**A simplified acute physiology score for ICU patients**

We used 14 easily measured biologic and clinical variables to develop a simple scoring system reflecting the risk of death in ICU patients. The simplified acute physiology score (SAPS) was evaluated in 679 consecutive patients admitted to eight multidisciplinary referral ICUs in France. Surgery accounted for 40% of admissions. Data were collected during the first 24 h after ICU admission. SAPS correctly classified patients in groups of increasing probability of death, irrespective of diagnosis, and compared favourably with the acute physiology score (APS), a more complex scoring system which has also been applied to ICU patients. SAPS was a simpler and less time-consuming method for comparative studies and management evaluation between different ICUs.

The purpose of the acute physiology score (APS or APACHE) is to facilitate multicentre studies and reliable outcome comparisons in patient groups of similar pathology. APS is calculated from 34 physiologic measurements. A value of 0 to 4 is assigned to each variable according to its degree of abnormality, and the APS is the sum of the assigned weights for all measurements recorded. Although APS is generally accepted as a reliable estimate of severity of illness in individual patients,' variations in the mean number of data collected per patient may introduce a systematic bias in patient scoring2 because missing values are interpreted as normal. It seems appropriate, therefore, to select a standardized subgroup of routinely available measurements which would give unbiased results.

**METHODS**

The simplified acute physiology score (SAPS) variables were specifically selected to evaluate, directly or indirectly, the majority of systemic failures encountered in ICU patients (Table 1). All the SAPS data were collected during the first 24 h after ICU admission. Variables reflected simple and routine ICU measurements. For variables measured repeatedly during this period, only the most abnormal value was used.

Thirteen values, plus age, were selected. Age was considered because we thought it would be an important predictive factor. Like the other variables, it was assigned a range of 0 to 4. However, in order to be certain that we had not underestimated its importance, SAPS was also recalculated using a double weight for age(0 to 8).

A fixed value of 3 was assigned to ventilated patients, rather than the alveolar-arterial oxygen tension difference (P[A-a]O2) value used in APS. All remaining variables were scored from 0 to 4.

The APS and SAPS were calculated in each of 679unselected patients from eight ICUs, using data collected in the first 24 h after admission. Forty percent of patients had undergone surgery, whereas 30% were hospital transfers. Receiver operating characteristic (ROC) curves were drawn for APS, SAPS, SAPS recalculated with P(A-a)O2 in ventilated patients, and SAPS recalculated with a double-weight value for age. An ROC curve3 depicts the relation between true positives (number of predicted deaths/number of deaths) and false positives (number of predicted deaths/number of survivors) for each score. This method compares scores without fixing arbitrary cut-off points. The sensitivity (proportion of true positives) and the specificity (1minus proportion of false positives) were calculated for the two scores at the cut-off point giving the best Youden index, i.e., the fewest false positives for the most true positives.

**RESULTS**

A good correlation was found between ICU mortality and SAPS. Mortality increased from 0 to 80% with increasing SAPS (Table 2). Sensitivity and specificity were 0.56 and 0.82, respectively, for APS at a cut-off of 14 points and 0.69 and 0.69 for SAPS at a cut-off of 12points. The predictions of SAPS and APS differed in 126 patients. The correct prediction was given by SAPS in 81 patients and by APS in 45 patients(p<.001). There was no significant difference between ROC curves for each score (Fig. 1).

Respiratory rate in spontaneously breathing patients, or a fixed value of three points in ventilated patients, adequately replaced P(A-a)O2 values and thus did not modify SAPS efficiency. As anticipated, age proved to be an important predictive factor; most deaths in low scores were old patients, whereas survivors in the high scores were young. The double weighting for age did not improve SAPS efficiency.

The SAPS was far less time-consuming. A trained data collector or ICU nurse took only about 1 min to collect the relevant data, compared to 6 min for APS. Although at least seven values were unavailable in 70%of APS patients, the data were complete in 50% of SAPS patients and a maximum of three values was missing from each of the remaining 50%.

**DISCUSSION**

The APACHE or APS proposed by Knaus et al. has proved to be adequate in multicentre and international studies. However, because it is both complex and time-consuming, it is not used routinely by many ICU teams. In an attempt to simplify APS, we initially tried a discriminant analysis of the 34 variables, to test their influence on mortality with a multiple linear regression. Several subgroups of five or six variables had the same discriminant power. However, each of these subgroups reflected only one or two physiologic systems. We therefore selected the 13 most easily measured variables, found in 90% of patients in the APS survey.2 These variables covered most physiologic systems.

specific scoring systems. A recent study using APS and SAPS to evaluate patients with gastrointestinal disease and hepatic failure showed an excellent correlation with mortality. The similarity of the two ROC curves for SAPS and APS is a strong argument for the simpler scoring system. Moreover, retrospective studies' using SAPS have shown that all requisite variables, including the Glasgow coma score, one venous blood sample and a clinical evaluation, are readily obtainable from medical records in most ICUs. Because fewer biologic measurements are necessary for SAPS than for APS, SAPS causes less discomfort to the patient and is less expensive.

However, SAPS has its limitations. It is calculated from the worst value during the first 24 h of ICU admission, a period when unforeseen events may be the major determinant of outcome. This could explain deaths of patients with a low SAPS.

APS and SAPS were both designed specifically to classify patients into groups of comparable probability of death. Whereas one can confidently predict a 40%mortality fora patient subgroup with a SAPS of 17, it is impossible to identify individual survivors or non-survivors. SAPS and APS should not, therefore, be used for individual prognosis or treatment decisions.

CONCLUSION

A simple standardized scoring system such as SAPS, valid for a majority of pathologies, would largely eliminate the need for specific scoring systems, thereby facilitating inter-ICU comparisons of treatment and

**CONCLUSION**

A simple standardized scoring system such as SAPS, valid for a majority of pathologies, would largely eliminate the need for specific scoring systems, thereby facilitating inter-ICU comparisons of treatment and management. Although SAPS cannot replace highly specific scoring systems such as those used for burn patients or patients with myocardial infarction, it is an efficient indicator of mortality over a wide range of pathologies. However, further prospective multicentre studies are required to test the reliability of SAPS in specific pathologies. Although it is possible o improve a score by changing the variables, modifying weights, and including information on previous health status or diagnosis, this also complicates the score and hence prohibits its routine application. However, although no score is without limitations, the SAPS has the advantage of being simple, inexpensive, and reliable.

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| TABLE 1. Scoring values for the 14 variables of SAPS | | | | | | | | | |
| Variable SAPS Scale | 4 | 3 | 2 | 1 | 0 | 1 | 2 | 3 | 4 |
| Age (yr) |  |  |  |  | ≤45 | 46-55 | 56-65 | 66-75 | >75 |
| Heart rate(beat/min) | ≥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 (℃) | ≥41 | 39.0-40.9 |  | 38.5-38.9 | 36.0-38.4 | 34.0-35.9 | 32.0-33.9 | 30.0-31.9 | <30.0 |
| Spontaneous respiratory rate (breath/min) | ≥50 | 35-49 |  | 25-34 | 12-24 | 10-11 | 6-9 |  | <6 |
| Or Ventilation or CPAP |  |  |  |  |  |  |  | Yes |  |
| Urinary output (L/24 h) |  |  | >5.00 | 3.50-4.99 | 0.70-3.49 |  | 0.50-0.69 | 0.20-0.49 | <0.20 |
| Blood urea (mMol/L) | ≥55.0 | 36.0-54.9 | 29.0-35.9 | 7.5-28.9 | 3.5-7.4 | <3.5 |  |  |  |
| Hematocrit (%) | ≥60.0 |  | 50.0-59.9 | 46.0-49.9 | 30.0-45.9 |  | 20.0-29.9 |  | <20.0 |
| White blood cell count (103/mm2) | ≥40.0 |  | 20.0-39.9 | 15.0-19.9 | 3.0-14.9 |  | 1.0-2.9 |  | <1.0 |
| Serum glucose(mMol/L) | ≥44.5 | 27.8-44.4 |  | 14.0-27.7 | 3.9-13.9 |  | 2.8-3.8 | 1.6-2.7 | <1.6 |
| 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) |  | >40.0 |  | 30.0-39.9 | 20.0-29.9 | 10.0-19.9 |  | 5.0-9.9 | <5.0 |
| Glasgow coma score |  |  |  |  | 13-15 | 10-12 | 7-9 | 4-6 | 3 |

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| TABLE 2. Relation between SAPS and ICU mortality rate | | |
| SAPS | No. of Patients | Mortality Rate (%) |
| 4 | 64 | - |
| 5-6 | 56 | 10.7±4.1 |
| 7-8 | 75 | 13.3±3.9 |
| 9-10 | 103 | 19.4±7.8 |
| 11-12 | 106 | 24.5±4.1 |
| 13-14 | 70 | 30.0±5.5 |
| 15-16 | 81 | 32.1±5.1 |
| 17-18 | 43 | 44.2±7.6 |
| 19-20 | 28 | 50.0±9.4 |
| ≥21 | 53 | 81.1±5.4 |

A diagram of a positive result

Description automatically generated with medium confidence

Receiver operating characteristic (ROC) curves drawn at different cut-off values for SAPS and APS. There is no significant difference between the two curves.

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| **Albumin** | A protein produced by the liver, important for maintaining blood volume and pressure. |
| **ALP (Alkaline Phosphatase)** | An enzyme linked to the liver, bile ducts, and bone health. |
| **ALT (Alanine Transaminase)** | An enzyme that helps the liver convert food into energy, indicative of liver health. |
| **AST (Aspartate Transaminase)** | An enzyme found in the liver, heart, and other tissues. Elevated levels may indicate liver or heart damage. |
| **Bilirubin** | A waste product processed by the liver from old blood cells. High levels can indicate liver issues. |
| **BUN (Blood Urea Nitrogen)** | Measures the amount of nitrogen in the blood that comes from urea, a waste product processed by the kidneys. |
| **Cholesterol** | A fatty substance essential for building cells, but high levels can indicate a risk for heart disease. |
| **Creatinine** | A waste product produced by muscles and processed by the kidneys, used to measure kidney function. |
| **DiasABP (Diastolic Arterial Blood Pressure)** | The lower number in blood pressure readings, representing pressure between heartbeats. |
| **FiO2 (Fraction of Inspired Oxygen)** | The percentage of oxygen in the air mixture that a patient breathes. |
| **GCS (Glasgow Coma Score)** | A scale to assess consciousness after brain injury. |
| **Glucose** | The level of sugar in the blood, important for diagnosing and managing diabetes. |
| **HCO3 (Bicarbonate)** | An ion that helps maintain the blood's pH balance. |
| **HCT (Hematocrit)** | The proportion of red blood cells in the blood, important for diagnosing anemia. |
| **HR (Heart Rate)** | The number of heartbeats per minute. |
| **K (Potassium)** | An essential mineral for heart, kidney, and other organ function. |
| **Lactate** | An indicator of how well oxygen is being used by the body; high levels can indicate shock. |
| **Mg (Magnesium)** | Important for many processes in the body, including nerve function and blood pressure regulation. |
| **MAP (Mean Arterial Pressure)** | An average blood pressure reading that reflects the average pressure in a patient's arteries. |
| **MechVent (Mechanical Ventilation)** | Indicates whether a patient is on mechanical breathing support. |
| **Na (Sodium)** | Essential for blood pressure, nerve, and muscle function. |
| **NIDiasABP (Non-invasive Diastolic Blood Pressure)** | Diastolic blood pressure measured without penetrating the skin. |
| **NIMAP (Non-invasive Mean Arterial Pressure)** | Average arterial pressure measured non-invasively. |
| **NISysABP (Non-invasive Systolic Blood Pressure)** | Systolic blood pressure measured non-invasively. |
| **PaCO2 (Partial Pressure of CO2)** | The level of carbon dioxide in arterial blood, indicating lung function. |
| **PaO2 (Partial Pressure of O2)** | The level of oxygen in arterial blood, important for assessing lung function. |
| **pH** | The acidity or alkalinity of arterial blood. |
| **Platelets** | Blood cells involved in clotting; important for identifying bleeding disorders. |
| **RespRate (Respiratory Rate)** | Number of breaths taken per minute. |
| **SaO2 (Oxygen Saturation)** | The level of oxygen saturation in the blood. |
| **SysABP (Systolic Arterial Blood Pressure)** | The upper number in blood pressure readings, representing pressure during a heartbeat. |
| **Temp (Temperature)** | Body temperature, important for identifying fevers or hypothermia. |
| **TropI (Troponin I)** | A protein that indicates heart muscle damage. |
| **TropT (Troponin T)** | Similar to Troponin I, it indicates heart damage. |
| **Urine** | Measures the volume of urine output to assess kidney function. |
| **WBC (White Blood Cell Count)** | Indicates immune function; important for diagnosing infections. |
| **Weight** | Body weight in kilograms. |
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| **min**: The minimum value recorded, reflecting the lowest physiological point. | |
| **max**: The maximum value recorded, indicating the highest point of stress or dysfunction. | |
| **diff**: The difference between the mean value and the most extreme value (min or max), | |

**#### Clinical Measures Overlap:**

Here is the comparison based on the information of SAPS and SOFA score tables from the papers:

1. \*\*Respiration\*\*:

- SOFA considers PaO2/FiO2 (oxygenation index) and mechanical ventilation, which could calcuated from our ICU PaO2 and FiO2 measures.

- SAPS-I considers spontaneous respiratory rate or the use of ventilation/CPAP we have RespRate and MechVent in IUC data set.

2. \*\*Coagulation\*\*:

- SOFA looks at platelet counts, directly aligning with our ICU dataset Platelets measure.

- SAPS-I does not seem to consider coagulation directly.

3. \*\*Liver\*\*:

- SOFA uses bilirubin levels, aligning with our ICU dataset Bilirubin measure.

- SAPS-I does not have a direct liver function measure.

4. \*\*Cardiovascular\*\*:

- SOFA includes hypotension and the use of vasopressors, which might be inferred from measures like SysABP, DiasABP, MAP, NISysABP, NIDiasABP, and NIMAP.

- SAPS-I includes heart rate and systolic blood pressure, which are directly covered by our ICU dataset HR and SysABP measures.

5. \*\*Central Nervous System\*\*:

- Both SOFA and SAPS-I include the Glasgow Coma Score, aligning with ICU dataset GCS measure.

6. \*\*Renal\*\*:

- SOFA considers creatinine levels and urine output, corresponding to our Creatinine and Urine measures.

- SAPS-I includes urine output and blood urea (which is related to BUN) measures.

**#### Selection of Clinical Variables:**

Based on the overlap with SAPS-I and SOFA scoring systems, the following clinical variables from our 36 clinical measures list might be important for the models:

1. \*\*PaO2, FiO2 and MechVent\*\* - For assessing respiratory function.

2. \*\*Platelets\*\* - A direct match with coagulation assessment in SOFA.

3. \*\*Bilirubin\*\* - To evaluate liver function.

4. \*\*HR, SysABP, DiasABP, MAP, NISysABP, NIDiasABP, NIMAP\*\* - For cardiovascular function and blood pressure assessment.

5. \*\*GCS\*\* - As a measure of neurological status.

6. \*\*Creatinine, BUN, Urine\*\* - To assess renal function.

**#### Please Note:** Additional variables from the original 36 may also be significant depending on the specific focus of the analysis.