Intensive Care Med (1996) 22:707–710

MEETING REPORT

J.-L. Vincent
R. Moreno
J. Takala
S. Willatts
A. De Mendonça
H. Bruining
C.K. Reinhart
P.M. Suter
L.G. Thijs

The SOFA (Sepsis-related Organ Failure Assessment) score to describe organ dysfunction/failure

On behalf of the Working Group on Sepsis-Related Problems of the European Society of Intensive Care Medicine (see contributors to the project in the appendix)

Received: 18 January 1996
Accepted: 19 April 1996

J.-L. Vincent (✉) · R. Moreno
J. Takala · S. Willatts · A. De Mendonça
H. Bruining · C.K. Reinhart
P.M. Suter · L.G. Thijs
Erasme University Hospital,
808 route de Lennik,
B-1070 Brussels, Belgium

Multiple organ failure (MOF) is a major cause of morbidity and mortality in the critically ill patient. Emerging in the 1970s, the concept of MOF was linked to modern developments in intensive care medicine [1]. Although an uncontrolled infection can lead to MOF [2], such a phenomenon is not always found. A number of mediators and the persistence of tissue hypoxia have been incriminated in the development of MOF [3]. The gut has been cited as a possible "motor" of MOF [4]. Nevertheless, our knowledge regarding the pathophysiology of MOF remains limited. Furthermore, the development of new therapeutic interventions aiming at a reduction of the incidence and severity of organ failure calls for a better definition of the severity of organ dysfunction/failure to quantify the severity of illness. Accordingly, it is important to set some simple but objective criteria to define the degree of organ dysfunction/failure.

The evolution of our knowledge of organ dysfunction/failure led us to establish several principles:

1. Organ dysfunction/failure is a process rather than an event. Hence, it should be seen as a continuum and should not be described simply as "present" or "absent." Hence, the assessment should be based on a scale.
2. The time factor is fundamental for several reasons: (a) Development and similarly resolution of organ failure may take some time. Patients dying early may not have time to develop organ dysfunction/failure. (b) The time course of organ dysfunction/failure can be multimodal during a complex clinical course, what is sometimes referred to as a "multiple-hit" scenario. (c) Time evaluation allows a greater understanding of the disease process as a natural process or under the influence of therapeutic interventions. The collection of data on a daily basis seems adequate.
3. The evaluation of organ dysfunction/failure should be based on a limited number of simple but objective variables that are easily and routinely measured in every institution. The collection of this information should not impose any intervention beyond what is routinely performed in every ICU. The variables used should as much as possible be independent of therapy, since therapeutic management may vary from one institution to another and even from one patient to another (Table 1).

Until recently, none of the existing systems describing organ failure met these criteria, since they were based on categorial definitions or described organ failure as present or absent [5–7].

The ESICM organized a consensus meeting in Paris in October 1994 to create a so-called sepsis-related organ failure assessment (SOFA) score, to describe quantitatively and as objectively as possible the degree of organ dysfunction/failure over time in groups of patients or even in individual patients (Fig. 1). There are two major applications of such a SOFA score:

1. To improve our understanding of the natural history of organ dysfunction/failure and the interrelation between the failure of the various organs.

Table 1 Ideal variables for describing organ dysfunction/failure

– Objective
– Simple, easily available, but reliable
– Obtained routinely and regularly in every institution
– Specific for the function of the organ considered
– Continuous variable
– Independent of the type of patients
– Independent of the therapeutic interventions

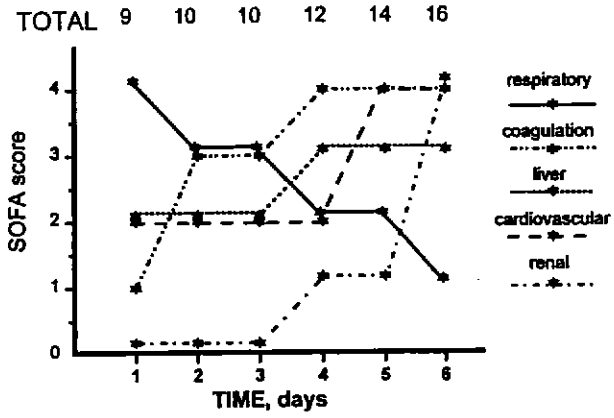

Fig. 1 Time course of the SOFA score in a 61-year-old patient who presented with severe sepsis due to extensive bronchopneumonia. Improvement of the respiratory failure was associated with worsening of the coagulation, cardiovascular, hepatic and eventually renal systems before the patient died.

2. To assess the effects of new therapies on the course of organ dysfunction/failure. This could be used to characterize patients at entry (and even serve within the entry criteria) or to evaluate the effects of treatment.

It is important to realize that the SOFA score is designed not to *predict* outcome but to *describe* a sequence of complications in the critically ill. Although any assessment of morbidity must be related to mortality to some degree, the SOFA is not designed just to describe organ dysfunction/failure according to mortality. Hence, the SOFA score does not compete with the existing severity indexes, but complements them (Table 2). Severity indices have been designed primarily to evaluate a risk of death from an initial evaluation [8], even though there has been a recent tendency to evaluate severity indexes repeatedly to evaluate the time course of the disease [9]. Most importantly, the existing severity indices do not allow evaluation of the individual function of each organ separately.

Table 2 Differences between commonly used scoring systems and the SOFA score

Scoring systems	SOFA score
Evaluate risk of mortality	Evaluate morbidity
Aim = prediction	Aim = description
Often complex	Simple, easily calculated
Does not individualize the degree of dysfunction/failure of each organ usually obtained early after admission	Does individualize the degree of dysfunction/failure of each organ obtained daily

The participants decided: (1) to limit the number of organs studied to 6. As an example, attempting to include dysfunction/failure of the gut was felt to be very important, but also too complex and was therefore abandoned. (2) To use a score from 0 (normal) to 4 (most abnormal) for each organ. (3) To record the worst values on each day. The SOFA score is presented in Table 3.

Since the mortality rate is directly related to the degree of organ dysfunction, it is evident that it must also be related to the SOFA score for each organ system. Nevertheless, the relation between the score and the mortality rate of critically ill patients needs to be documented. Such an

Table 3 The SOFA score

SOFA score	1	2	3	4
Respiration PaO_2/FiO_2, mmHg	<400	<300	<200	<100
			with respiratory support	
Coagulation Platelets $\times 10^3/mm^3$	<150	<100	<50	<20
Liver Bilirubin, mg/dl (μmol/l)	1.2–1.9 (20–32)	2.0–5.9 (33–101)	6.0–11.9 (102–204)	>12.0 (<204)
Cardiovascular Hypotension	MAP < 70 mmHg	Dopamine ≤5 or dobutamine (any dose)[a]	Dopamine >5 or epinephrine ≤0.1 or norepinephrine ≤0.1	Dopamine >15 or epinephrine >0.1 or norepinephrine >0.1
Central nervous system Glasgow Coma Score	13–14	10–12	6–9	<6
Renal Creatinine, mg/dl (μmol/l) or urine output	1.2–1.9 (110–170)	2.0–3.4 (171–299)	3.5–4.9 (300–440) or <500 ml/day	>5.0 (>440) or <200 ml/day

[a] Adrenergic agents administered for at least 1 h (doses given are in μg/kg·min)

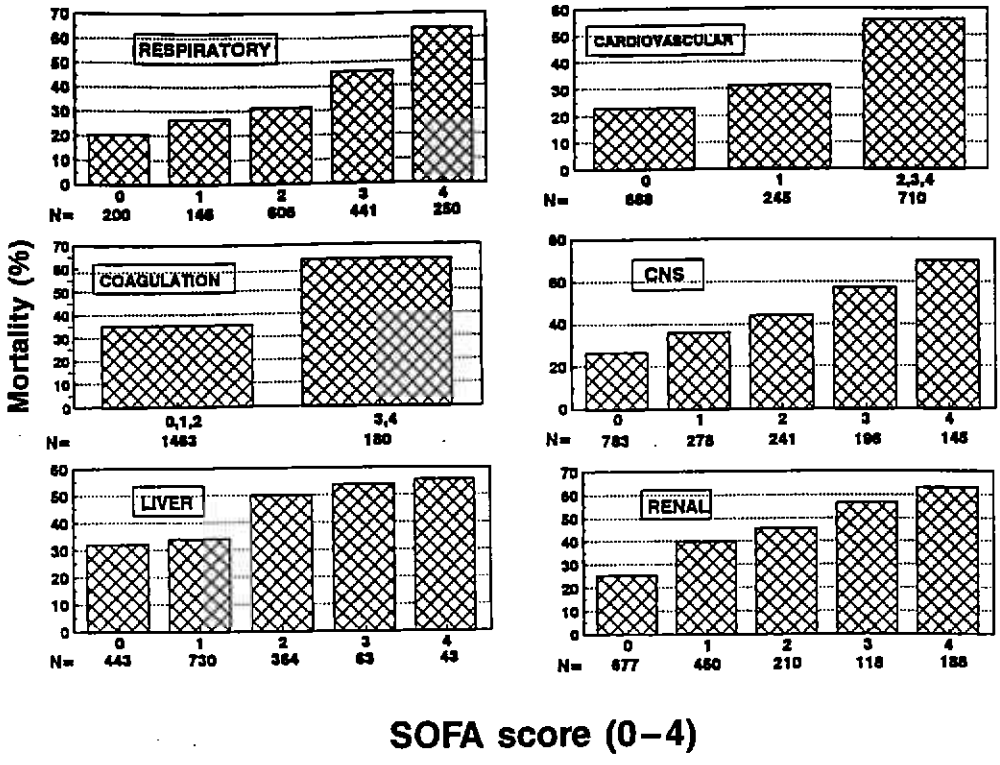

Fig. 2 Mortality rate versus SOFA score in 1643 septic patients included in the European/North American Study of Severity Systems.

analysis may also result in revision of the limits of the parameters used to score each organ. The relation between the SOFA score on ICU admission and the mortality rate was studied in 1643 patients with sepsis by the European/North American Study of Severity System (ENAS). Such a retrospective analysis has several problems. First, the ENAS data base was not created to study sepsis and septic shock specifically, so that the identification of sepsis was accomplished retrospectively. Second, it was not always possible to separate the patients in the ENAS data base for all value limits used in the SOFA. This was true for the cardiovascular status (only three groups) and for the coagulation system (only two groups). Finally, patient prognosis was only related to the SOFA on ICU admission. Nevertheless two aspects of the data are encouraging. First, they generally show an increasing mortality rate with a greater SOFA score for each organ. Second, they show a good distribution of patient numbers among the different scores.

In addition, a prospective collection of data was also performed on all patients admitted to the ICU throughout the month of May 1995, except for those staying for less than 48 h for elective surgery (routine postoperative surveillance). Although the SOFA score is primarily designed for use in the septic patient, it was felt that the series should not be limited to those patients. However, the presence or absence of infection was noted. These patients were monitored throughout their ICU stay. A report on this analysis will follow.

At least two similar scores have been proposed recently. A "Multiple Organ Dysfunction Score" was developed by J. Marshall et al. [10] and a so-called "Brussels Score" [11] was developed by G. Bernard et al. at the time of the round table conference on clinical trials in sepsis [12]. A major difference between the three scores lies in the definition of cardiovascular dysfunction/failure. In the "Multiple Organ Dysfunction Score," it is based on the complex calculation of the pressure adjusted heart rate, defined as the product of heart rate times the right atrial (central venous) pressure divided by the mean arterial pressure. Such a score, calculated a number of times over any 24 h period, can only be computed, so that it removes the simplicity of the score. In the "Brussels Score," it is based on hypotension and acidemia, but acidemia can be caused by factors other than circulatory failure, including renal failure or (permissive) hypercapnia. Thus, even if it is significantly related to mortality, it does not reflect the degree of cardiovascular dysfunction. In the SOFA score, cardiovascular dysfunction/failure is based on the requirements for adrenergic support. Even though it is preferable to avoid treatment-related criteria, the participants found no better way to describe cardiovascular dysfunction/failure. Although the type of adrenergic support may differ from one institution to another, the categories were broad enough to avoid a major impact of local protocols on this assessment.

The neurological evaluation is complicated by the frequent use of sedative agents in critically ill patients. Al-

though the Glasgow Coma Score is considered to be most useful in this assessment, it is not clear whether the actual or the assumed (in the absence of sedative/relaxant drugs) should be used, so that it was decided to include both, at least initially. Importantly, any given score is not established indefinitely. This is a continuing process, requiring regular re-evaluation.

The assessment of organ dysfunction/failure remains difficult, but we believe that the development of the SOFA score represents a valuable approach. The criteria used and especially the individual values for each of the parameters used in the SOFA score should not be considered as definitive, but can be altered when sufficient data are collected.

Acknowledgements The authors acknowledge the expertise of Critical Care Analytics (Amherst, Mass.) in the analysis of the data from the ENAS data base.

References

1. Baue AE (1975) Multiple, progressive, or sequential systems failure. A syndrome of the 1970s. Arch Surg 110: 779–781
2. Fry DE, Pearlstein L, Fulton RL, Hiram CP (1980) Multiple system organ failure: the role of uncontrolled infection. Arch Surg 115:136–140
3. Beal AL, Cerra FB (1994) Multiple organ failure in the 1990s. JAMA 271: 226–233
4. Deitch EA (1992) Multiple organ failure: pathophysiology and potential future therapy. Ann Surg 216:117–134
5. Goris RJA, Boekhorst TPA (1985) Multiple-organ failure. Arch Surg 120: 1109–1115
6. Knaus WA, Draper EA, Wagner DP, Zimmerman JE (1985) Prognosis in acute organ-system failure. Ann Surg 202:685–693
7. Fagon JY, Chastre J, Novara A, Medioni P, Gibert C (1993) Characterization of intensive care unit patients using a model based on the presence or absence of organ dysfunction and/or infection: the ODIN model. Intensive Care Med 19:137–144
8. Le Gall JR, Lemeshow S, Leleu G et al (1995) Customized probability models for early severe sepsis in adult intensive care patients. JAMA 237:644–650
9. Chang RWS, Jacobs S, Lee B (1988) Predicting outcome among intensive care unit patients using computerized trend analysis of daily APACHE II scores corrected for organ system failure. Intensive Care Med 14:558–566
10. Marshall JC, Cook DJ, Christou NV, Bernard GR, Sprung CL, Sibbald WJ (1995) The multiple organ dysfunction (MOD) score: a reliable descriptor of a complex clinical outcome. Crit Care Med 23:1638–1652
11. Bernard GR, Doig BG, Hudson G et al (1995) Quantification of organ failure for clinical trials and clinical practice. Am J Respir Crit Care Med 151:A323 (abstract)
12. Sibbald WJ, Vincent JL (1995) Round table conference: clinical trials in sepsis. Intensive Care Med 21:184–189

Appendix

Contributors to the SOFA project were: J.L. Vincent (Brussels, Belgium, chairman); G. Bernard (Nashville, USA), D. Bihari (Sydney, Australia), C. Brun-Buisson (Paris, France), H. Burchardi (Göttingen, Germany), M. Langer (Milan, Italy), J. Marshall (Toronto, Canada), C.K. Reinhart (Jena, Germany), P. Suter (Geneva, Switzerland), L.G. Thijs (Amsterdam, The Netherlands), R. Abizanda (Castellon, Spain), M. Antonelli (Rome, Italy), A. Artigas (Sabadell, Spain), R. Beale (London, United Kingdom), G. Berlot (Trieste, Italy), H. Bruining (Rotterdam, The Netherlands), J. Carlet (Paris, France), V. Cerny (Hradec Kralove, Czech Republic), F. Colardyn (Ghent, Belgium), N.M. Dearden (Leeds, United Kingdom), D.J. Edwards (Manchester, United Kingdom), J. Fagon (Paris, France), J. Goris (Nijmegen, The Netherlands), J. Groeneveld (Amsterdam, The Netherlands), A. Gullo (Trieste, Italy), J. Hazelzet (Rotterdam, The Netherlands), J. Ibañez-Nolla (Barcelona, Spain), J. Labrousse (Paris, France), M. Lamy (Liège, Belgium), J.R. Le Gall (Paris, France), M. Levi (Amsterdam, The Netherlands), C. Martin (Marseille, France), D. Miller (Edinburgh, United Kingdom), R. Moreno (Lisboa, Portugal), P. Nightingale (Manchester, United Kingdom), M. Nolla-Salas (Barcelona, Spain), G. Nowak (Jena, Germany), M. Palazzo (London, United Kingdom), A. Pesenti (Monza, Italy), H. Prange (Göttingen, Germany), P. Radermacher (Ulm, Germany), M. Rogy (Vienna, Austria), C. Ronco (Vicenza, Italy), A. Salgado (Barcelona, Spain), M. Singer (London, United Kingdom), C. Sprung (Jerusalem, Israel), J. Strom (Glostrup, Denmark), J. Takala (Kuopio, Finland), D. Teres (Springfield, USA), D. Villers (France), S. Willats (United Kingdom).