Overview:
Annane et al studied the effect of stress from septic shock on the hypothalamic-pituitary-adrenal axis. They found that the pattern of serum cortisol levels before and after cortitropin stimulation could identify patients with septic shock who were at high risk for death. These patients might benefit from more aggressive or novel therapies.

Short corticotropin stimulation test:
(1) 0.25 mg tetracosactrin (corticotropin) injected intravenously
(2) blood samples were collected just before the injection (baseline), at 30 minutes after injection, and at 60 minutes after injection.

maximum cortisol level in µg/dL =
= MAX(serum cortisol at 30 minutes in µg/dL, serum cortisol at 60 minutes in µg/dL)

change in peak cortisol from baseline levels =
= (maximum cortisol level in µg/dL) – (baseline cortisol level in µg/dL)

Baseline Cortisol	Change in Peak Cortisol from Baseline Levels in Response to Corticotropin	Prognostic Group
<= 34 µg/dL	> 9 µg/dL	good
<= 34 µg/dL	<= 9 µg/dL	intermediate
> 34 µg/dL	> 9 µg/dL	intermediate
> 34 µg/dL	<= 9 µg/dL	poor

Prognostic Group	28 Day Mortality Rate
good	26%
intermediate	67%
poor	82%

References:

Annane D, Sebille V, et al. A 3-level prognostic classification in septic shock based on cortisol levels and cortisol response to corticotropin. JAMA. 2000; 283: 1038-1045.

30.08.08 The Baltimore Sepsis Scale

Overview:

The Baltimore Sepsis Scale provides a daily measure of disease severity in a patient with the sepsis syndrome. It can be used to monitor a patient over time and to evaluate the effectiveness of interventions. It was developed in Baltimore, Maryland.

Parts of the scale

(1) physiologic measures (based on daily findings)

(2) modified Glasgow Coma Scale

Parameter	Point Assignment	Maximum Points per Day
tachycardia	1 point for each 10 beats per minute > 120	none
systolic blood pressure	1 point for each 10 mm Hg < 90, OR 1 point for each cumulative 10 µg pressor	none
body temperature	1 point for each °C > 38.5 OR 1 point for each °C < 36.0	none
base deficit	1 point for each 3 mmol/L > 5	none
platelet count	1 point for each 5,000 < 35,000 per µL	none (7)
white blood cell count	1 point for each 5,000 > 15,000 per µL	none
creatinine	1 point for each 2 mg/dL > 2 mg/dL, OR patient on dialysis	5
systemic vascular resistance	1 point for each 100 < 800 dynes per second per cm^(-5)	none (8)
urine output	1 point for each 50 mL/day < 500 mL/day	none (10)
PEEP	1 point for each 3 mm > 5 mm Hg	none
PaO2 to FIO2 ratio	1 point for each 0.3 < 2.0	none

where:

• systolic blood pressure has 2 possible scoring methods: (a) maximum points for either low pressure or pressor use, or (b) combination of points for each. I will use (b) in the implementation.
• base deficit is the negative of base excess
• an elevated WBC count from leukemia would cause a falsely high value
• FIO2 appears to be from 21 to 100 (percent rather than fraction)
• maximal value: tachycardia, base deficit, WBC count, creatinine, PEEP
• minimal value: systolic blood pressure, platelet count, systemic vascular resistance, PaO2 to FIO2 ratio
• either, whichever is greater from baseline: temperature
• cumulative value: pressor dose, urine output
• it appears as if points are assigned as each milestone is reached, rather than on the continuum

Modified Glasgow Coma Scale

Clinical Finding	Points
oriented to person, place and time (x3) and cooperative	1
occasional confusion but mostly oriented	2
frequent confusion but cooperative, tries to help with dressings, recognizes family and staff	3
semiconscious or delerious most of the time, cannot help with dressings, does not recognize family or friends	4
expresses pain response to stimulation, no other response	5
coma, with no pain response	6

Baltimore sepsis scale =
= (points for physiologic findings) + (points for modified Glasgow Coma Scale)

Interpretation:
• minimum score: 1
• maximum score: 200+
• In practice the highest score observed in patients at any time is 50.
• The higher the score, the more severe the sepsis syndrome.

Sepsis Scale	Interpretation
0 – 10	The patient is injured but doing well.
11 – 20	The patient is having problems.
21 – 30	The patient is gravely ill.
> 30	The patient is in critical condition and has multiple organ failure.

References:

Meek M, Munster AM, et al. The Baltimore Sepsis Scale: Measurement of sepsis in patients with burns using a new scoring system. J Burn Care Rehabil. 1991; 12: 564-568.

30.09 Organ Dysfunctions and/or Infection (ODIN)

Overview:
The Organ Dysfunctions and/or Infection (ODIN) model assesses the number and type of organ dysfunctions in the intensive care patient. This information can be used to predict the patient's outcome.

Organ System		Finding
Respiratory		PaO2 < 60 mm Hg on FIO2 0.21
	OR	need for ventilatory support
Cardiovascular (excluding patients showing hypovolemia, with CVP < 5 mm Hg)		systolic arterial pressure < 90 mm Hg with signs of peripheral hypoperfusion
	OR	continuous infusion of vasopressor or inotropic agents required to maintain systolic pressure > 90 mm Hg
Renal (excluding patients on chronic hemodialysis before hospital admission)		serum creatinine > 3.4 mg/dL (300 µmol/L)
	OR	urine output < 500 mL in 24 hours or < 180 mL in 8 hours
	OR	need for hemodialysis or peritoneal dialysis
Neurologic		Glasgow coma scale <= 6 in the absence of sedation at any time during day
	OR	sudden onset of confusion or psychosis
Hepatic		serum bilirubin > 5.9 mg/dL (100 µmol/L)
	OR	alkaline phosphatase > 3 times normal
Hematologic		hematocrit <= 20 per cent
	OR	white blood cell count < 2,000 per µL
	OR	platelet count < 40,000 per µL
Infection (with clinical evidence of infection)		2 or more positive blood cultures
	OR	presence of gross pus in a closed space

	OR	**source of infection determined during hospitalization, or at autopsy in case of death within 24 hours**

where:
• conversion for bilirubin from mg/dL to µmol/L is 17.1; reverse 0.0585
• conversion for creatinine from mg/dL to µmol/L is 88.4; reverse 0.0113

ODIN score =
= (1 if respiratory dysfunction present) + (1 if cardiovascular dysfunction present) + (1 if renal dysfunction present) + (1 if neurologic dysfunction present) + (1 if hepatic dysfunction present) + (1 if hematologic dysfunction present) + (1 if infection present)

Interpretation
• maximum score = 7
• minimum score = 0

ODIN score	mortality
0	2.6%
1	9.7%
2	16.7%
3	32.3%
4	64.9%
5	75.9%
6	94.4%
7	100%

Logistic Regression Analysis

q =
= (-3.59) + (1.09 if respiratory dysfunction) + (1.19 if cardiovascular dysfunction) + (1.18 if renal dysfunction) + (0.86 if hematologic dysfunction) + (0.57 if hepatic dysfunction) + (0.99 if neurologic dysfunction) + (0.53 if infection present)

probability of death =
= (1 / (1 + EXP (-q)))

References:
Fagon JY, Chastre J, et al. Characterization of intensive care unit patients using a model based on the presence or absence of organ dysfunctions and/or infections: the ODIN model. Intensive Care Med. 1993; 19: 137-144.

30.10 Therapeutic Intervention Scoring System (TISS) and its Derivatives

30.10.01 Therapeutic Intervention Scoring System (TISS) of 1974

Overview

The Therapeutic Intervention Scoring System (TISS) can be used to assess the level of care that a patient receives in a critical care unit. It can help in making quantitative comparisons of patient care and can help in allocating resources.

Scoring

- **Points are assigned for specific interventions in the critical care unit over a 24 hour period and range from 1 to 4**
- **Higher values given for more specialized, critical or life-sustaining activities.**

Patient Care and Monitoring

Interventions	Points
chest physiotherapy	1
continuous ECG monitoring	1
decubitus care	1
dressing changes	1
frequent stat blood tests (more than 1 per shift) [1]	1
hourly vital signs	1
orthopedic traction	1
standard intake and output [2]	1
urinary catheter	1
hourly neurologic signs	2
central venous pressure (CVP)	2
multiple arterial blood gases, and/or stat tests (more than 3 per shift) [1]	3
accurate, precise input and output [2]	3
arterial catheter	3
pulmonary artery catheter	4
intracranial pressure monitoring	4
measurement of cardiac output	4

Procedures

Interventions	Points
GI decompression	1
tracheostomy care	2
new tracheostomy (< 48 hours)	2
hemodialysis, stable patient [3]	2
hypothermia blanket [4]	3
chest tube	3
emergency thora-, para- or pericardiocentesis	3
nasotracheal or orotracheal intubation	3

emergency endoscopy or bronchoscopy	**4**
lavage of acute GI bleeding	**4**
emergency operative procedure (within 24 hours)	**4**
induced hypothermia [4]	**4**
peritoneal dialysis [3]	**4**
hemodialysis in unstable patient [3]	**4**
balloon tamponade of varices	**4**

Infusions and Medications

Interventions	Points
IV antibiotics, 1 or 2 [5]	**1**
intermittent scheduled IV medications	**1**
chronic anticoagulation	**1**
1 peripheral IV catheter [6]	**1**
parenteral chemotherapy	**2**
replacement of excess fluid loss	**2**
> 2 IV lines [6]	**2**
active anticoagulation	**3**
IV antibiotics, more than 2 [5]	**3**
phlebotomy for fluid overload	**3**
acute treatment for metabolic acidosis or alkalosis	**3**
bolus IV medications	**3**
central intravenous hyperalimentation	**3**
multiple (3+) parenteral lines [6]	**3**
treatment of seizures or metabolic encephalopathy (within 48 hours of onset)	**3**
active diuresis for fluid overload or cerebral edema	**3**
frequent infusions of blood products (>= 20 mL/kg)	**3**
concentrated potassium infusion	**3**
pressure activated blood transfusion	**4**
continuous arterial infusions	**4**
platelet transfusion	**4**

Cardiopulmonary Support

Interventions	Points
supplemental oxygen [7]	**1**
spontaneous ventilation via tracheostomy tube [7]	**2**
pacemaker on standby [8]	**3**
cardioversion for arrhythmias	**3**

continuous antiarrhythmia infusions	**3**
vasoactive drug infusions	**3**
blind intra-tracheal suctioning (non-intubated)	**3**
acute digitalization (within 48 hours)	**3**
continuous positive airway pressure (CPAP) [7]	**3**
intermittent mandatory ventilation or assisted ventilation [7]	**3**
membrane oxygenation	**4**
intra-aortic balloon assist	**4**
G-suit	**4**
atrial and/or ventricular pacing [8]	**4**
cardiac resuscitation and/or countershock within past 48 hours	**4**
controlled ventilation with/without PEEP [7]	**4**
controlled ventilation with intermittent or continuous muscle paralyis/relaxants [7]	**4**

where:
• items in brackets ("[]") indicate mutually exclusive items

therapeutic intervention score =
= SUMMATION (all interventions made for the patient for a 24 hour period)

Interpretation
• a higher TISS score tends to be associated with a higher mortality rate
• the TISS score from sequential days can be compared for the difference in magnitude between scores and the general trends shown by the values

Pediatric Population

TISS scores have been used in pediatric intensive care units, often performed in conjunction with the Physiologic Stability Index (PSI).

TISS score	mortality rate (in 1985)
>= 50	75%
40-49	35%
30-39	20%
20-29	13%
10-19	6%

References:

Cullen DJ, Civetta JM, et al. Therapeutic intervention scoring system: a method for quantitative comparison of patient care. Crit Care Med. 1974; 2: 57-60.

Pollack MM, Ruttimann UE, et al. Monitoring patient in pediatric intensive care. Pediatrics. 1985; 76: 719-725.

Rothstein P, Johnson P. Pediatric intensive care: Factors that influence outcome. Crit Care Med. 1982; 10: 34-37.

Yeh TS, Pollack MM, et al. Assessment of pediatric intensive care - application of the Therapeutic Intervention Scoring System. Crit Care Med. 1982; 10: 497-500.

30.10.02 Revised TISS of 1983 (TISS-76)

Overview:

A revision of the original Therapeutic Intervention Scoring System was proposed in 1983. It itemizes 76 clinical activities, and so it is sometimes referred to as the TISS-76.

Activity	Points
cardiac arrest and/or countershock within past 48 hours	4
controlled ventilation with or without PEEP [1]	4
controlled ventilation with intermittent or continuous muscle relaxants [1]	4
balloon tamponade of varices	4
continuous arterial infusion	4
pulmonary artery catheter	4
atrial and/or ventricular pacing [12]	4
hemodialysis in unstable patient [2]	4
peritoneal dialysis [2]	4
induced hypothermia	4
pressure-activated blood infusion	4
G-suit	4
intracranial pressure monitoring	4
platelet transfusion	4
intra-aortic balloon assist	4
emergency operative procedure within past 24 hours	4
lavage of acute GI bleeding	4
emergency endoscopy or bronchoscopy	4
vasoactive drug infusion (> 1 drug) [3]	4
central IV hyperalimentation (includes renal, cardiac, hepatic failure fluid) [11]	3
pacemaker on standby [12]	3
chest tubes	3
intermittent mandatory ventilation or assisted ventilation [1]	3
continuous positive airway pressure (CPAP) [1]	3

concentrated potassium infusion via central catheter	**3**
nasotracheal or orotracheal intubation [6]	**3**
blind intratracheal suctioning	**3**
complex metabolic balance (frequent intake and output) [8]	**3**
multiple ABG, bleeding and/or STAT studies (> 4 per shift) [9]	**3**
frequent infusions of blood products (> 5 units in 24 hours)	**3**
bolus IV medication (nonscheduled)	**3**
vasoactive drug infusion (1 drug) [3]	**3**
continuous antiarrhythmia infusion	**3**
cardioversion for arrhythmia (not defibrillation)	**3**
hypothermia blanket	**3**
arterial line	**3**
acute digitalization within 48 hours	**3**
measurement of cardiac output by any method	**3**
active diuresis for fluid overload or cerebral edema	**3**
active therapy for metabolic alkalosis	**3**
active therapy for metabolic acidosis	**3**
emergency thora-, para- or pericardio-centesis	**3**
active anticoagulation (initial 48 hours) [7]	**3**
phlebotomy for volume overload	**3**
coverage with more than 2 IV antibiotics [4]	**3**
therapy of seizures or metabolic encephalopathy (within 48 hours of onset)	**3**
complicated orthopedic traction [10]	**3**
central venous pressure monitoring	**2**
2 peripheral IV catheters [5]	**2**
hemodialysis in a stable patient [2]	**2**
fresh tracheostomy (less than 48 hours) [6]	**2**
spontaneous ventilation via endotracheal tube or tracheostomy (T piece or trach mask) [1]	**2**
GI feedings	**2**
replacement of excess fluid loss	**2**
parenteral chemotherapy	**2**
hourly neuro vital signs	**2**
multiple dressing changes	**2**
pitressin infusion IV	**2**
ECG monitoring	**1**
hourly vital signs	**1**
1 peripheral IV catheter [5]	**1**
chronic anticoagulation [7]	**1**
standard intake and output, daily [8]	**1**
STAT blood tests [9]	**1**
intermittent scheduled medications	**1**
routine dressing changes	**1**
standard orthopedic traction [10]	**1**

tracheostomy care [6]	**1**
decubitus ulcer (treatment but not preventive care)	**1**
urinary catheter	**1**
supplemental oxygen (nasal or mask) [1]	**1**
antibiotics (2 or less) [4]	**1**
chest physiotherapy	**1**
extensive irrigations, packings or debridement of wound, fistula or colostomy	**1**
GI decompression	**1**
peripheral hyperalimentation, intralipid therapy [11]	**1**

where:
• items in brackets "[ ]" appear to be mutually exclusive to each other

TISS 76 =
= SUM(points for activities performed)

Interpretation
• minimum score = 1
• maximum score = about 164
• Most patients in the intensive care unit have scores from 10 to 60.

Limitations of the TISS-76 (Miranda, 1996, page 65)
(1) It is time consuming.
(2) It can be rather cumbersome and boring to use.
(3) The items listed do not always adequately reflect the patient care activities of nurses in the ICU.
(4) Other aspects of nurse activities which are important to the organization or nursing profession are not accounted for.

References:
Keene AR, Cullen DJ. Therapeutic Intervention Scoring System: Update 1983. Crit Care Med. 1983; 11: 1-3.
Miranda DR, de Rijk A, Schaufeli W. Simplified Therapeutic Intervention Scoring System: The TISS-28 items - Results from a multicenter study. Crit Care Med. 1996; 24: 64-73.

30.10.03 Neonatal Therapeutic Intervention Scoring System (NTISS)

Overview:
The Neonatal Therapeutic Intervention Scoring System (NTISS) can be used to assess the severity of illness for a neonate in the Intensive Care Unit (ICU). The NTISS on the day of admission to the ICU correlates with length of stay, total hospital charges and resource utilization.

Parameter	Item	Subscore
respiratory	supplemental oxygen [1]	1
	surfactant administration	1
	tracheostomy care [2]	1
	tracheostomy placement [2]	1
	continuous positive airway pressure administration [1]	2
	endotracheal intubation	2
	mechanical ventilation [1]	3
	mechanical ventilation with muscle relaxation [1]	4
	high-frequence ventilation [1]	4
	extracorporeal membrane oxygenation	4
cardiovascular	indomethacin administration	1
	volume expansion (<= 15 mL/kg) [3]	1
	vasopressor administration (1 agent) [4]	2
	volume expansion (> 15 mL/kg) [3]	3
	vasopressor administration (> 1 agent) [4]	3
	pacemaker on standby [5]	3
	pacemaker used [5]	4
	cardiopulmonary resuscitation	4
drug therapy	antibiotic administration (<= 2 agents) [6]	1
	diuretic administration (enteral) [7]	1
	steroid administration (postnatal)	1
	anticonvulsant administration	1
	aminophylline administration	1
	other unscheduled medication	1
	antibiotic administration (> 2 agents) [6]	2
	diuretic administration (parenteral) [7]	2
	treatment of metabolic acidosis	3
	potassium binding resin administration	3
monitoring	frequent vital signs	1
	cardiorespiratory monitoring	1
	phlebotomy (5-10 blood draws) [8]	1
	thermoregularted environment	1
	noninvasive oxygen monitoring	1
	arterial pressure monitoring	1
	central venous pressure monitoring	1
	urinary catheters	1
	quantitative intake and output	1
	extensive phlebotomy (> 10 blood draws) [8]	2
metabolic/nutrition	gavage feeding	1
	intravenous fat emulsion	1

	intravenous amino acid solution	**1**
	phototherapy	**1**
	insulin administration	**2**
	potassium infusion	**3**
transfusion	**intravenous gamma globulin**	**1**
	red blood cell transfusion (<= 15 mL/kg) [9]	**2**
	partial volume exchange transfusion	**2**
	red blood cell transfusion (> 15 mL/kg) [9]	**3**
	platelet transfusion	**3**
	white blood cell transfusion	**3**
	double volume exchange transfusion	**3**
procedural	**transport of patient**	**2**
	single chest tube in place [11]	**2**
	minor operation [12]	**2**
	multiple chest tubes in place [11]	**3**
	thoracentesis	**3**
	major operation [12]	**4**
	pericardiocentesis [13]	**4**
	pericardial tube in place [13]	**4**
	dialysis	**4**
vascular access	**peripheral intravenous line**	**1**
	arterial line	**2**
	central venous line	**2**

where:
- **items in brackets ("[ ]") are mutually exclusive**
- **partial and double volume exchange transfusions are not listed as mutually exclusive**
- **endotracheal intubation and tracheostomy use are not listed as mutually exclusive**
- **potassium infusion and binding resin administration are not listed as mutually exclusive**

NTISS =
=SUM(applicable subscores)

Interpretation:
- **minimum score: 0**
- **maximum score: 100**

NTISS	Estimated Risk	Mortality (in 1992)
0 - 9	**low**	**1%**
10 - 19	**mild-to-moderate**	**4-5%**
20 - 29	**moderate**	**18-19%**
>= 30	**high**	**20-30%**

(after Figure 2, page 564)

References:

Gray JE, Ricahardson DK, et al. Neonatal Therapeutic Intervention Scoring System: A therapy-based severity-of-illness index. Pediatrics. 1992; 90: 561-567.

30.10.04 Intermediate TISS for Non-ICU Patients

Overview:
A modification of the original TISS was developed for patients in non-ICU settings such as intermediate ("step-down") and regular nursing units. This can be used both to quantitate the severity of patient illness and to measure the nursing workload.

Items relative to original TISS
(1) retained, with same point score (49)
(2) retained, but reweighted (10)
(3) new (26)
(4) deleted (18)

Scoring: Points are scored if the modality was used within the previous 24 hours, except for a new tracheostomy or acute digitalization (48 hours).

Patient Care and Monitoring

Intervention	Type	Points
vital signs every shift [1]	new	1
vital signs every 2-4 hours [1]	new	2
vital signs hourly or procedure checks [1]	reweighted	3
intake and output every 24 hours [2]	retained	1
intake and output every 6-8 hours [2]	retained	3
pulse volume recorder, Doppler	new	2
pulse oximetry	new	2
Glasgow Coma Scale every 4 hours [3]	new	2
Glasgow Coma Scale every 1-2 hours [3]	new	4
central venous pressure	retained	2
EKG monitoring or telemetry	reweighted	2
unscheduled 12 lead EKG	new	2
serial EKG or isoenzymes	new	3
multiple STAT specimens (more than 1 per shift)	retained	3
sputum, wound or other cultures [6]	new	1
initial "PAN" cultures, including blood [6]	new	4

Procedures

Intervention	Type	Points
simple dressing changes [4]	retained	1

multiple dressing changes [4]	**retained**	**2**
simple orthopedic therapy or cast care [5]	**retained**	**1**
complicated orthopedic therapy or special care beds [5]	**retained**	**3**
Foley catheter	**retained**	**1**
drainage tube(s)	**new**	**1**
nasogastric and/or gastric tubes	**retained**	**1**
hemodialysis [7]	**retained**	**2**
hemodialysis, initial [7]	**retained**	**4**
peritoneal dialysis chronic [7]	**new**	**3**
peritoneal dialysis, initial [7]	**retained**	**4**
chest tubes	**reweighted**	**2**
arterial catheter	**retained**	**3**
hypo or hyperthermia blanket	**retained**	**3**
emergency bronchoscopy or endoscopy	**retained**	**4**
emergency surgery within 24 hours	**retained**	**4**
lavage for acute GI bleed	**retained**	**4**
isolation	**new**	**4**
4 point restraints	**new**	**4**
emergency thora, para, peri or cardiocentesis	**reweighted**	**4**
arterial sheath	**new**	**4**

Infusions and Medications

Intervention	Type	Points
one IV catheter [8]	**retained**	**1**
2 IV catheters [8]	**retained**	**2**
anticoagulation, oral	**retained**	**1**
anticoagulation, IV (heparin, etc.)	**retained**	**3**
IV medications, scheduled	**retained**	**1**
IV medications, unscheduled	**retained**	**3**
IV antibiotic, 1 [9]	**retained**	**1**
IV antibiotic, > 1 [9]	**reweighted**	**2**
intralipid/peripheral hyperalimentation [10]	**retained**	**1**
GI feedings [10]	**retained**	**2**
hyperalimentation by central catheter [10]	**retained**	**3**
epidural infusion	**new**	**2**
continuous IV sedation, patient controlled anesthesia	**new**	**2**
IV aminophylline/theophylline	**new**	**2**
IV chemotherapy	**retained**	**2**
IV diuresis [11]	**retained**	**3**
oral diuresis or change in oral diuretic therapy [11]	**retained**	**3**
replacement of excess fluid loss	**retained**	**2**
diabetic management (glucose monitoring with	**new**	**3**

sliding scale insulin administration)		
acute treatment of seizures or encephalopathy	retained	3
digitalization within 48 hours	retained	3
continuous antiarrhythmia infusion	retained	3
vasoactive drug infusion, 1 [12]	retained	3
vasoactive drug infusion, > 1 [12]	retained	4
blood products, frequent infusion (3 units within 24 hours)	retained	3
pressure activated blood infusion	retained	4
platelet infusion	retained	4
tissue plasminogen activation streptokinase/urokinase infusion	retained	4
concentrated potassium chloride infusion (40 mEq/dL)	retained	3

Cardiac Support

Intervention	Type	Points
pneumatic boots	new	1
chronic implanted pacemaker [13]	reweighted	2
temporary A/V pacing [13]	retained	4
cardiac pacer implanted within 24 hours [13]	new	4
chronic implanted automatic internal cardiac defibrillator [14]	new	3
automatic internal cardiac defibrillator [14]	new	4
cardioversion	reweighted	4
cardiac arrest within 24 hours	retained	4

Respiratory Support

Intervention	Type	Points
tracheostomy care [15]	retained	1
fresh tracheostomy within 48 hours [15]	reweighted	3
minitracheostomy [15]	new	2
intubation [15]	retained	3
incentive spirometry	new	1
formal chest physiology	reweighted	2
endotracheal suctioning more than 2 times every 6-8 hours [16]	new	1
blind endotracheal suctioning [16]	retained	3
oxygen by mask or cannula [17]	reweighted	2
spontaneous respiration via tracheostomy mask or T-piece [17]	retained	2
continuous positive airway pressure (CPAP) [17]	retained	3
mechanical ventilation [17]	retained	4

where:
- **separation into subgroups not in the original table, which merely separted interventions by point scores (Table 2, page 1409, Cullen et al, 1994)**
- **items in brackets "[]" appear to be mutually exclusive (my choice)**
- **I am not sure what an "arterial sheath" refers to**
- **formal chest "physiology" may refer to physiotherapy (as in original TISS)**

Deleted items from original TISS (18)
- **controlled ventilation with intermittent or continuous muscle relaxants**
- **balloon tamponade of varices**
- **pulmonary artery catheter**
- **induced hypothermia**
- **G suit**
- **intracranial pressure monitoring**
- **intra-aoritc balloon assist**
- **intermittent mandatory ventilation or assisted ventilation**
- **measurement of cardiac output by any means**
- **active therapy of metabolic alkalosis**
- **active therapy of metabolic acidosis**
- **phlebotomy for volume overload**
- **coverage with > 2 IV antibiotics**
- **hourly neuro vital signs**
- **vasopressin infusion**
- **decubitus ulcer**
- **STAT blood tests (weighted 1 point; 3 point intervention retained)**
- **extensive irrigation, packings or debridement of wounds, fistula or colostomy**

intermediate TISS =
= SUM [therapeutic interventions being used]

The intermediate TISS results in the test patients showed good correlation with the original TISS results, with a linear relation.

intermediate TISS =
= 4.4 + (1.4 * (original TISS))

This can be rearranged:

original TISS =
= ((intermediate TISS) - 4.4) / 1.4

References:
Cullen DJ, Nemeskal AR, Zaslavsky AM. Intermediate TISS: A new Therapeutic Intervention Scoring System for non-ICU patients. Crit Care Med. 1994; 22: 1406-1411.

30.10.05 TISS-28

Overview:
The Simplified Therapeutic Intervention Scoring System TISS-28 consists of 28 items. It is intended to accurately measure the level of care required for a patient in the Intensive Care Unit (ICU) but be simpler to administer than previous TISS forms. It correlates well with the TISS-76 score and can be used in its place.

Parameter	Action	Points
basic activities	standard monitoring (hourly vital signs, calculation of fluid balance, regular registration)	5
	laboratory investigations	1
	[1] single medication, any route (IV, po, IM, etc.)	2
	[1] multiple intravenous medications (more than 1 drug, single injections, or continuously)	3
	routine dressing changes (care and prevention of decubitus and daily dressing change)	1
	frequent dressing changes (at least one time per nursing shift and/or extensive wound care)	1
	care of drains (all excpet gastric tube)	3
ventilatory support	[2] mechanical ventilation (any form of mechanical or assisted ventilation with or without PEE), with or without muscle relaxants; spontaneous breathing with PEEP)	5
	[2] supplementary ventilatory support (breathing spontaneously through endotracheal tube without PEEP; supplementary oxygen by any method except if mechanical ventilation used)	2
	care of artificial airways (endotracheal tube or tracheostoma)	1
	treatment for improving lung function (thorax physiotherapy, incentive spirometry, inhalation therapy)	1
cardiovascular support	[3] single vasoactive medication (any vasoactive drug)	3
	[3] multiple vasoactive medications (more than1 vasoactive drug)	4
	intravenous replacement of large fluid losses; fluid replacement > 3 liters per square meter per day; disregard type of fluid administered	4
	peripheral arterial catheter	5
	left atrium monitoring; pulmonary artery flotation catheter with or without cardiac output measurement	8
	central venous line	2

	cardiopulmonary resuscitation after arrest in the past 24 hours (a single precordial percussion not included)	**3**
renal support	**hemofiltration techniques. Dialytic techniques**	**3**
	quantitative urine output measurement	**2**
	active diuresis	**3**
neurologic support	**measurement of intracranial pressure**	**4**
metabolic support	**treatment of complicated metabolic acidosis/alkalosis**	**4**
	intravenous hyperalimentation	**3**
	enteral feeding (through gastric tube or other GI route such as jejunostomy)	**2**
specific interventions	**[4] single specific intervention**	**3**
	[4] multiple specific interventions	**5**
	specific interventions outside of ICU (surgery, diagnostic procedures)	**2**

where:
- **The selection of one item marked [1], [2], [3] and [4] excludes the other matching numbered item.**
- **single specific interventions = naso- or oro-tracheal intubation, introduction of a pacemaker, cardioversion, endoscopies, emergency surgery in the past 24 hours, and gastric lavage.**

TISS-28 =
= SUM(points for actions involved in the care of the patient)

estimated the TISS-76 =
= ((TISS28) - 3.33) / 0.97

Interpretation
- **minimum score = 0 (unlikely in patient requiring true intensive care)**
- **maximum score = 78**
- **Each nurse is capable of providing care for 46.35 TISS-28 points per shift. Each TISS-28 point requires 10.6 minutes of each nurse's shift.**

References:
Miranda DR, de Rijk A, Schaufeli W. Simplified Therapeutic Intervention Scoring System: The TISS-28 items - Results from a multicenter study. Crit Care Med. 1996; 24: 64-73.
Moreno R, Morais P. Validation of the simplified therapeutic intervention scoring system on an independent database. Intensive Care Med. 1997; 23: 640-644.

30.11 Simplified Acute Physiology Score (SAPS)

30.11.01 Original Simplified Acute Physiology Score (SAPS)

Overview:
The Simplified Acute Physiology Score (SAPS) is a simplified version of the APACHE acute physiology score (APS). It provides a simply calculated score using clinical data ; the score correlates with a patient's mortality rate in the ICU.

Data
• collected during the first 24 hours after ICU admission
• 14 data items, versus 34 items in the APACHE APS

	+4	+3	+2	+1	0	+1	+2	+3	+4
age in years					<= 45	46 - 55	55 - 65	66 - 75	> 75
heart rate (beats per minute)	>= 180	140-179	110-139		70-109		55 - 69	40 - 54	< 40
systolic blood pressure (mm Hg)	>= 190		150-189		80-149		55 - 79		< 55
body temperature (°C)	>= 41	39 - 40.9		38.5-38.9	36 - 38.4	34 - 35.9	32 - 33.9	30 - 31.9	< 30
spontaneous respiratory rate (breaths/min) OR	>= 50	35 - 49		25 - 34	12 - 24	10 - 11	6 - 9		< 6
ventilation or CPAP								Yes	
urinary output (L per 24 hours)			>= 5.00	3.5-4.99	0.70-3.49		0.50-0.69	0.20-0.49	< 0.20
blood urea nitrogen in mg/dL	>= 154	101-153	81-100	21-80	10-20	< 10			
hematocrit (%)	>= 60		50-59.9	46-49.9	30-45.9		20.0-29.9		< 20.0
white blood cell count (1000/µL)	>= 40		20 - 39.9	15 - 19.9	3.0 - 14.9		1.0 - 2.9		< 1.0
serum glucose	>= 800	500-799		250-499	70-249		50-69	29-49	<29
serum potassium (mEq/L)	>= 7.0	6.0-6.9		5.5-5.9	3.5-5.4	3.0-3.4	2.5-2.9		<2.5
serum sodium (mEq/L)	>= 180	161-179	156-160	151-155	130-150		120-129	110-119	< 110
serum HCO3 (mEq/L)		>= 40		30-39.9	20-29.9	10-19.9		5.0-9.0	< 5.0
Glasgow Coma					13 -	10 -	7 - 9	4 - 6	3

Score					15	12			
	+4	+3	+2	+1	0	+1	+2	+3	+4

where
• glucose converted from mmol/L to mg/dL (multiply mmol/L by 18.018)
• blood urea nitrogen converted from mmol/L to mg/dL (multiple mmol/L by 2.801)

SAPS score =
= SUMMATION (points for each data item)

Interpretation
• minimum score: 0
• maximum score: 56

SAPS	Mortality Rate
4	
5-6	10.7 +/- 4.1
7-8	13.3 +/- 3.9
9-10	19.4 +/- 7.8
11-12	24.5 +/- 4.1
13-14	30.0+/- 5.5
15-16	32.1 +/- 5.1
17-18	44.2 +/- 7.6
19-20	50.0 +/- 9.4
>= 21	81.1+/- 5.4

References:
Le Gall J-R, Loirat P, et al. A simplified acute physiology score for ICU patients. Crit Care Med. 1984; 12: 975-977.

30.11.02 New Simplified Acute Physiology Score (SAPS II)

Overview:
The New Simplified Acute Physiology Score (SAPS II) is a revision of the Simplified Acute Physiology Score. It is used to assess patients in the ICU and can predict mortality risk based on the most marked abnormalities of 15 variables.

Comparison with SAPS
• dropped: glucose, hematocrit
• added: bilirubin, chronic disease, reason for admission
• altered: PaO2/FIO2 (no score if not ventilated or on CPAP)
• SAPS II scores range from 0 to 26, vs 0 to 4 in SAPS

Variables	Scoring Guidelines
age	age in years at time of last birthday

heart rate	**use the highest or lowest heart rate in past 24 hours , whichever gives the higher number of points**
systolic blood pressure	**use the highest or lowest blood pressure in past 24 hours , whichever gives the higher number of points**
body temperature	**use highest temperature**
PaO2/FIO2 ratio	**use only if on ventilation or CPAP, using the lowest ratio**
urinary output	**if time period is less than 24 hours, adjust urine output for period to 24 hours**
SUN	**use the highest value**
WBC count	**use the highest or lowest WBC count in past 24 hours , whichever gives the higher number of points**
serum potassium	**use the highest or lowest potassium in past 24 hours , whichever gives the higher number of points**
serum sodium	**use the highest or lowest sodium in past 24 hours , whichever gives the higher number of points**
serum bicarbonate	**use the lowest value**
serum bilirubin	**use the lowest value**
Glasgow Coma Score	**use the lowest value; if patient sedated, use the score before sedated**
type of admission	**scheduled surgery if scheduled at least 24 hours prior to operation; unscheduled if operated on with less than 24 hour notice; medical if no surgery within 1 week of admission to ICU**
AIDS	**HIV positive with AIDS defining opportunistic infection or tumor**
hematologic malignancy	**malignant lymphoma, Hodgkins disease, leukemia or multiple myeloma**
metastatic cancer	**metastases demonstrated at surgery, radiographically or other suitable method**

Variable	Finding	Points
age in years	**< 40**	**0**
	40 - 59	**7**
	60 - 69	**12**
	70 - 74	**15**
	75 - 79	**16**
	>= 80	**18**
heart rate in beats per	**< 40**	**11**

minute		
	40 - 69	**2**
	70 - 119	**0**
	120 - 159	**4**
	>= 160	**7**
systolic blood pressure in mm Hg	**< 70**	**13**
	70 - 99	**5**
	100 - 199	**0**
	>= 200	**2**
body temperature in °C	**< 39 °C**	**0**
	>= 39	**3**
if on ventilation or CPAP, PaO2/FIO2	**< 100**	**11**
	100 - 199	**9**
	>= 200	**6**
urinary output in L per 24 hours	**< 0.500**	**11**
	0.500 - 0.999	**4**
	>= 1.000	**0**
serum urea nitrogen in mg/dL	**< 28**	**0**
	28 - 83	**6**
	>= 84	**10**
WBC count in 1000 per µL	**< 1.0**	**12**
	1.0 - 19.9	**0**
	>= 20	**3**
serum potassium in mEq/L	**< 3.0**	**3**
	3.0 - 4.9	**0**
	>= 5.0	**3**
serum sodium in mEq/L	**< 125**	**5**
	125 - 144	**0**
	>= 145	**1**
serum bicarbonate in mEq/L	**< 15**	**6**
	15 - 19	**3**
	>= 20	**0**
bilirubin level in mg/dL	**< 4.0**	**0**
	4.0 - 5.9	**4**
	>= 6.0	**9**
Glasgow Coma score	**< 6**	**26**
	6 - 8	**13**

	9 - 10	7
	11 - 13	5
	14 - 15	0
chronic diseases	metatastic carcinoma	9
	hematologic malignancy	10
	AIDS	17
type of admission	scheduled surgery	0
	medical	6
	unscheduled surgery	8

SAPS II =
= (points for age) + (points for heart rate) + (points for systolic blood pressure) + (points for body temperature) + (points for ventilation) + (points for urinary output) + (points for SUN) + (points for WBC count) + (points for potassium) + (points for serum) + (points for bicarbonate) + (points for bilirubin) + (points for Glasgow Coma Score) + (points for chronic diseases) + (points for type of admission)

Interpretation
• minimum score 0
• maximum score 160

logit =
= (-7.7631) + (0.0737 * (SAPSII)) + ((0.9971 * (LN((SAPSII)+1)))

probability of hospital mortality =
= EXP(logit) / (1 + (EXP(logit)))

References:
Le Gall J-R, Lemeshow S, Saulnier F. A new simplified acute physiology score (SAPS II) based on a European/North American multicenter study. JAMA. 1993; 270: 2957-2963.
Lemeshow S, Le Gall J-R. Modeling the severity of illness in ICU patients. JAMA. 1994; 272: 1049-1055.

30.12 Mortality Probability Models (MPM)

Overview:
Mortality Probability Models (MPM) is used to assess the prognosis of patients in the adult medical-surgical intensive care unit (ICU). Comparison of actual outcomes versus estimates allows different ICUs to be evaluated for quality of care. The estimates can also be used to help inform a patient's family members of her/his relative prognosis.

30.12.01 MPM at Admission

Overview:
The MPM at admission (MPM-0) collects data at the time the patient is admitted to the ICU.

Parameter	Value	beta value
patient in deep stupor or coma	1 if yes, else 0	2.8902
emergency admission	1 if yes, else 0	1.2671
CPR prior to admission	1 if yes, else 0	1.0137
cancer part of present problem	1 if yes, else 0	0.94131
history of chronic renal failure	1 if yes, else 0	0.64049
infection probable	1 if yes, else 0	0.55592
age in years	age	0.047789
previous ICU admission within past 6 months	1 if yes, else 0	0.43946
on surgical service at ICU admission	1 if yes, else 0	-0.37987
heart rate at ICU admission in beats per minute	heart rate	0.00736
systolic blood pressure	SBP	-0.04591
	(SBP) ^2	0.000116
constant	1	-2.9678

logit =
= SUM ((value) * (beta-value))

probability of hospital mortality =
= (EXP(logit)) / (1 + (EXP(logit)))

References:
Lemeshow S, Teres D, et al. Refining intensive care unit outcome prediction by using changing probabilities of mortality. Crit Care Med. 1988; 16: 470-477.

30.12.02 MPM at 24 Hours

Overview:
The MPM at 24 hours (MPM-24) collects data from the 24 hour period after the patient was admitted to the ICU.

Parameter	Value	beta value
patient in deep stupor coma at 24 hours	1 if yes, else 0	3.4986
cancer part of present problem at admission	1 if yes, else 0	0.99476

emergency admission	**1 if yes, else 0**	**0.80224**
patient's prothrombin time in seconds	**1 if (patient prothrombin time > 3 seconds above laboratory standard), else 0**	**0.73764**
patient in shock during first 24 hours	**1 if yes, else 0**	**0.67367**
urine output in any 8 hour during first 24 hours	**1 if < 180 mL, else 0**	**0.65128**
infection confirmed at 24 hours	**1 if yes, else 0**	**0.53755**
PaO2 in mm Hg in first 24 hours	**1 if < 60 mm Hg, else 0**	**0.49666**
FIO2 in first 24 hours	**1 if > 0.50, else 0**	**0.47462**
creatinine in mg/dL in first 24 hours	**1 if > 2.0, else 0**	**0.45716**
age in years	**age**	**0.044142**
hours of mechanical ventilation	**hours**	**0.026336**
number of lines at 24 hours	**number of lines (see below)**	**0.15376**
patient on surgical service at 24 hours	**1 if yes, else 0**	**-0.70808**
constant	**1**	**-6.5917**

number of lines
• number of intravascular lines (arterial, invtravenous, pulmonary artery catheter)
• ventilation tube (endotracheal or tracheal)
• Foley catheter
• pacing wires (count as 1 if one or more present)
• number of chest tubes
• nasogastric tube
• drains in each abdominal quadrant (count as 1 if one or more present)

logit =
= SUM ((value) * (beta-value))

probability of hospital mortality =
= (EXP(logit)) / (1 + (EXP(logit)))

References:
Lemeshow S, Teres D, et al. Refining intensive care unit outcome prediction by using changing probabilities of mortality. Crit Care Med. 1988; 16: 470-477.

30.12.03 MPM at 48 hours

Overview:
The MPM at 48 hours (MPM-48) collects data from the 24-48 hour period after the patient was admitted to the ICU.

Parameter	Value	beta value
patient in deep stupor or coma at 48 hours	1 if yes, else 0	2.8644
urine output in mL during any 8 hour during 24-48 hour period	1 if < 180 mL, else 0	0.99015
patient in deep stupor or coma at time of ICU admission	1 if yes, else 0	0.97702
emergency admission	1 if yes, else 0	0.9602
prothrombin time in seconds	1 if (patient prothrombin time > 3 seconds above laboratory standard), else 0	0.90928
FIO2 in period 24-48 hours	1 if > 0.50, else 0	0.84206
cancer part of present problem	1 if yes, else 0	0.8155
infection confirmed at 48 hours	1 if yes, else 0	0.47138
age in years	age	0.042383
total hours on mechnical ventilation in ICU	total hours	0.021409
total hours of continuous IV vasoactive drug therapy	total hours	0.017262
constant	1	-5.8601

logit =
= SUM ((value) * (beta-value))

probability of hospital mortality =
= (EXP(logit)) / (1 + (EXP(logit)))

References:
Lemeshow S, Teres D, et al. Refining intensive care unit outcome prediction by using changing probabilities of mortality. Crit Care Med. 1988; 16: 470-477.

30.12.04 MPM Over Time

Overview:
Evaluation of the MPM-0, MPM-24 and MPM-48 together allows a global assessment for the period covered by the individual measures.

Value	beta value
(probability of mortality as determined by MPM-0)	6.3373
(probability of mortality as determined by MPM-0) minus (probability of mortality as determined by MPM-24)	-5.1914
(probability of mortality as determined by MPM-24) minus (probability of mortality as determined by	-3.0546

MPM-48)	
constant	**-2.9287**

logit =
= SUM ((value) * (beta-value))

probability of hospital mortality =
= (EXP(logit)) / (1 + (EXP(logit)))

References:
Lemeshow S, Teres D, et al. Refining intensive care unit outcome prediction by using changing probabilities of mortality. Crit Care Med. 1988; 16: 470-477.

30.13 Mortality Probability Models (MPM II)

30.13.01 MPM II at Admission to the ICU

Overview:
Mortality Probability Models (MPM II) can be used to assess patients at the time of admission to the ICU and to predict hospital mortality. It also can be used in the quality assessment of the care given in different intensive care units.

Patients excluded
- **age < 18 years**
- **burn patients**
- **coronary care patients**
- **cardiac surgery patients**

Definitions for Variables

Coma or deep stupor at time of ICU admission
- **not due to drug overdosage**
- **if patient is on paralyzing muscle relaxant, awakending from anesthesia or heavily sedated, use best judgment of the level of consciousness prior to sedation**
- **coma: no response to any stimulation, no twitching, no movements in extremities, no response to pain or command, Glasgow coma scale 3**
- **deep stupor: decorticate or decerebrate posturing; posturing is spontaneous or in response to stimulation or deep pain; posturing is not in response to commands; Glasgow coma scale 4 or 5**

Heart rate at ICU admission
- **heart rate >= 150 beats per minute within 1 hour before or after ICU admission**

Systolic blood pressure at ICU admission
- **systolic blood pressure <= 90 mm Hg within 1 hour before or after ICU admission**

Chronic renal compromise or insufficiency
- **elevation of serum creatinine > 2 mg/dL and documented as chronic in the medical record**
- **if there is the acute diagnosis on chronic renal failure, then only record yes for acute renal failure**

Cirrhosis
- **history of heavy alcohol use with portal hypertension and varices**
- **other causes of liver disease with evidence of portal hypertension and varices**
- **biopsy confirmation of cirrhosis**

Metastatic malignant neoplasm
- **stage IV carcinomas with distant metastases**
- **do not include involvement only of regional lymph nodes**
- **include if metastases are obvious by clinical assessment or confirmed by a pathology report**
- **do not include if metastases not obvious or if pathology report is not available at the time of ICU admission**
- **acute hematologic malignancies are included**
- **chronic leukemias are not included unless there are findings attributable to the disease or the patient is under active treatment for the leukemia. Findings include sepsis, anemia, stroke caused by clumping of white blood cells, tumor lysis syndrome with elevated uric acid following chemotherapy, pulmonary edema or lymphangiectatic form of ARDS**

Acute renal failure
- **acute tubular necrosis, or acute diagnosis on chronic renal failure**
- **prerenal azotemia is not included**

Cardiac dysrhythmia
- **cardiac arrhythmia, paroxysmal tachycardia, fibrillation with rapid ventricular response, second or third degree heart block**
- **do not include chronic and stable arrhythmias**

Cerebrovascular incident
- **cerebral embolism, occlusion, CVA, stroke, brain-stem infarction, cerebrovascular arteriovenous malformation (acute stroke or cerebrovascular hemorrhage, not chronic arteriovenous malformation)**

Gastrointestinal bleeding
- **hematemesis, melena**
- **a perforated ulcer does not necessarily indicate GI bleeding; may be identified by obvious "coffee grounds" in nasogastric tube**
- **a drop of hemoglobin by itself is not sufficient evidence of acute GI bleeding**

Intracranial mass effect

• intracranial mass (abscess, tumor, hemorrhage, subdural) as identified by CT scan associated with any of the following: (1) midline shift, (2) obliteration or distortion of cerebral ventricles, (3) gross hemorrhage in cerebral ventricles or subarachnoid space, (4) visible mass > 4 cm or (5) any mass that enhances with contrast media
• if the mass effect is known within 1 hour of ICU admission, it can be indicated as yes
• CT scanning is not mandated and is only indicated for patients with major neurological insult

Age in years
• patient's age at last birthday

CPR within 24 hours prior to ICU admission
• CPR includes chest compression, defibrillation or cardiac massage
• not affected by the location where the CPR was administered

Mechanical ventilation
• patient is using a ventilator at the time of ICU admission or immediatey thereafter

Medical or unscheduled surgery admission
• do not include elective surgical patients (surgery scheduled at least 24 hours in advance) or pre-operative Swan-Ganz catheter insertion in elective surgery patients

Class	Variable	coefficient
chronic health status	cirrhosis	1.13681
	metastatic carcinoma	1.19979 i
	chronic renal insufficiency	0.91906
physiology	heart rate >= 150 beats/minute	0.45603
	systolic blood pressure <= 90 mm Hg	1.06127
	Glasgow Coma Scale or modified	1.48592
acute diagnoses	acute renal failure	1.48210
	cardiac dysrhythmia	0.28095
	cerebrovascular incident	0.21338
	gastrointestinal bleeding	0.39653
	intracranial mass effect	0.86533
other	age in years at last birthday	0.03057
	type of admission (medical or unscheduled surgery admission)	1.19098
	CPR prior to ICU admission	0.56995
	mechanical ventilation	0.79105
constant		-5.46836

beta value for each variable =
= (coefficient) * (if age, then age in years; else, 1 if present or 0 if absent)

logit =
= SUM (beta values)

probability of hospital mortality =
= (EXP(logit)) / (1 + (EXP(logit)))

References:
Lemeshow S, Teres D, et al. Mortality Probability Models (MPM II) based on an international cohort of intensive care patients. JAMA. 1993; 270: 2478-2486.
Lemeshow S, Le Gall J-R. Modeling the severity of illness of ICU patients. JAMA 1994; 272: 1049-1055.

30.13.02 MPM II during Admission

Overview:
Mortality Probability Models (MPM II) can be used during a patient's stay in the ICU to predict mortality.

Continued Variables
- **age in years**
- **cirrhosis**
- **metastatic carcinoma**
- **Glasgow coma scale**
- **intracranial mass effect**
- **nonelective surgical admission**
- **mechanical ventilation**

Discontinued Variables
- **chronic renal insufficiency**
- **acute renal failure**
- **heart rate**
- **systolic blood pressure**
- **cardiac dysrhythmia**
- **cerebrovascular incident**
- **gastrointestinal bleeding**
- **CPR prior to ICU admission**

New Variables
- **creatinine > 2 mg/dL**
- **urine output < 150 mL in an 8 hour period**
- **PaO2 < 60 mm Hg**
- **prothrombin time > 3 seconds above control**

• infection
• intravenous vasoactive drug therapy >= 1 hour

Constant
• varies for 24, 48 and 72 hours

Class	Variable	coefficient
chronic health status	cirrhosis	1.08745
	metastatic carcinoma	1.16109
physiology	creatinine > 2 mg/dL	0.72283
	urine output < 150 mL in 8 hours	0.82286
	PaO2 < 60 mm Hg	0.46677
	prothrombin time > 3 seconds above control	0.55352
	Glasgow Coma Scale or modified	1.68790
acute diagnoses	infection	0.49742
	intracranial mass effect	0.91314
other	age	0.03268
	type of admission (medical or unscheduled surgery admission)	0.83404
	mechanical ventilation	0.80845
	vasoactive drug therapy >= 1 hour intravenously	0.71628
constant		-5.646 (24) -5.392 (48) -5.238 (72)

beta value for each variable =
= (coefficient) * (if age, then age in years; else, 1 if present or 0 if absent)

logit =
= SUM (beta values)

probability of hospital mortality =
= (EXP(logit)) / (1 + (EXP(logit)))

References:
Lemeshow S, Teres D, et al. Mortality Probability Models (MPM II) based on an international cohort of intensive care patients. JAMA. 1993; 270: 2478-2486.
Lemeshow S, Le Gall J-R. Modeling the severity of illness of ICU patients. JAMA 1994; 272: 1049-1055.

30.13.03 Comparison of MPM II Assessments

Overview:
The Mortality Probability Models (MPM II) can be used for predicting the mortality of patients in the ICU and for comparing the care received in different intensive care units.

Features of MPM assessments
- **multiple diagnoses can be included, rather than a single, most severe condition**
- **adjustments made in conditions considered and weightings given at admission and during hospitalization, reflecting differing impact on mortality**

Class	Variable	MPM II at admission	MPM II at 24, 48, 72 hours
chronic health status	cirrhosis	1.137	1.087
	metastatic carcinoma	1.200	1.161
	chronic renal insufficiency	0.919	
physiology	heart rate	0.456	
	systolic blood pressure	1.061	
	creatinine		0.723
	urine output		0.823
	PaO2		0.467
	prothrombin time		0.554
	Glasgow Coma Scale or modified	1.486	1.688
acute diagnoses	acute renal failure	1.482	
	cardiac dysrhythmia	0.281	
	cerebrovascular incident	0.213	
	gastrointestinal bleeding	0.397	
	infection		0.497
	intracranial mass effect	0.865	0.913
other	age	0.031	0.033
	type of admission	1.191	0.834
	CPR prior to ICU admission	0.570	
	mechanical ventilation	0.791	0.808
	vasoactive drug therapy		0.716
constant		-5.468	-5.646 (24) -5.392 (48) -5.238 (72)

Use in quality assessment of ICU care

• the MPM-0 is independent of ICU care, while later MPM scores are affected by care received

References:

Lemeshow S, Teres D, et al. Mortality Probability Models (MPM II) based on an international cohort of intensive care patients. JAMA. 1993; 270: 2478-2486.

Lemeshow S, Le Gall J-R. Modeling the severity of illness of ICU patients. JAMA 1994; 272: 1049-1055.

30.14 The SUPPORT Prognostic Model

30.14.01 Calculating the SUPPORT Physiologic Score

Overview:

The SUPPORT Physiologic Score needs to be calculated before the prognosis for a patient in the Intensive Care Unit can be determined.

Data

• All data is from day 3 after admission, except for albumin.

• The albumin data used is from day 1.

	Primary	Secondary	Value
1	acute renal failure or multiorgan failure present?		259.9
2	COPD or CHF present?		263.4
3	cirrhosis or coma present?		241.4
4	lung or colon cancer present?		281.5
5	PaO2/FIO2	PaO2/FIO2 < 225 PaO2/FIO2 >= 225	- 0.06174 * (PaO2/FIO2) - 0.06174 * 225
6	blood pressure	mean blood pressure < 60 mean blood pressure >= 60	-0.6316 * (mean BP) -0.6316 * 60
7	WBC	WBC <= 9 and ARF/MOSF present WBC <= 9 and not ARF/MOSF	1.0205 * WBC 1.0205 * 9

		WBC > 9, < 40 WBC >= 40	1.0205 * WBC 1.0205 * 40
8	WBC > 8	WBC <= 9 and ARF/MOSF present WBC <= 9 and not ARF/MOSF WBC > 9, < 40 WBC >= 40	-0.3676 * (WBC - 8) -0.3676 * (9 - 8) -0.3676 * (WBC - 8) -0.3676 * (40 - 8)
9	WBC > 11	WBC > 11, < 40 WBC >= 40	-0.5631 * (WBC - 11) -0.5631 * (40 - 11)
10	albumin	albumin < 4.6 albumin >= 4.6	0.2691 * (albumin) 0.2691 * 4.6
11	apache III respiration score		0.2312 * (score)
12	temperature °C		-2.362 * (temperature)
13	temperature > 36.6 °C		1.326 * ((temperature) - 36.6)
14	temperature > 38.3 °C		2.473 * ((temperature) - 38.3)
15	heart rate		-0.1579 * (heart rate)
16	heart rate > 55		9.77 * 10^(-5) * (((heart rate) - 55)^3)
17	heart rate > 80		-2.189 * 10^(-4) * (((heart rate) - 80)^3)
18	heart rate > 110		1.518 * 10^(-4) * (((heart rate) - 110)^3)
19	heart rate > 149		-3.062 * 10^(-5) * (((heart rate) - 149)^3)
20	bilirubin		0.9763 * (bilirubin)
21	bilirubin > 7		- 0.7481 * ((bilirubin) - 7)
22	creatinine	creatinine <= 15 creatinine > 15	-6.8761 * (creatinine) -6.8761 * 15
23	creatinine > 0.600	creatinine <= 15 creatinine > 15	11.6058 * (((creatinine) - 0.6) ^3) 11.6058 * (((15) - 0.6) ^3)

24	**creatinine > 1.000**	**creatinine <= 15** **creatinine > 15**	**-21.8413 * (((creatinine) - 1.0) ^3)** **-21.8413 * (((15) - 1.0) ^3)**
25	**creatinine > 1.500**	**creatinine <= 15** **creatinine > 15**	**10.3574 * (((creatinine) - 1.5) ^3)** **10.3574 * (((15) - 1.5) ^3)**
26	**creatinine > 5.399**	**creatinine <= 15** **creatinine > 15**	**-0.1219 * (((creatinine) - 5.399) ^3)** **-0.1219 * (((15) - 5.399) ^3)**
27	**sodium**		**-0.6167096 * (sodium)**
28	**sodium > 128**		**0.0021118 * (((sodium) - 128) ^3)**
29	**sodium > 135**		**-0.0036730 * (((sodium) - 135) ^3)**
30	**sodium > 139**		**0.0006126 * (((sodium) - 139) ^3)**
31	**sodium > 148**		**0.0009486 * (((sodium) - 148) ^3)**
32	**COPD or CHF present**	**albumin < 4.6** **albumin >= 4.6**	**-6.278 * (albumin)** **-6.278 * 4.6**
33	**lung or colon cancer present**	**albumin < 4.6** **albumin >= 4.6**	**-11.45 * (albumin)** **-11.45 * 4.6**
34	**acute renal failure or multiorgan failure present**	**WBC < 8** **WBC >= 8, < 11** **WBC >= 11, < 40** **WBC >= 40**	**-2.3549 * (WBC)** **-2.3549 * (WBC) + 2.7494 (WBC - 8)** **-2.3549 * (WBC) + 2.7494 (WBC - 8) - 0.4638 * (WBC - 11)** **-2.3549 * (40) + 2.7494 (40 - 8) - 0.4638 * (40 - 11)**

where:

- **Definitions for acute renal failure, multi-organ failure, and the other clinical conditions are available in Murphy and Cluff (1990; Chapter 3, pages 11S-28S)**

• The WBC value is set to 9 if the WBC count is < 9,000 and the patient does not have ARF or MOSF. The WBC value is set to 40 if the WBC count is > 40,000.
• The creatinine value is set to 15 if creatinine is > 15.
• The value to use for the "APACHE III respiration score" is not precisely defined but is assumed to be based on the following score from APACHE III based on the respiratory rate.

respiratory rate in breaths per minute	Points
<= 5	17
6 - 11	8 if not on mechanical ventilation; 0 if on mechanical ventilation
12- 13	7 (0 points if rate 12 and patient on mechanical ventilation)
14 - 24	0
25 - 34	6
35 - 39	9
40 - 49	11
>= 50	18

SUPPORT physiologic score =
= SUM (values from 34 elements listed above)

Note:
• The SUPPORT physiologic equation is copyrighted by George Washington University and cannot be used for commerical purposes without permission.
• This equation is fairly complex and confusing. Before using, verifying the assumptions and calculations are recommended.

References
Knaus WA, Harrell FE Jr, et al. The SUPPORT prognostic model. Ann Intern Med. 1995; 122: 191-203.
Murphy DJ, Cluff LE (editors). SUPPORT: Study to understand prognoses and preferences for outcomes and risks of treatment. J Clin Epidemiol. 1990; 43 (supplement): 1S-123S.

30.15 Blood Lactate and Survival

Overview:
Critically ill patients develop tissue hypoxia with lactic acidosis and high blood lactate levels. High lactate levels can correlate with the patient's prognosis.

Parameters

• lactate in mmol/L (conversion factor from mg/dL to mmol/L is 0.111)
• urine output in mL per 8 hour period
• qualitative severity rating, from 1 (good) to 5 (very bad)

Survivor if:	False NonSurvivor	False Survivor
lactate in mmol/L <= 3.830	0.04	0.49
((5.649 * LOG10 (lactate)) - (0.0008 * (urine output))) <= 3.040	0.05	0.41
((4.592 * LOG10 (lactate)) + (1.073 * (severity rating))) <= 6.409	0.03	0.44
((4.456 * LOG10 (lactate)) - (0.0009 * (urine output))+ (1.087 * (severity rating))) <= 6.002	0.05	0.44

Approximating the survival curve in Figure 7 (Weil, 1973) with JMP,

lactate in mmol/L	probability of survival =
< 0.7	100%
0.7 to 3.0	(0.0005149 * ((lactate)^3)) - (0.026797 * ((lactate) ^ 2)) + (0.0082298 * (lactate)) + 0.9992159
3.0 to 6.0	(0.0314286* ((lactate) ^ 2)) - (0.467143 * (lactate)) + 1.9214286
6.0 to 20	(0.0000303 * ((lactate)^4)) - (0.001872 * ((lactate)^3)) + (0.0425701 * ((lactate) ^ 2)) - (0.427473 * (lactate)) + 1.6471193
> 20	0%

References:

Cady LD Jr, Weil MH, et al. Quantitation of severity of critical illness with special reference to blood lactate. Crit Care Med. 1973; 1: 75-80.

Weil MH, Afifi AA. Experimental and clinical studies in lactate and pyruvate as indicators of the severity of acute criculatory failure (shock). Circulation. 1970; 41: 989-1001.

30.16 Physiology Stability Index

30.16.01 Physiologic Stability Index (PSI)

Overview:
The Physiologic Stability Index is an attempt to assess severity of acute illness in pediatric patients admitted to the ICU.

Physiologic Systems (7) and Variables (34)

• cardiovascular: systolic blood pressure, diastolic blood pressure, heart rate, cardiac index, C(a-v)O2, CVP, PCWP
• respiratory: respiratory rate, PaO2, PaO2/FIO2, PaCO2
• neurologic: Glasgow coma score, intracranial pressure, seizures, pupils
• hematologic: hemoglobin, WBC count, platelet count, PT/PTT, FSP
• renal: BUN, creatinine, urine output
• gastrointestinal: AST/ALT, amylase, total bilirubin, albumin
• metabolic: sodium, potassium, calcium, glucose, osmolality, pH, HCO3

Points for each variable
• 0, 1, 3, 5
• reflect clinical importance of derangement, with more abnormal having higher point value
• not intended to reflect magnitude of deviation from the normal value

Variable	0 points	1 points	3 points	5 points
systolic blood pressure in mm Hg • infants • children	 • 66-129 • 66-149	 • 55-65, or 130-160 • 65-75, or 150-200	 • 40-54, or > 160 • 50-74, or > 200	 • < 40 • < 50
diastolic blood pressure, in mm Hg	< 90	90-110	> 110	
heart rate, in beats per minute • infants • children	 • 91-159 • 81-149	 • 75-90, or 160-180 • 60-80, or 150-170	 • 50-74, or 181-220 • 40-59, or 171-200	 • < 50, or > 220 • < 40 or > 200
cardiac index, in L per min per square meter	> 3.0	2.0-3.0	1.0-1.9	< 1.0
arterial to mixed venous oxygen content difference, C(a-v)O2, in ml O2 per dL (vol%)	3.0-5.4	< 3.0, or 5.5-6.5	> 6.5	
CVP, in mm Hg	0-15	< 0, or > 15		
wedge pressure, or left atrial pressure, in mm Hg	5-14	< 5, or 15-25	> 25	
respiratory rate, in breaths per minute • infants • children	 • < 50 • < 30	 • 50-60 • 51-70	 • 61-90 • 51-70	 • > 90, apnea • > 70
PaO2, in mm Hg	> 50	50-60	40-49	< 40
PaO2/FIO2	> 300	200-300	< 200	

PaCO2 in mm Hg	**30-44**	**< 30, or 45-50**	**51-65**	**< 65**
pH	**7.31-7.54**	**7.20-7.30, or 7.55-7.65**	**7.10-7.19, or > 7.65**	**< 7.10**
Glasgow Coma Score	**> 11**	**8-11**	**5-7**	**< 5**
intracranial pressure, in mm Hg	**< 15**	**15-20**	**21-40**	**> 40**
seizures		**focal**	**grand mal or status epilepticus**	
pupils	**equal and responsive**	**equal and sluggish**	**unequal and sluggish**	**fixed and dilated**
hemoglobin, in g/dL	**7.1-17.9**	**5.0-7.0, or 18.0-22.0**	**3.0-5.0, or 22.1-25.0**	**< 3.0**
WBC count, per µL	**5,001 - 19,999**	**3,000-5,000, or 20,000 - 40,000**	**< 3,000, or > 40,000**	
platelet count, per µL	**51,000 - 999,999**	**20,000-50,000, or > 1 M**	**< 20,000**	
PT/PTT ratio, relative to normal control PT/PTT	**<= 1.5**	**> 1.5**		
fibrin split products in µg/mL	**<= 40**	**> 40**		
BUN, in mg/dL	**< 40**	**40-100**	**> 100**	
creatinine, in mg/dL	**< 2.0**	**2.0-10.0**	**> 10.0**	
urine output, in mL per kg per hour	**> 1.0**	**0.5-1.0**	**< 0.5**	
AST / ALT, in IU/L	**<= 100**	**> 100**		
amylase, in U/L	**<= 500**	**> 500**		
total bilirubin, in mg/dL	**<= 3.5**	**> 3.5**		
serum albumin, in g/dL	**> 2.0**	**1.2-2.0**	**< 1.2**	
sodium, in mEq/L	**126-149**	**115-125, or 150-160**	**< 115, or > 160**	
potassium, in mEq/L	**3.6-6.4**	**3.0-3.5, or 6.5-7.5**	**2.5-2.9, or 7.6-8.0**	**< 2.5, or > 8.0**
calcium, in mg/dL	**8.1-11.9**	**7.0-8.0, or 12.0-15.0**	**5.0=6.9, or > 15.0**	**< 5.0**
glucose, in mg/dL	**61-249**	**40-60, or 250-400**	**20-39, or > 400**	**< 20**
osmolality, in mOsm/L	**< 320**	**320-350**	**> 350**	
bicarbonate, in mEq/L	**16-32**	**< 16 or > 32**		

where

• infants are all those under 1 year of age; children are all those older than 1 year of age
• AST/ALT is taken to be the ratio of the transaminases
• hypoosmolality does not seem be included for evaluation

physiologic stability index =
= SUM (points for each physiologic variable)

Interpretation

Index scores
• minimum score 0
• maximum score 119
• higher scores indicate more severe disease

Scores compared
• on day of admission
• maximum score
• 4-day average
• trend over hospital course

Trends over hospital course
• decreasing indicates improvement
• increasing indicates worsening
• unchanging

probability of mortality =
= (EXP((0.277 * (4 day average PSI)) - 5.241)) / (1 + (EXP((0.277 * (4 day average PSI)) - 5.241)))

References:
Pollack MM, Yeh TS, et al. Evaluation of pediatric intensive care. Crit Care Med. 1984; 12: 376-383.
Pollack MM, Ruttimann UE, et al. Accurate prediction of the outcome of pediatric intensive care. N Eng J Med. 1987; 316: 134-139.
Yeh TS, Pollack MM, et al. Validation of a physiologic stability index for use in critically ill infants and children. Pediatric Res. 1984; 18: 445-451.

30.16.02 PSI/TISS Ratio

Overview:
The Physiologic Stability Index (PSI) measures severity of illness, while the Therapeutic Intervention Scoring System (TISS) measures quantity of care. The ratio of the two relates the level of physiologic instability to amount of therapy required. Analysis of the ratio over time can show differences not apparent by

analysis of the PSI or TISS alone. The ratio can be used to evaluate pediatric intensive care units.

The patients studied were classified by the Clinical Classification System:
- **Class III (physiologically stable, requires intensive nursing and monitoring)**
- **Class IV (physiologically unstable, requires intensive nursing and physician care, with frequent patient assessment and therapy adjustment)**

Admission service
- **medicine**
- **cardiovascular surgery**
- **non-cardiovascular surgery**

PSI/TISS ratio =
= (PSI) / (TISS)

Interpretation
- **Survivors tend to have lower ratios than nonsurvivors.**
- **Patients on the different services differ in the ratios seen, with highest ratios seen on medical services and lowest on the cardiovascular surgery service**

PSI/TISS ratio at admission	Survivors	Nonsurvivors
medicine	0.40 +/- 0.03	0.57 +/- 0.05
cardiovascular surgery	0.18 +/- 0.01	0.33 +/- 0.05
other surgery	0.33 +/- 0.04	0.52 +/- 0.10

When the ratio is plotted over time, the slope of the line correlates with survival or nonsurvival.

Trend analysis over time	Survivor	Nonsurvivor
PSI	negative slope	zero or positive slope (except cardiovascular surgery)
TISS	negative slope	zero or positive slope
PSI/TISS, medicine	zero slope	zero slope
PSI/TISS, cardiovascular surgery	positive slope	negative slope
PSI/TISS, non-cardiovascular surgery	negative slope	positive slope

References:
Pollack MM, Yeh TS, et al. Evaluation of pediatric intensive care. Crit Care Med. 1984; 12: 376-383.

30.17 PRISM Scores

30.17.01 Pediatric Risk of Mortality (PRISM) Score

Overview:
Pediatric risk of mortality (PRISM) score allows for mortality risk assessment in the pediatric ICU. It was developed from the Physiologic Stability Index (PSI), but is intended to be not only simpler but also more objective in its use of physiologic variables. It is institution independent and can be used within limits to compare different intensive care units.

Parameter	Age Limit	Ranges	Points
systolic blood pressure in mm Hg	infants	130-160	2
		55-65	2
		> 160	6
		40-54	6
		< 40	7
	children	150-200	2
		65-75	2
		> 200	6
		50-64	6
		< 50	7
diastolic blood pressure in mm Hg	all ages	> 110 mm Hg	6
heart rate in beats per minute	infants	> 160	4
		< 90	4
	children	> 150	4
		< 80	4
respiratory rate in breaths per minute	infants	61-90	1
		> 90	5
		apnea	5
	children	51-70	1
		> 70	5
		apnea	5
PaO2/FIO2	all ages	200-300	2
		< 200	3
PaCO2 in torr (mm Hg)	all ages	51-65	1
		> 65	5
Glasgow coma score	all ages	< 8	6
pupillary reactions	all ages	unequal or dilated	4
		fixed and	10

		dilated	
PT/PTT	all ages	1.5 times control	2
total bilirubin in mg/dL	> 1 month	> 3.5	6
potassium in mEq/L	all ages	3.0-3.5	1
		6.5-7.5	1
		< 3.0	5
		> 7.5	5
calcium in mg/dL	all ages	7.0-8.0	2
		12.0-15.0	2
		< 7.0	6
		> 15.0	6
glucose in mg/dL	all ages	40-60	4
		250-400	4
		< 40	8
		> 400	8
bicarbonate in mEq/L	all ages	< 16	3
		> 32	3

where:
• infants: 0-1 years of age

PRISM score =
= (systolic blood pressure points) + (diastolic blood pressure points) + (heart rate points) + (respiratory rate points) + (oxygenation points) + (glasgow coma score points) + (pupillary reaction points) + (coagulation points) + (bilirubin points) + (potassium points) + (calcium points) + (glucose points) + (bicarbonate points)

Interpretation
• maximum score 76, which is almost invariably associated with death
• minimum score 0, which has an excellent prognosis

Prediction of Mortality in ICU

R =
= (0.207 * (PRISM score)) - (0.005 * (age in months)) - (0.433 * (operative status)) - 4.782

where:
• operative status = 1 if postoperative or = 0 if nonoperative
• upper limit for age used in implementation will be 19th birthday

probability of mortality in the ICU =
= EXP(R) / (1 + EXP(R))

probability of survival from the ICU =
= 1 - (probability of mortality)

Assessment
• sensitivity: correct prediction of nonsurvival
• specificity: correct prediction of survival

Limitations:
• The PRISM score underpredicts deaths after cardiac surgery.

References:
Balakrishnan G, Aitchison T, et al. Prospective evaluation of the Pediatric Risk of Mortality (PRISM) score. Arch Dis Child. 1992; 67: 196-200.
Pollack MM, Ruttimann UE, et al. Accurate prediction of the outcome of pediatric intensive care. N Eng J Med. 1987; 316: 134-139.
Pollack MM, Ruttimann UE, Getson PR. Pediatric risk of mortality score. Crit Care Med. 1988; 16: 1110-1116.
Pollack MM. Chapter 199: Evaluating pediatric intensive care units. pages 1788-1792. IN: Ayres SM, et al. Textbook of Critical Care, Third Edition. W.B. Saunders Company. 1995.

30.17.02 Dynamic Objective Risk Assessment (DORA) Score

Overview:
The Dynamic Objective Risk Assessment (DORA) Score uses the PRISM scores for a patient's admission to predict the patient's risk of mortality in the next 24 hours.

If PRISM scores were determined upon admission and during the time in the ICU, then

DORA score =
= (0.154 * (PRISM score from previous day)) + (0.053 * (PRISM score on day of admission to ICU)) - (6.791)

On the second day in the ICU, the previous day and the day of admission are the same. The equation then is:

DORA score =
= (0.160 * (PRISM score on admission)) - (6.427)

probability of mortality within the next 24 hours =
= EXP(DORA score) / (1 + EXP(DORA score))

References:

Heard CMB, Fletcher JE, Papo MC. A report of the use of the Dynamic Objective Risk Assessment (DORA) score in the changing pediatric intensive care environment. Crit Care Med. 1998; 26: 1593-1595.
Ruttimann UE, Pollack MM. Objective assessment of the changing mortality risks in pediatric intensive care unit patients. Crit Care Med. 1991; 19: 474-483.

30.17.03 PRISM III Score

Overview:
The PRISM III score is an improved version of the PRISM score developed at the Children's National Medical Center in Washington, DC based on data collected at 32 pediatric intensive care units using 11,165 admissions.

Age groups recognized:
• neonate: 0 to < 1 month
• infant: 1 month to 12 months
• child: > 12 months to 144 months (12 years)
• adolescent: > 144 months (12 years)

Subscores:
(1) cardiovascular and neurologic vital signs: 5 measures
(2) acid-base and blood gas: 5 measures
(3) chemistry tests: 4 measures
(4) hematology tests: 3 measures (with PT and PTT counted as one)

Grading variables
• Use the highest and/or lowest values for scoring.

Cardiovascular and Neurologic Vital Signs	Findings	Points
systolic blood pressure	neonate AND > 55 mm Hg	0
	neonate AND 40 -55 mm Hg	3
	neonate AND < 40 mm Hg	7
	infant AND > 65 mm Hg	0
	infant AND 45 -65 mm Hg	3
	infant AND < 45 mm Hg	7
	child AND > 75 mm Hg	0
	child AND 55 -75 mm Hg	3
	child AND < 55 mm Hg	7
	adolescent AND > 85 mm Hg	0
	adolescent AND 65 -85 mm Hg	3
	adolescent AND < 65 mm Hg	7
heart rate	neonate AND < 215 beats/minute	0
	neonate AND 215 - 225 bpm	3
	neonate AND > 225 beats/minute	4

	infant AND < 215 beats/minute	**0**
	infant AND 215 - 225 bpm	**3**
	infant AND > 225 beats/minute	**4**
	child AND < 185 beats/minute	**0**
	child AND 185 - 205 bpm	**3**
	child AND > 205 beats/minute	**4**
	adolescent AND < 145 beats/minute	**0**
	adolescent AND 145 - 155 bpm	**3**
	adolescent AND > 155 beats/minute	**4**
temperature	**< 33°C**	**3**
	33 - 40°C	**0**
	> 40°C	**3**
mental status	**Glasgow coma score >= 8**	**0**
	Glasgow coma score < 8	**5**
pupillary response	**both reactive**	**0**
	1 reactive AND (1 fixed AND > 3 mm)	**7**
	both fixed AND both > 3 mm	**11**

where:

- **The heart rate should not be monitored during crying or iatrogenic agitation.**
- **Pupillary size should not be assessed after iatrogenic dilatation.**
- **Body temperature may be rectal, oral, axillary or blood.**
- **Mental status should not be scored within 2 hours of sedation, paralysis or anesthesia. If sedation, paralysis or anesthesia is continuous, score based status prior to sedation, paralysis or anesthesia.**

Acid-Base and Blood Gases	**Findings**	**Points**
acidosis	**pH > 7.28 AND total CO2 >= 17 mEq/L**	**0**
	(pH 7.0 - 7.28) OR (total CO2 5 - 16.9 mEq/L)	**2**
	pH < 7.0 OR total CO2 < 5	**6**
pH	**< 7.48**	**0**
	7.48 - 7.55	**2**
	> 7.55	**3**
PCO2	**< 50 mm Hg**	**0**
	50 - 75 mm Hg	**1**
	> 75 mm Hg	**3**
total CO2	**<= 34 mEq/L**	**0**
	> 34 mEq/L	**4**
PaO2	**>= 50 mm Hg**	**0**
	42.0 - 49.9 mm Hg	**3**
	< 42 mm Hg	**6**

where:
- **PaO2 requires arterial blood.**
- **PCO2 can be measured from arterial, venous or capillary specimens.**

Chemistry Tests	Findings	Points
glucose	<= 200 mg/dL	0
	> 200 mg/dL	2
potassium	<= 6.9 mEq/L	0
	> 6.9 mEq/L	3
creatinine	neonate AND <= 0.85 mg/dL	0
	neonate AND > 0.85 mg/dL	2
	infant AND <= 0.90 mg/dL	0
	infant AND > 0.90 mg/dL	2
	child AND <= 0.90 mg/dL	0
	child AND > 0.90 mg/dL	2
	adolescent AND <= 1.30mg/dL	0
	adolescent AND > 1.30 mg/dL	2
BUN	neonate AND <= 11.9 mg/dL	0
	neonate AND > 11.9 mg/dL	3
	not neonate AND <= 14.9 mg/dL	0
	not neonate AND > 14.9 mg/dL	3

where:
- **whole blood measurements for glucose are increased 10% over serum; for potassium 0.4 mEq/L**

Hematologic Tests	Findings	Points
white blood cell count	>= 3,000 per µL	0
	< 3,000 per µL	4
platelet count	> 200,000 per µL	0
	100,000 - 200,000 per µL	2
	50,000 - 99,999 per µL	4
	< 50,000 per µL	5
PT and PTT	neonate AND PT <= 21 seconds AND PTT <= 85 seconds	0
	neonate AND (PT > 22 seconds OR neonate and PTT > 85 seconds)	3
	not neonate AND PT <= 21 seconds AND PTT <= 57 seconds	0
	not neonate AND (PT > 22 seconds OR PTT > 57 seconds)	3

Other factors to document:
- **nonoperative cardiovascular disease**
- **chromosomal anomaly**

• cancer
• previous ICU admission during current admission
• pre-ICU CPR during current admission
• post-operative (not including catheterizations) during past 24 hours
• acute diabetes with ketoacidosis or other severe complication
• admission from inpatient unit (do not count if in ICU for < 2 hours or if transferred from surgical recovery room)

cardiovascular and neurologic subscore =
= (points for systolic pressure) + (points for temperature) + (points for mental status)+ (points for heart rate) + (points for pupillary reflex)

acid-base and blood gas subscore =
= (points for acidosis) + (points for pH) + (points for PaCO2)+ (points for total CO2) + (points for PaO2)

chemistry subscore =
= (points for glucose) + (points for potassium) + (points for creatinine)+ (points for blood urea nitrogen)

hematology subscore =
= (points for WBC count) + (points for platelet count) + (points for PT and PTT testing)

total PRISM III score =
= (cardiovascular and neurologic subscore) + (acid base and blood gas subscore) + (chemistry subscore)+ (hematology subscore)

Interpretation:
• minimum subscore and total score: 0
• maximum cardiovascular and neurologic subscore: 30
• maximum acid-base and blood gas subscore: 22
• maximum chemistry subscore: 10
• maximum hematology subscore: 12
• maximum total PRISM III score: 74
• The higher the total score, the worse the prognosis.
• A rising score indicates deterioration.
• If performed during the first 12 hours in the ICU, the score is designated PRISM-12.
• If performed during the first 24 hours in the ICU, it is designated PRISM-24.

Predictive equations
• Predictive equations for prognosis are available for the 12 hour and 24 hour scores.
• The equations for predicting prognosis from total score are patented and unpublished but can be obtained for research purposes from the authors.

References:
Pollack MM, Patel KM, Ruttimann UE. PRISM III: An updated Pediatric Risk of Mortality score. Crit Care Med. 1996; 24: 743-752.

30.18 Score for Neonatal Acute Physiology (SNAP)

30.18.01 Score for Neonatal Acute Physiology (SNAP) Determination

Overview:
The Score for Neonatal Acute Physiology (SNAP) is a illness severity measure which can be used to compare outcomes of care in different neonatal intensive care units. It scores the worst physiologic derangement in each organ system for the first 24 hours after admission to the NICU.

	1 point	3 point	5 point
mean blood pressure, maximum, in mm Hg	66-80	81-100	> 100
mean blood pressure, minimum, in mm Hg	30-35	20-29	< 20
heart rate, maximum, in beats per minute	180-200	201-250	> 250
heart rate, minimum, in beats per minute	80-90	40-79	< 40
respiratory rate, in breaths per minute	60-100	> 100	
temperature in °F	95-96	92-94.9	< 92
PaO2 in mm Hg	50-65	30-50	< 30
PaO2/FIO2, with FIO2 as a percent	2.5-3.5	0.3-2.49	< 0.3
PaCO2 in mm Hg	50-65	66-90	> 90
oxygenation index	0.07-0.20	0.21-0.40	> 0.40
hematocrit, maximum, as percent	66-70	> 70	
hematocrit, minimum, as percent	30-35	20-29	< 20
white blood cell count, per µL	2,000 - 5,000	< 2,000	
immature-to- total neutrophil ratio	> 0.21		
absolute neutrophil count (percent neutrophils * WBC)	500-999	< 500	
platelet count, per µL	30,000 - 100,000	< 30,000	
blood urea nitrogen, in mg/dL	40-80	> 80	
creatinine, in mg/dL	1.2-2.4	2.5-4.0	> 4.0
urine output in mL per kilogram per hour	0.5-0.9	0.1-0.49	< 0.1

indirect bilirubin in mg/dL if birthweight > 2 kg	**15-20**	**> 20**	
indirect bilirubin in mg/dL/kg if birthweight <= 2 kg	**5-10**	**> 10**	
direct bilirubin, in mg/dL	**>= 2.0**		
sodium, maximum, in mEq/L	**150-160**	**161-180**	**> 180**
sodium, minimum, in mEq/L	**120-130**	**< 120**	
potassium, maximum, in mEq/L	**6.6-7.5**	**7.6-9.0**	**> 9.0**
potassium, minimum, in mEq/L	**2.0-2.9**	**< 2.0**	
total calcium, maximum, in mg/dL	**>= 12**		
total calcium, minimum, in mg/dL	**5.0-6.9**	**< 5.0**	
ionized calcium, maximum, in mg/dL	**>= 1.4**		
ionized calcium, minimum, in mg/dL	**0.8-1.0**	**< 0.8**	
glucose, maximum, in mg/dL	**150-250**	**>= 250**	
glucose, minimum, in mg/dL	**30-40**	**< 30**	
serum bicarbonate, maximum, in mEq/L	**>= 33**		
serum bicarbonate, minimum, in mEq/L	**11-15**	**<= 10**	
serum pH	**7.20-7.30**	**7.10-7.19**	**< 7.10**
seizures	**single**	**multiple**	
apnea	**responsive to stimulation**	**unrespon-sive to stimulation**	**complete apnea**
stool guiac	**positive**		

where

- **mean blood pressure = ((systolic blood pressure) + (2 * (diastolic blood pressure))) / 3**
- **immature-to-total neutrophil ratio is the (summation of promyelocytes + myelocytes + metamyelocytes + bands-stabs) divided by (total neutrophils)**
- **for indirect bilirubin, only one value is entered based on body weight**
- **for total calcium and ionized calcium, only one value is returned for high or low (total and ionized "mutually exclusive")**
- **oxygenation index = ((mean airway pressure) * (FIO2) * 100) / (PaO2)**

Limitations

- **The immature-to-total neutrophil ratio assumes that the findings are consequent to a left shift in neutrophilia and that there is no leukemia.**

Interpretation

- **maximum score 127 (16 at 5 points, 14 at 3 points, and 5 at 1 point)**
- **since 9 of the parameters involve high range (total 29) and low range (total 33), and since most patients will normally meet one of these extremes, the practical maximum score is around 103 (maximum value for each parameter pair)**

References:

Gray JE, Richardson DK, et al. Score for Neonatal Acute Physiology (SNAP) and risk of intraventricular hemorrhage (abstract). Ped Research. 1992; 31: 249A.

Richardson DK, Gray JE, et al. Score for Neonatal Acute Physiology: A physiologic severity index for neonatal intensive care. Pediatrics. 1993; 91: 617-623.

Richardson DK, Phibbs CS, et al. Birth weight and illness severity: Independent predictors of neonatal mortality. Pediatrics. 1993; 91: 969-975.

Rodwell RL, Leslie AL, Tudehope DI. Early diagnosis of neonatal sepsis using a hematologic scoring system. J Pediatr. 1988; 112: 761-767.

Samaik AP, Meert KL, et al. Predicting outcome in children with severe acute respiratory failure with high-frequency ventilation. Crit Care Med. 1996; 24: 1396-1402.

Seebach JD, Morant R, et al. The diagnostic value of the neutrophil left shift in predicting inflammatory and infectious disease. Am J Clin Pathol. 1997; 107: 582-591.

30.18.02 Score for Neonatal Acute Physiology Perinatal Extension (SNAP-PE)

Overview:

The Score for Neonatal Acute Physiology Perinatal Extension (SNAP-PE) extends the SNAP score by the addition of birthweight and Apgar score information.

Parameter	Finding	Points
SNAP score for 1st 24 hours after NICU admit		SNAP score
birthweight	< 749 grams	30
	750-999 grams	10
	>= 1000 grams	0
Apgar score at 5 minutes	< 7	10
	> = 7	0
small for gestational age	< 5th%	5
	> 5th%	0

Bodyweight Small for Gestional Age

equation for determining if small for gestational age

weight at 5th% for body weight =
= (-0.06217 * ((week gestation) ^ 4)) + (7.585979 * ((week gestation) ^ 3)) - (337.3942 * ((week gestation) ^ 2)) + (6583.4774 * (week gestation)) - 47312.4

where
• week of gestation is weeks since last menstrual period

NOTE: This equation is for Caucasian infants. Equations for other races will be needed.

Mortality Based on SNAP-PE Information

SNAP-PE	mortality, all birth weights	mortality with birthweight <1500 grams	mortality with birthweight >= 1500 grams
0-9	0%	0%	0%
10-19	1.2%	0.9%	1.3%
20-29	12%	14%	11%
30-39	35%	38%	32%
40-49	52%	52%	50%
50-59	47%	44%	100% (N=1)
60-69	63%	63%	
>= 70	75%	75%	

References:
Richardson DK, Gray JE, et al. Score for Neonatal Acute Physiology: A physiologic severity index for neonatal intensive care. Pediatrics. 1993; 91: 617-623.
Richardson DK, Phibbs CS, et al. Birth weight and illness severity: Independent predictors of neonatal mortality. Pediatrics. 1993; 91: 969-975.
Usher R, McLean F. Intrauterine growth of live-born Caucasian infants at sea level: Standards obtained from measurements in 7 dimensions of infants born between 25 and 44 weeks of gestation. J Pediatrics. 1969; 74: 901-910.

30.18.03 SNAP and Mortality Risk

Overview:
From the SNAP score and data incluced in the Perinatal Extension, it is possible to calculate the expected mortality risk for neonates in the NICU.

logit =
= -14.6889 +
(8.6774 * (1/ (birthweight in kilograms))) +
(1.4414 * (1 if Apgar at 5 minutes < 7, 0 if Apgar >= 7) +
(1.0898 * (1 if <5th% for gestational age, 0 if >= 5th% for gestational age) +
(0.7422 * (SNAP) * (1 if SNAP <= 15, 0 if SNAP > 15)) +
(0.6251 * (SNAP) * (1 if SNAP >= 16 and <=20, 0 if SNAP < 16 or > 20)) +
(0.4674 * (SNAP) * (1 if SNAP >= 21 and <=27, 0 if SNAP < 21 or > 27)) +
(0.4073 * (SNAP) * (1 if SNAP >= 28, 0 if SNAP < 28)) -
(0.5429 * (SNAP/birthweight) * (1 if SNAP <= 15, 0 if SNAP > 15)) -

(0.4088 * (SNAP/birthweight) * (1 if SNAP >= 16 and <=20, 0 if SNAP < 16 or > 20)) -
(0.2809 * (SNAP/birthweight) * (1 if SNAP >= 21 and <=27, 0 if SNAP < 21 or > 27)) -
(0.2399 * (SNAP/birthweight) * (1 if SNAP >= 28, 0 if SNAP < 28))

risk of mortality =
= EXP(logit) / (1 + EXP(logit))

chance for survival =
= 1 - (risk of mortality)

References:

Richardson DK, Gray JE, et al. Score for Neonatal Acute Physiology: A physiologic severity index for neonatal intensive care. Pediatrics. 1993; 91: 617-623.
Richardson DK, Phibbs CS, et al. Birth weight and illness severity: Independent predictors of neonatal mortality. Pediatrics. 1993; 91: 969-975.

30.19 Acute Physiologic Score for Children (APSC)

Overview:
The Acute Physiologic Score for Children (APSC) can be used to clinically evaluate critically ill infants and children.

Scoring
- **The APSC is based on a scale of 0-4 with a more abnormal result given a higher point value.**
- **Points are assigned for physiologic, chronic health and operative status.**
- **The physiologic status uses 17 variables to cover 7 organ systems.**
- **The APSC is calculated at admission, and then 24, 48, and 96 hours after admission to the instensive care unit**

Data Collection
- **The most abnormal recorded value in each parameter within the first 4 hours after admission is used for the admission calculation.**
- **The most abnormal recorded value in each parameter during the 24 hours is used for the 24, 48 and 96 hour calculations.**

Physiologic Points

		Points				
Parameter	**Age**	**0**	**1**	**2**	**3**	**4**
temperature in °C		**36.0 - 38.4**	**34.0-35.9; 38.5-38.9**	**32.0-33.9**	**30.0-31.9; 39.0-41**	**< 30; > 41**
heart rate per	**< 1 mo**	**100-180**		**80-99;**	**60-79;**	**< 60;**

minute				**181-200**	**201-220**	**> 220**
	< 1 year	**80-160**		**65-79; 161-180**	**50-64; 181-200**	**< 50; > 200**
	1-5 yr	**75-130**		**60-74; 131-160**	**45-59; 161-190**	**< 45; > 190**
	> 5 yr	**70-120**		**55-69; 121-150**	**40-54; 151-180**	**< 40; > 180**
systolic blood pressure in mm Hg	**< 1 mo**	**50-100**		**35-49; 101-120**		**< 35; > 120**
	< 1 year	**60-120**		**45-59; 121-150**		**< 45; > 150**
	1-5 yr	**70-140**		**50-69; 141-160**		**<50; > 160**
	> 5 yr	**75-150**		**55-74; 151-180**		**< 55; > 180**
respiratory rate	**< 1 mo**	**40-60**	**21-39; 61-75**	**15-20**	**76-100**	**< 15; > 100**
	< 1 year	**25-40**	**16-24; 41-65**	**12-15**	**66-90**	**< 12; > 90**
	1-5 yr	**20-30**	**16-19; 31-50**	**10-15**	**51-75**	**< 10; > 75**
	> 5 yr	**15-25**	**11-14; 26-40**	**8-10**	**41-65**	**< 8; > 65**
CPAP or ventilation						**Yes**
(PaO2 in mm Hg) / FIO2			**200- 249**	**150-199**	**100-149**	**< 100**
urine output in mL/kg/h		**1.0-2.0**	**0.5 - 0.99; 2.01-3.0**	**0.3-0.49; > 3.0**	**0.15-0.29**	**< 0.15**
serum creatinine in mg/dL		**< 1.0**	**1.0-1.5**	**1.51-2.0**	**2.01-3.5**	**> 3.5**
bilirubin in mg/dL		**< 1.0**	**1.0-2.0**	**2.01-3.0**	**3.01-5.0**	**> 5.0**
serum sodium in mEq/L		**130-150**	**151-155**	**120-129; 156-160**	**110-119; 161-180**	**< 110; > 180**
serum potassium in mEq/L		**3.5-5.5**	**3.0-3.49; 5.51-6.0**	**2.5-2.99**	**6.01-7.0**	**< 2.5; > 7.0**
blood glucose in mg/dL		**70-200**	**50-69; 201-350**	**30-49; 351-500**	**501-800**	**< 30; > 800**
arterial pH		**7.33-7.50**	**7.51-7.6**	**7.25-7.32**	**7.15-7.24; 7.61-7.7**	**< 7.15; > 7.70**

hematocrit in percent		30-45	25-29; 46-50	20-24; 51-60		< 20; > 60
	1 week	30-45	25-29; 46-50	20-24; 51-70		< 20; > 70
leukocytes in 1000/µL		3.0-15.0	15.1-20.0	1.0-2.9; 20.1-40		< 1; > 40
platelets in 1000/µL		100-400	50-99; 400-1000	20-49; > 1000	5-19	< 5
Glasgow coma score		13-15	10-12	7-9	4-6	3

where

- **data for scoring respiratory rates in the following groups was absent in the source reference (< 1 month, 21-39; < 1 year, 16-24; 1-5 years, 16-19; > 5 years, 11-14); data assigned based on gaps in existing data in table**
- **data for scoring hematocrit scores at 1 week of age sketchy in reference**
- **data for scoring platelet counts from 400,000-1,000,000 absent in source reference; value used inferred**

Chronic Health Care Points

Organ	Condition	Points
cardiovascular	chronic heart failure on anticongestive therapy	1
respiratory	chronic obstructive or restrictive lung disease with exercise restriction	1
renal	receiving chronic dialysis	1
liver	liver cirrhosis	1
hematology-immunology	patients with congenital or acquired immunosuppression; tumor patients	1

Operative Status Points

	Points
emergency post-operative patients	5
elective post-operative patients	2

Calculation

acute physiologic score for children =
= (physiologic points) + (chronic health care points) + (operative status points)

Interpretation

- **nonsurvivors tended to have higher APSC scores on admission than survivors**

References:

Zobel G, Kuttnig M, et al. Evaluation of clinical scoring systems in critically ill infants and children. Clin Intens Care. 1990; 1: 202-206.

30.20 Prediction of Seizures in ICU Patients with Gram-negative Infections

Overview:
The risk for developing seizures in Intensive Care Unit (ICU) patients with Gram-negative infections can be estimated using an additive predictive risk index.

Population
- **ICU patients with serious Gram-negative infections**
- **seizures were divided into early onset (within 48 hours of ICU admission) and late onset**

Derivation of clinical risk score
- **factors identified by multiple logistic regression**
- **the weight assigned is based on rounding the regression coefficient to the nearest integer**

History	Factor	Weight
history before admission	prior history of seizures	2
	any previous or current CNS tumors	4
concurrent factors before onset of seizure	acute stroke, intracranial hemorrhage, CNS surgery or CNS infection during or within 1 month before hospitalization	3
	coma or anoxic encephalopathy while in the ICU	1
	renal impairment (serum creatinine > 1.6 mg/dL, or dialysis)	2
	acute hypotensive episode while in the ICU	1

clinical risk score =
= SUM(weights present)

Interpretation
- **minimum clinical risk score = 0**
- **maximum clinical risk score = 13**
- **clinical risk score <=2 indicates low risk for seizures**
- **clinical risk score >= 3 indicates a high risk for seizures**

References:
Guess HA, Resseguie LJ, et al. Factors predictive of seizures among intensive care unit patients with Gram-negative infections. Epilepsia. 1990; 31: 567-573.

30.21 A 24 Hour ICU Point System for Prediction of Outcome in Trauma Patients

Overview:
A 24 hour point system for trauma patients in the Intensive Care Unit (ICU) can be used to predict outcome.

Parameters
(1) neurologic (brain injury and Glasgow Coma Scale)
(2) pulmonary (ventilation and PaO2/FIO2 index)
(3) cardiovascular (24 hour fluid balance)

Parameter	Finding	Points
neurologic	no brain injury	0
	brain injury and Glasgow Coma Scale 13-15	0
	brain injury and Glasgow Coma Scale 9-12	1
	brain injury and Glasgow Coma Scale 6-8	2
	brain injury and Glasgow Coma Scale 4-5	3
	brain injury and Glasgow Coma Scale 3	4
pulmonary	extubated	0
	intubated with PaO2/FIO2 >= 325	0
	intubated with PaO2/FIO2 225-324	1
	intubated with PaO2/FIO2 175-224	2
	intubated with PaO2/FIO2 125-174	3
	intubated with PaO2/FIO2 < 125	4
cardiovascular (24 hour ICU fluid balance)	fluid balance < 3 L	0
	fluid balance >= 3 L	4

24 hour ICU score =
= (neurologic points) + (pulmonary points) + (cardiovascular points)

Interpretation
• minimum score 0
• maximum score 12
• The higher the score, the worse the prognosis.

24 hour ICU score	estimated mortality
0-1	2%
2-3	18%
4-5	22%
6-7	32%

8-9	84%
10-11	96%
12	98%

(after Figure 2, page 493)

Probability of Mortality

regression equation =
= (-3.900) + (0.911 * (neurologic points)) + (0.588 * (pulmonary points)) + (0.468 * (cardiovascular points))

probability of death =
= 1 / (1 + EXP ((-1) * (regression equation)))

NOTE: In the paper the equation is given as (page 492):

probability of death = 1 - (probability equation above)

but when data is applied, this gives results hard to understand. For example, a patient with no brain injury, intubated with an index > 325 and fluid balance < 3 liters (all scores 0) would have a survival rate of 2% and mortality rate of 98%, which seems the opposite of the intuitive prediction.

References:
Vassar MJ, Wilerson CL, et al. Comparison of APACHE II, TRISS, and a proposed 24-hour ICU point system for prediction of outcome in ICU trauma patients. J Trauma. 1992; 32: 490-500.

30.22 Hypotension Score for Predicting Outcome in Critically Ill Patients with Unexplained Hypotension

Overview:
The Hypotension Score can be used to predict the mortality rate for critically ill patients with sustained, unexplained hypotension.

Patient population
• 101 adults admitted to the ICU of an academic medical center (UCSF)
• hypotension lasting > 60 minutes which was unexplained

Parameters
(1) number of days from time of admission to onset of hypotension
(2) APACHE II score at the onset of hypotension
(3) reason for hospital admission

hypotension score =

= (number of days from hospital admission to onset of hypotension) + (1.5 * (APACHE II score)) + (20 * (admission value))

where
• admission value = 0 if admitted for surgery or for treatment of malignancy, else 1

Interpretation
• The values can range widely depending on the number of days and the APACHE II scores (range of values 0 to 71).
• minimum score: theoretically 0
• maximum score: dependent on number of days. It could be 156 for a 30 day interval, which would be a relatively long admission by today's standards.

Hypotension Score	Mortality Rate
< 40	7%
40 - 64	70%
>= 65	92%

References:
Heidenreich PA, Foster E, Cohen NH. Prediction of outcome for critically ill patients with unexplained hypotension. Crit Care Med. 1996; 24: 1835-1840.

30.23 Predictors of Early After-Discharge Mortality in ICU Patients

Overview:
Patients discharged from the intensive care unit (ICU) can have a high early after-discharge mortality (EADM). Latour et al developed an equation which can be used to identify a group of patients at high risk (21-46%) for early death after discharge from the ICU.

Population
• 700 patients older than 14 years discharged from ICUs at 3 hospitals in Valencia, Spain, during the period of January 1986 to May 1987.

Parameters found predictive of outcome
(1) age
(2) days in the ICU
(3) number of organ system failures
(4) SAPS score in the first hour after admission to the ICU

Parameter	beta	Finding	Value
age	-0.633	<= 65	- 1
		>= 66	+ 1
days in ICU	-0.415	<= 9	- 1
		>= 10	+ 1
organ system failure	-0.423	none	- 1

		>= 1	+ 1
SAPS	-0.822	<= 10	- 1
		>= 11	+ 1

X =
= 2.08 - (0.822 * (SAPS value)) - (0.423 * (organ system failure value)) - (0.415 * (days in ICU value)) - (0.633 * (age value))

probability of early death within 2 months after discharge from the ICU =
= 1 / (1 + EXP(X))

Interpretation
- **The minimum mortality rate is about 1% with all favorable parameters.**
- **The maximum mortality rate is about 56% with all unfavorable parameters.**
- **The authors found that the equation was not suitable to make predictions in the individual patient since the variables had a low predictive value. However, it did allow identification of a high risk group of patients who might benefit from more intensive care.**
- **Patients with an initial SAPs score >= 11 had a 6-fold greater risk of dying in the immediate post-ICU period than those with a score <= 10.**

Note: On page 126, ln (p / (1 - p)) = X. If this is rearranged, p = 1 / (1 + EXP(-X)), not 1 / (1 + EXP(X)) as given. Since (1 / (1 + EXP(-X))) + (1 / (1 + EXP(X))) = 1, one value is the probability of death and the other is the probability of survival. I have elected to go with the example given at the bottom of the page.

References:
Latour J, Lopez-Camps V, et al. Predictors of death following ICU discharge. Intensive Care Med. 1990; 16: 125-127.

30.24 Multiple Organ System Failure Score of Tran et al

Overview:
Tran et al developed a scoring system for multiple organ failure developing in patients receiving intensive care.

Organ systems: 7 evaluated
(1) cardiovascular
(2) pulmonary
(3) renal
(4) hepatic
(5) hematologic
(6) gastrointestinal
(7) neurologic

Organ System	Finding	Score

cardiovascular	**• mean arterial pressure > 70 mm Hg • heart rate > 70 beats per minute**	**0**
	• mean arterial pressure 51-70 mm Hg • heart rate 51 - 70 beats per minute • ventricular tachycardia	**1**
	• mean arterial pressure <= 50 mm Hg • heart rate <= 50 beats per minute • need for inotropic agents • ventricular fibrillation • cardiac arrest • acute myocardial infarction	**2**
pulmonary	**• PEEP <= 4 cm H2O • FIO2 <= 0.3 • respiratory rate 12-24 per minute**	**0**
	• PEEP 5 - 9 cm H2O • FIO2 > 0.3 and <= 0.4 • respiratory rate 6-11 per minute, or 25-49 per minute	**1**
	• PEEP >= 10 cm H2O • FIO2 > 0.4 • respiratory rate <= 5 per minute or >= 50 per minute	**2**
renal	**serum creatinine <= 2.0 mg/dL**	**0**
	serum creatinine > 2.0 and <= 3.5 mg/dL	**1**
	• serum creatinine > 3.5 mg/dL • chronic renal insufficiency • acute renal replacement therapy	**2**
hepatic	**• bilirubin <= 2.0 mg/dL • AST <= 25 U/L**	**0**
	• bilirubin > 2.0 and <= 3.0 mg/dL • AST > 25 and <= 50 U/L	**1**
	• bilirubin > 3.0 mg/dL • AST > 50 U/L • hepatic encephalopathy	**2**
hematologic	**• hematocrit >= 30% • WBC count >= 3,000 per µL • platelet count > 100,000 per µL**	**0**
	• hematocrit 21-29% • WBC count 290 - 3,000 per µL • platelet count 51,000 - 100,000 per µL	**1**
	• hematocrit <= 20% • WBC count < 300 per µL • platelet count <= 50,000 per µL • DIC	**2**
gastrointestinal	**normal functioning**	**0**

	• acalculous cholecystitis; • stress ulcer not requiring blood transfusion	1
	• bleeding from stress ulcer requiring > 2 units of blood in 24 hours; • necrotizing colitis; • necrotizing pancreatitis; • perforation of viscus or gallbladder	2
neurologic	Glasgow coma score 13-15	0
	Glasgow coma score 7-12	1
	Glasgow coma score <= 6	2

(Table I, page 22)

where
• mean arterial pressure = ((2 * (diastolic pressure)) + (systolic pressure)) / 3
• "acute renal replacement therapy" I infer to mean dialysis
• The WBC count entry in original tables says that a score of 2 is assigned if the WBC <= 3,000 per µL, which overlaps with the assignment for a score of 1.

MOSF score =
= SUM(score for all 7 organ systems)

Interpretation
• minimum score: 0
• maximum score: 14
• The higher the MOSF score, the higher the mortality rate.

According to Figure 4, page 28:

estimated mortality in percent =
= (8.18 * (MOSF score)) - 18.86

References:
Tran DD, Cuesta MA, et al. Risk factors for multiple organ system failure and death in critically injured patients. Surgery. 1993; 114: 21-30.

30.25 Nine Equivalents of Nursing Manpower Use Score

Overview:
The Nine Equivalents of Nursing Manpower Use Score (NEMS) is a simplified version of the TISS-28 which can be used in the intensive care unit (ICU) to measure nursing workload. Its development was supported by the Foundation for Research on Intensive Care in Europe and tested in the ICUs of 11 European countries.

No.	Item	Points
1	basic monitoring (hourly vital signs, regular record	9

	and calculation of fluid balance)	
2	**intravenous medications (bolus or continuous infusion, not including vasoactive drugs)**	**6**
3	**mechanical ventilatory support (any form of mechanical or assisted ventilation, with or without PEEP, with or without muscle relaxants)**	**12**
4	**supplementary ventilatory care (breathing spontaneously through endotracheal tube, supplemental oxygen by any method, excludes mechanical ventilatory support)**	**3**
5	**single vasoactive medication: any vasoactive drug**	**7**
6	**multiple vasoactive medications: more than one vasoactive drug, regardless of type and dose**	**12**
7	**dialysis techniques: all**	**6**
8	**specific interventions in the ICU (endotracheal intubation, pacemaker insertion, cardioversion, endoscopy, gastric lavage, emergency operation in the past 24 hours)**	**5**
9	**specific interventions outside of the ICU (surgical operations, diagnostic procedures)**	**6**

from Table 2, page 762

where
- **points are derived from rounding the calculated B coefficients**
- **PEEP = continuous positive airway pressure**
- **specific interventions in the ICU does not include routine interventions such as X-rays. echocardiography, electrocardiography, dressing changes, introduction of venous or arterial lines**
- **specific interventions outside of the ICU are related to the severity of illness of the patient and makes an extra demand upon manpower efforts in the ICU**

NEMS =
= SUM(points for items utilized)

Notes on scoring:
(1) The following appear to be mutually exclusive: 3 and 4, 5 and 6
(2) One option would be to score items 8 and 9 for each occurrence; however, based on Figure 1 page 763 the maximum NEMS score does not appear to exceed 56, which it would if each occurrence were scored

Interpretation
- **minimum score: 0**
- **maximum score (based on the interpretations above): 56**

The NEMS correlates with the TISS-28 (see Figure 1, page 763):

estimated NEMS based on TISS-28 =
= 6.7 + (0.76 * (TISS-28 score))

This can be rewritten:

estimated TISS-28 score =
= ((NEMS) - 6.7) * 1.316

References:
Miranda DR, Moreno R, Iapichino G. Nine equivalents of nursing manpower use score (NEMS). Intensive Care Medicine. 1997; 23: 760-765.

30.26 Transfer of Critically Ill Patients

30.26.01 Prediction of Respiratory Deterioration After Transfer in Critically Ill Patients

Overview:
The transfer of a critically ill patient on mechanical ventilation may be followed by respiratory deterioration. The ability to predict which patients are at risk for respiratory deterioration may help in the decisions for when and how to transfer the patient.

Population
- **98 patients at a teaching hospital in Hannover, Germany**
- **patients were 16-89 years of age (mean 46)**
- **all on mechanical ventilation**
- **respiratory deterioration after transfer indicated by a significant decrease in the PaO2-to-FIO2 ratio,**

Respiratory deterioration was predicted if either of the following was present (Table 4, page 1160)
(1) age > 43 years
(2) FIO2 > 50%

Performance
- **identified 20 of 22 patients who showed respiratory deterioration (sensitivity 91%)**
- **specificity 65%**

References:
Marx G, Vangerow B, et al. Predictors of respiratory function deterioration after transfer of critically ill patients. Intensive Care Medicine. 1998; 24: 1157-1162.

30.26.02 The Rapid Acute Physiology Score (RAPS)

Overview:

The Rapid Acute Physiology Score (RAPS) is a severity scale which can be used to assess patients being transported between intensive care units. This is a simplified version of the Acute Physiology and Chronic Health Evaluation (APACHE II) score.

Parameters
(1) mean arterial pressure
(2) heart rate
(3) respiratory rate
(4) Glasgow coma score

Parameter	Finding	Points
mean arterial pressure	<= 49	+4
	50 - 69	+2
	70 - 109	0
	110 - 129	+2
	130 - 159	+3
	>= 160	+4
heart rate	<= 39	+4
	40 - 54	+3
	55 - 69	+2
	70 - 109	0
	110 - 139	+2
	140 - 179	+3
	>= 180	+4
respiratory rate	<= 5	+4
	6 - 9	+2
	10 - 11	+1
	12 - 24	0
	25 - 34	+1
	35 - 49	+3
	>= 50	+4
Glasgow coma score	14 or 15	0
	11, 12 or 13	+1
	8, 9 or 10	+2
	5, 6 or 7	+3
	3 or 4	+4

where:
- **mean arterial pressure = ((2* (diastolic pressure)) + (systolic pressure)) / 3**
- **The respiratory rate is either (1) the spontaneous respiratory rate or (2) the ventilated rate if not spontaneous**

RAPS =
= SUM(points for the 4 parameters)

Interpretation:
• minimum score: 0
• maximum score: 16

RAPS	Percent Survival
0	96%
1	94%
2	92%
3	89%
4	83%
5	77%
6	69%
7	58%
8	50%
9	38%
10	29%
11	22%
12	15%
13	10%
14	7%
15	5%
16	3%

from Figure 3, page 260.

References:
Rhee KJ, Fisher CJ Jr, Willitis NH. The Rapid Acute Physiology Score. Am J Emerg Med. 1987; 5: 278-286.

30.27 Hannover Intensive Score (HIS)

Overview:
The Hannover Intensive Score can be used to assess patients in the intensive care unit (ICU). This can help identify those patients who might benefit from more aggressive therapy, and it can be used to compare outcomes between different institutions.

NOTE: This is based on my translation from the German. I did not have a medical dictionary at the time of translation, so some nuances may have been lost as well as some outright errors introduced.

Patient population
• I believe this applies to adults and not neonates or small children.
• The score was developed in a large series of patients admitted to an ICU at an academic center in Hannover, Germany.

Evaluation can be performed on the first day in the ICU, after 1 week, and after 2 weeks.

Major functions assessed to derive score
(1) immunologic and hematologic: temperature, WBC count, platelet count
(2) cerebral: level of consciousness, Glasgow Coma Score
(3) gastrointestinal: intestinal status, liver function, prothrombin time (Quick test), PTT, antithrombin III level, blood glucose
(4) cardiovascular: Shock Index, pulse, arrhythmias
(5) renal: creatinine clearance, serum creatinine, urea or BUN, urine output, serum potassium
(6) respiratory: ventilatory status, use of PEEP or CPAP, FIO2

Parameter	Finding	Points	Supple-mental
temperature (°C)	< 34.0	2	
	34.0 - 36.4	1	
	36.5 - 38.4°C	0	
	38.5 - 38.9	1	
	39.0 - 40.9	2	
	>= 41	3	
	positive blood culture		+1
WBC	< 3,000 per µL	2	
	3,000 - 14,900	0	
	15,000 - 19,900	1	
	20,000 - 29,900	2	
	>= 30,000	3	
platelet count	< 120,000 per µL		+1
CNS	conscious, responds to verbal commands	0	
	responds to pain but does not responds to verbal commands	1	
	does not respond to pain	2	
	no reaction to pain, pupils do not react to light	3	
	positive Babinski, convulsions, disturbances of central regulatory functions		+1
Glasgow coma score	13 - 15	0	
	7 - 12	1	
	4 - 6	2	
	3	3	
Intestine function	normal	0	
	partial ileus	1	

	ileus	**2**	
	operation needed due to ileus; GI tract bleeding	**3**	
	anastomosis insufficiency; bowel perforation		**+1**
liver function	**normal**	**0**	
	SGOT, SGPT > 200 U bilirubin >= 1.1 mg/dL amylase > 500 U	**1**	
	SGOT, SGPT > 1000 U evidence of cirrhosis jaundice	**2**	
Quick test (%)	**>= 50%**	**0**	
	20 - < 50%	**1**	
	< 20%	**2**	
	consumptive coagulopathy (DIC)		**+1**
PTT in seconds	**<= 60 seconds**	**0**	
	> 60 seconds	**1**	
antithrombin III in percent	**>= 70%**	**0**	
	< 70%	**1**	
	coagulation factor replacement therapy		**+1**
glucose in mmol/L	**< 2 mmol/L**		**+1**
	> 30 mmol/L		**+1**
shock index	**<= 0.85**	**0**	
	0.86 - 0.99	**1**	
	1.0 - 1.2	**2**	
	> 1.2	**3**	
	resuscitation performed		**+1**
pulse in beats/minute	**< 40**	**3**	
	40 - 110	**0**	
	111 - 140	**1**	
	141 - 180	**2**	
	> 180	**3**	
	dopamine > 200 mg/day or catecholamines		**+1**
heart rhythm	**ventricular tachycardia; supraventricular tachycardia; atrial arrhythmias; antiarrhythmic agents**		**+1**
creatinine clearance	**>= 100 mL/min**	**0**	
	50 - 99 mL/min	**1**	

	< 50 mL/min	2	
	dialysis	3	
serum creatinine	< 2.3 mg/dL	0	
	2.3 - 4.4 mg/dL	1	
	4.5 - 7.8 mg/dL	2	
	>= 7.9 mg/dL	3	
"urea" (see below)	20 - 39 mg/dL	0	
	>= 40 mg/dL	1	
urine output	patient receiving diuretics	1	
	oliguria	2	
	polyuria	2	
	uremia	3	
	anuria	3	
	gross hematuria		+1
serum potassium	<= 6 mEq/L	0	
	> 6 mEq/L	3	
respiration	spontaneous without assistance	0	
	spontaneous breathing with assistance	1	
	mechanical ventilation	2	
	pneumothorax or thoracic drainage		+1
PEEP/CPAP	none	0	
	<= 10 cm H2O	1	
	> 10 cm H2O	2	
FIO2	0.21	0	
	0.22 - 0.40	1	
	0.41 - 0.60	2	
	> 0.60	3	

where:

- **I translated Streckkrampfe and Zerebr. Krampfe as seizures**
- **I translated Platzbauch as "bowel perforation"**
- **shock index = (heart rate) / (systolic blood pressure)**
- **I translated "VES" as "ventricular tachycardia"**
- **urea vs BUN: I believe "serumharnstoff" translates to urea, but when looking at the point assignment, values for BUN made more sense than values for urea (the value I got for BUN correspondint to a urea of 40 mg/dL was pretty low), Only 1 point is assigned for this, so a small error seemed acceptable. For serious usage, this needs to be checked.**
- **The use of values for SGOT, SGPT, bilirubin and amylase without knowing the reference range could introduce error, but the breakpoints seem to handle minor variations between institutions. If this system is to be seriously used, then finding the reference ranges used at Hannover would be indicated.**

• The Quick test is the prothrombin time. The percent is read from a graph correlating prothrombin time vs the percent dilution of normal plasma (viz, a PT of 45 seconds is seen at an X% of normal plasma) .

HIS =
= SUM(points for parameters present)

Interpretation
• minimum score: 0
• maximum score: 60
• The performance of HIS was found comparable to Apache II and TISS. It may be better for predicting outcome during longer admissions.

HIS Score	Mortality Rate
0-1	2%
2-3	5%
4-5	12%
6-7	25%
8-9	28%
10-11	36%
12-13	33%
14-15	55%
> 15	72%

approximated from Table 2, page 530, von Bierbrauer 1998

Limitations
• Correlations between score and mortality rate will be affected by improved technologies.

Implementation Notes
• When more than one item is present (in liver function tests, supplemental scores for CNS function, etc.) the options are to add one point if any one of the findings is present (OR function), or to add one point for each finding present (AND function). I have opted for the OR approach.

References:
Lehmkuhl P, Lips U, Pichlmayr I. Der Hannover Intensiv Score (HIS) als neues Klassifikationssystem zu Verlaufskontrollen und Prognosestellung bei Intensivpatienten. Medizinische Klinik. 1986; 81: 235-240.
von Bierbrauer A, Burchardt C, et al. Die Aussagekraft der Hannover Intensiv Score (HIS) in der internistischen Intensivmedizin. Medizinische Klinik. 1998; 93: 524-532.

30.28 The Abdominal Compartment Syndrome

Overview:

The abdominal compartment syndrome occurs when raised intra-abdominal pressure is associated with signs of organ failure in critically ill patients.

Settings:
(1) after abdominal surgery
(2) in injured patients, with or without abdominal trauma
(3) critically ill patients, including patients with burns, sepsis or ascites

Criteria for the diagnosis of the abdominal compartment syndrome:
(1) elevated intra-abdominal pressure (>= 25 mm Hg)
(2) one or more of the following, indicating organ damage
- **oliguria**
- **raised pulmonary pressure**
- **hypoxia**
- **decreased cardiac output**
- **hypotension**
- **acidosis**

(3) abdominal decompression results in clinical improvement

where:
- **Pressure in the urinary bladder correlates with the actual intra-abdominal pressure over the pressure range of 5-70 mm Hg. It can be measured with the patient in the supine position, a Foley catheter in the bladder and a water pressure manometer held at the level of the symphysis pubis (Meldrum et al, 1997).**

Complications:
(1) failure in one or more organs (heart. lung, kidneys)
(2) breakdown of surgical sites
(3) impaired blood flow with decreased visceral perfusion
(4) intestinal obstruction

Management:
- **prompt abdominal decompression when the pressure becomes elevated**
- **prevention through the use of tension-free abdominal closures**

Meldrum et al (1997) developed a grading system based on intra-abdominal pressure levels, with recommended management steps.

Pressure	Grade	Management
10-15 mm Hg	I	maintain normovolemia
16-25 mm Hg	II	hypervolemic resuscitation
26-35 mm Hg	III	decompression
> 35 mm Hg	IV	decompression and re-exploration

References:

Ivatury RR, Porter JM, et al. Intra-abdominal hypertension after life-threatening abdominal trauma: prophylaxis, incidence and clinical relevance to gastric mucosal pH and abdominal compartment syndrome. J Trauma. 1998; 44: 1016-1023.

Mayberry JC. Commentary: Prevention of the abdominal compartment syndrome. Lancet. 1999; 354: 1749-1750.

Meldrum DR, Moore FA, et al. Prospective characterization and selective management of the abdominal compartment syndrome. Am J Surg. 1997; 174: 667-673.

30.29 POSSUM Scoring System for Surgical Audit

Overview:
The POSSUM (Physiologic and Operative Severity Score for the enUmeration of Mortality and morbidity) is a scoring system which allows for either retrospective or prospective evaluation of surgical and post-operative care. This can allow comparison of care between different providers and/or institutions. It was developed at the Broadgreen Hospital in Liverpool, England.

Components
(1) physiologic score
(2) operative score
(3) tally of complications
(4) calculations of estimated morbidity and mortality rates from scores

Physiologic Score

The physiologic score is calculated before surgery.

Parameters:
(1) age
(2) cardiac signs
(3) respiratory history
(4) systolic blood pressure
(5) pulse in beats per minute
(6) Glasgow coma score
(7) hemoglobin
(8) white blood cell count
(9) urea
(10) sodium
(11) potassium
(12) electrocardiogram

Parameter	Finding	Points
age in years	<= 60 years	1
	61 - 70 years	2

	>= 71 years	4
cardiac signs	no failure	1
	diuretics, digoxin, antianginal therapy, antihypertensive therapy	2
	peripheral edema, warfarin therapy, borderline cardiomegaly on chest X-ray	4
	raised jugular venous pressure, cardiomegaly on chest X-ray	8
respiratory findings	no dyspnea	1
	dyspnea on exertion; mild evidence of COPD on chest X-ray	2
	limiting dyspnea after 1 flight of stairs; moderate COPD on chest X-ray	4
	dyspnea at rest; respiratory rate > 30 breaths per minute; fibrosis or consolidation on chest X-ray	8
systolic blood pressure	<= 89 mm Hg	8
	90 - 99 mm Hg	4
	100 - 109 mm Hg	2
	110 - 130 mm Hg	1
	131 - 170 mm Hg	2
	>= 171 mm Hg	4
pulse	<= 39 beats per minute	8
	40 - 49 beats per minute	2
	50 - 80 beats per minute	1
	81 - 100 beats per minute	2
	101 - 120 beats per minute	4
	>= 121 beats per minute	8
Glasgow coma score	15	1
	12 - 14	2
	9 - 11	4
	<= 8	8
hemoglobin	<= 9.9 g/dL	8
	10.0 - 11.4 g/dL	4
	11.5 - 12.9 g/dL	2
	13.0 - 16.0 g/dL	1
	16.1 - 17.0 g/dL	2
	17.1 - 18.0 g/dL	4
	>= 18.1 g/dL	8
white blood cell count	<= 3,000 per µL	4
	3,100 - 3,999 per µL	2
	4,000 - 10,000 per µL	1
	10,100 - 20,000 per µL	2

	>= 20,100 per μL	4
urea	<= 7.5 mmol/L	1
	7.6 - 10.0 mmol/L	2
	10.1 - 15.0 mmol/L	4
	>= 15.1 mmol/L	8
sodium	<= 125 mmol/L	8
	126 - 130 mmol/L	4
	131 - 135 mmol/L	2
	>= 136 mmol/L	1
potassium	<= 2.8 mmol/L	8
	2.9 - 3.1 mmol/L	4
	3.2 - 3.4 mmol/L	2
	3.5 - 5.0 mmol/L	1
	5.1 - 5.3 mmol/L	2
	5.4 - 5.9 mmol/L	4
	>= 6.0 mmol/L	8
electrocardiogram	normal	1
	atrial fibrillation with heart rate 60-90	4
	any other abnormal rhythm	8
	>= 5 ectopics per minute	8
	Q waves or ST-T wave changes	8

(from Table 1, page 356)

where:

- **Table 1 on page 356 includes "chest radiograph" as an indented entry below both "cardiac signs" and "respiratory history". I have merged the radiograph findings with the clinical findings into one score; this corresponds to the 12 factors mentioned on page 355.An alternative approach would be to have as separate parameters. This would increase the number of parameters from 12 to 14, the minimum score from 12 to 14, and maximum score from 96 to 112.**

Operative Score

The operative score is calculated at discharge.

Parameters
(1) operative severity
(2) number of procedures done
(3) total blood loss
(4) peritoneal soiling
(5) presence of malignancy
(6) mode of surgery

Parameter	Finding	Points
operative severity	minor	1

	moderate	**2**
	major	**4**
	very major	**8**
number of procedures	**1**	**1**
	2	**4**
	> 2	**8**
total blood loss in mL	**<= 100 mL**	**1**
	101 - 500 mL	**2**
	501 - 999 mL	**4**
	>= 1,000 mL	**8**
peritoneal soiling	**none**	**1**
	minor (serous fluid without pus)	**2**
	local pus	**4**
	free bowel content, pus or blood	**8**
presence of malignancy	**none**	**1**
	primary only	**2**
	nodal metastases	**4**
	distant metastases	**8**
mode of surgery	**elective**	**1**
	emergency with resuscitation >= 2 hours	**4**
	operation < 24 hours after admission	**4**
	immediate surgery	**8**

(from Table 2, page 356)

where:
- **moderate severity procedures: appendectomy, cholecystectomy, mastectomy, transurethral resection of prostate**
- **moderate severity procedures: laparotomy, bowel resection, cholecystectomy with choledochotomy, peripheral vascular procedure, major amputation**
- **very major severity procedures: procedure involving aorta, abdominoperineal resection, pancreatic resection, hepatic resection, esophago-gastrectomy**
- **emergency surgery with resuscitation: I am assuming that this refers to pre-operative stabilization.**

operative score =
= SUM(points for all 6 parameters)

Complications

Complications (defined pages 356-357)
(1) hemorrhage: wound, deep, other
(2) infection: chest, wound, urinary tract, deep, septicemia, fever of unknown origin, other
(3) wound dehiscence: superficial, deep

(4) anastomotic leak
(5) thrombosis: deep vein thrombosis, pulmonary embolus, other thrombosis, cerebrovascular accident, myocardial infarction
(6) cardiac failure
(7) impaired renal function ((urea post-operative) > (urea pre-operative) + (5 mmol/L))
(8) hypotension (systolic blood pressure < 90 mm Hg for 2 hours or more)
(9) respiratory failure
(10) any other complication
(11) death

Interpretation:
• minimum physiologic score:
• maximum physiologic score:
• mininum operative score: 6
• maximum operative score: 48

X =
= (0.16 * (physiologic score)) + (0.19 * (operative score)) - 5.91

Y =
= (0.13 * (physiologic score)) + (0.16 * (operative score)) - 7.04

probability of morbidity =
= 1 / (1 + EXP((-1) * (X)))

probability of mortality =
= 1 / (1 + EXP((-1) * (Y)))

where:
• The article uses the form: LN ((probability) / (1 - (probability))) = X

References:
Copeland GP, Jones D, Walters M. POSSUM: A scoring system for surgical audit. Br J Surg. 1991; 78: 356-360.