Clinical Study

Commonly Used Severity Scores Are Not Good Predictors of Mortality in Sepsis from Severe Leptospirosis: A Series of Ten Patients

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1. Introduction

Sepsis and multiple organ failure are associated with high ICU morbidity and mortality. Currently available organ failure scoring systems, such as the Sequential Organ Failure Assessment (SOFA) score can help assess organ dysfunction over time and have been associated with ICU mortality.

The term Leptospirosis refers to disease caused by any leptospira, regardless of specific serotype. Leptospirosis is thought to be the most widespread zoonosis in the world. Weil syndrome [1, 2] is defined as severe leptospirosis with multi-organ dysfunction. Weil syndrome can cause respiratory failure [3], renal failure requiring hemodialysis [4], hemorrhages, anemia, disturbances in consciousness, and persistent fever and sepsis with high mortality, even in previously healthy patients [5].

SOFA score has been shown to correlate with outcome in a variety of ICU populations [6]. Therefore, use of repeated SOFA score measures over time is a reasonable attempt to assess the severity of organ dysfunction and predict outcome in severe leptospirosis, even though SOFA score has not been validated in patients with leptospirosis. However, our experience with patients admitted to the ICU for severe leptospirosis suggests that patients can have good outcome despite severe multi-organ failure with high SOFA scores and very high predicted mortality on ICU admission. This retrospective study was conducted in an attempt to evaluate whether admission SOFA scores, repeated SOFA score
measurements over time, admission SAPS II or admission APACHE II scores can help predict mortality in severe leptospirosis.

2. Materials and Methods

2.1. Study Design and Data Collection. This retrospective study consisted of chart review and data extraction from all confirmed leptospirosis cases admitted to our ICU over a 4-year period. The project was approved by the Institution Ethics Committee. Demographic data and data on clinical history, physical examination at the time of ICU admission, initial and follow-up laboratory values, diagnostic tests used to confirm leptospirosis and treatment provided were collected from each medical record, and stored without any personally identifiable information in a secure electronic database. SOFA scores on admission and every day until death or discharge from the ICU were also recorded. Calculation of daily SOFA scores was based on the most abnormal value for each SOFA score parameter each day [7]. APACHE II and SAPS II were also calculated on the day of ICU admission. When patients were sedated and intubated we assumed they did not have any CNS abnormalities.

2.2. Statistical Analysis. Because data distribution was skewed and violated normality, comparisons between survivors and non-survivors were done with the non-parametric Mann-Whitney U test. Observed mortality was compared with expected mortality using Fisher’s exact test. Data analysis was done with the SPSS version 17.0 statistical software package (SPSS Inc, Chicago, IL). *P* < 0.05 was considered significant for all comparisons. Fisher’s exact test was done using the STATCALC component of the Epi Info statistics software package (freely available from the Centers for Disease Control at http://www.cdc.gov/Epiinfo/, January 5, 2010).

3. Results

3.1. Demographic and Clinical Data. Ten patients (9 men, one woman) were admitted to the ICU for multi-organ failure due to severe leptospirosis between 2006 and 2009. All patients lived and worked in rural areas, and therefore were at risk for occupational exposure to leptospira. Because data did not have a normal distribution, data in Table 1 are presented as median (minimum, maximum).

3.2. Initial Diagnosis and ICU Therapy. All patients in this case series were admitted to the ICU because of severe respiratory insufficiency, acute renal failure, hypotension, coagulopathy, coma or any combination of the above. All patients presented in the Emergency Department with a GCS of 15, except a female patient who had a GCS of 6, intubated initially in the ED and had the shortest ICU length of stay (died after 4 days). None of the patients developed lung hemorrhages or cardiac rhythm abnormalities either on admission or during ICU stay. Demographic and clinical data for each patient are presented in Table 2.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Overall</th>
<th>Surivors</th>
<th>Non-survivors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>54 (22, 74)</td>
<td>56 (22, 74)</td>
<td>52 (50, 58)</td>
</tr>
<tr>
<td>ICU LOS</td>
<td>10.5 (4, 37)</td>
<td>17 (5, 37)</td>
<td>8 (4, 13)</td>
</tr>
<tr>
<td>PaO2/FiO2</td>
<td>155 (70, 338)</td>
<td>215 (142, 338)</td>
<td>105 (70, 150)</td>
</tr>
<tr>
<td>Platelet count</td>
<td>35 (15, 82)</td>
<td>43 (20, 82)</td>
<td>21 (15, 28)</td>
</tr>
<tr>
<td>Bilirubin</td>
<td>8.64 (1, 17)</td>
<td>9.33 (1, 14)</td>
<td>7 (2, 17)</td>
</tr>
<tr>
<td>Creatinine</td>
<td>2.9 (1, 6)</td>
<td>3.7 (1, 6)</td>
<td>3 (3, 4)</td>
</tr>
<tr>
<td>Ventilator days</td>
<td>6 (0, 27)</td>
<td>0 (0, 27)</td>
<td>8 (4, 13)</td>
</tr>
<tr>
<td>SOFA score</td>
<td>15.5 (9, 18)</td>
<td>14 (9, 18)</td>
<td>17 (17, 18)</td>
</tr>
</tbody>
</table>

At the time of ICU admission, the diagnosis of leptospirosis was suspected on the basis of history and clinical presentation. Diagnosis was later confirmed on all patients by enzyme-linked immunosorbent assay (ELISA) [8]. Treatment in all 10 cases included broad spectrum antibiotics, oxygen supplementation by face mask, CPAP or intubation and mechanical ventilation, and support of all failing systems. Hemodynamic resuscitation and stabilization was based on the goal-directed therapy protocol described by Rivers et al. [9], in an attempt to optimize vital organ perfusion and oxygen delivery to peripheral tissues.

3.3. Disease Severity Scores on ICU Admission. All nine men were fully awake and oriented on ICU admission (GCS = 15), whereas the only female patient was comatose (GCS = 6), without evidence of meningeal infection on CSF testing. On ICU admission, oxygenation impairment was significantly worse in non-survivors (n = 3) compared to survivors (n = 7): Median PaO2/FiO2 was 105 in non-survivors versus 215 in survivors (*P* = 0.04). Similarly, admission platelet count was significantly lower in non-survivors (median 21,000) versus survivors (median 43,000, *P* = 0.05).

The cause of death in all three non-survivors was multiple organ failure and increased need for inotropic and vasoactive agents as shown in Table 2. No arrhythmias were recorded during their ICU stay.

SOFA, APACHE II and SAPS II on ICU admission are presented in Table 3. With regards to mortality, although the predicted mortality based on initial SOFA score was high, only 3 of 10 patients died.

4. Discussion

4.1. Leptospirosis in the ICU. Leptospirosis is a worldwide zoonosis [10, 11], and has been reported in most parts of the world, including North America (USA [8, 12, 13]), Europe (Germany [14], The Netherlands [15], Portugal [16, 17], Greece [18], Serbia [19], Turkey [20, 21]), The Middle East (Israel [22, 23]), Central and South America (Brazil...
Table 2: Demographic and clinical data for each patient.

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Age</th>
<th>ICU LOS</th>
<th>GCS</th>
<th>(\text{Pao}_2/\text{FiO}_2)</th>
<th>Inotrope/vasopressor Days</th>
<th>Serum Cr</th>
<th>Bili</th>
<th>(\text{PLT} \times 10^9)</th>
<th>SOFA/Predicted mortality</th>
<th>APACHE II/Predicted Mortality</th>
<th>SAPS II/predicted mortality</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>8</td>
<td>15</td>
<td>105</td>
<td>D 8</td>
<td>2.9</td>
<td>16.9</td>
<td>21</td>
<td>17/95</td>
<td>16/25</td>
<td>50/50</td>
<td>Death</td>
</tr>
<tr>
<td>2</td>
<td>56</td>
<td>32</td>
<td>15</td>
<td>160</td>
<td>N 25</td>
<td>5.4</td>
<td>10.02</td>
<td>20</td>
<td>18/95</td>
<td>17/25</td>
<td>68/75</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>52</td>
<td>37</td>
<td>15</td>
<td>150</td>
<td>D12</td>
<td>2.9</td>
<td>7.08</td>
<td>50</td>
<td>14/95</td>
<td>16/25</td>
<td>65/75</td>
<td>Good</td>
</tr>
<tr>
<td>4</td>
<td>22</td>
<td>17</td>
<td>15</td>
<td>142</td>
<td>D 6</td>
<td>6.1</td>
<td>10.6</td>
<td>30</td>
<td>17/95</td>
<td>13/15</td>
<td>50/50</td>
<td>Good</td>
</tr>
<tr>
<td>5</td>
<td>58</td>
<td>4</td>
<td>6</td>
<td>150</td>
<td>N40</td>
<td>2.5</td>
<td>1.52</td>
<td>28</td>
<td>17/95</td>
<td>18/25</td>
<td>34/15</td>
<td>Death</td>
</tr>
<tr>
<td>6</td>
<td>67</td>
<td>6</td>
<td>15</td>
<td>215</td>
<td>D3</td>
<td>2.7</td>
<td>1.23</td>
<td>82</td>
<td>9/33</td>
<td>4/4</td>
<td>22/5</td>
<td>Good</td>
</tr>
<tr>
<td>7</td>
<td>70</td>
<td>6</td>
<td>15</td>
<td>338</td>
<td>D3</td>
<td>5.6</td>
<td>14</td>
<td>40</td>
<td>14/95</td>
<td>6/8</td>
<td>32/10</td>
<td>Good</td>
</tr>
<tr>
<td>8</td>
<td>52</td>
<td>13</td>
<td>15</td>
<td>70</td>
<td>D10, N20</td>
<td>3.8</td>
<td>7</td>
<td>15</td>
<td>18/95</td>
<td>18/25</td>
<td>52/50</td>
<td>Death</td>
</tr>
<tr>
<td>9</td>
<td>52</td>
<td>5</td>
<td>15</td>
<td>300</td>
<td>D3</td>
<td>0.8</td>
<td>12.1</td>
<td>49</td>
<td>10/50</td>
<td>6/8</td>
<td>32/10</td>
<td>Good</td>
</tr>
<tr>
<td>10</td>
<td>74</td>
<td>31</td>
<td>15</td>
<td>300</td>
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<td>4.5</td>
<td>8.64</td>
<td>43</td>
<td>10/50</td>
<td>8/8</td>
<td>32/10</td>
<td>Good</td>
</tr>
</tbody>
</table>

GCS: Glasgow Coma Scale, D: Dopamine, N: Norepinephrine, Bili: Total bilirubin, PLT: Platelet count, HD: Hemodialysis.

Table 3: SOFA, APACHE II and SAPS II on ICU admission.

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Age</th>
<th>Sex (M/F)</th>
<th>Admission SOFA</th>
<th>Admission APACHE II</th>
<th>Admission SAPS II</th>
<th>Survived (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>M</td>
<td>17</td>
<td>16</td>
<td>50</td>
<td>N</td>
</tr>
<tr>
<td>2</td>
<td>56</td>
<td>M</td>
<td>18</td>
<td>17</td>
<td>68</td>
<td>Y</td>
</tr>
<tr>
<td>3</td>
<td>52</td>
<td>M</td>
<td>14</td>
<td>16</td>
<td>65</td>
<td>Y</td>
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<tr>
<td>4</td>
<td>22</td>
<td>M</td>
<td>17</td>
<td>13</td>
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<tr>
<td>5</td>
<td>58</td>
<td>F</td>
<td>17</td>
<td>18</td>
<td>34</td>
<td>N</td>
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<tr>
<td>6</td>
<td>67</td>
<td>M</td>
<td>9</td>
<td>4</td>
<td>22</td>
<td>Y</td>
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<tr>
<td>7</td>
<td>70</td>
<td>M</td>
<td>14</td>
<td>6</td>
<td>32</td>
<td>Y</td>
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<td>52</td>
<td>M</td>
<td>18</td>
<td>18</td>
<td>52</td>
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<tr>
<td>9</td>
<td>52</td>
<td>M</td>
<td>10</td>
<td>6</td>
<td>30</td>
<td>Y</td>
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<tr>
<td>10</td>
<td>74</td>
<td>M</td>
<td>10</td>
<td>8</td>
<td>32</td>
<td>Y</td>
</tr>
</tbody>
</table>

[4, 24, 25], Cuba [26], Nicaragua [27], Trinidad and Tobago [28], West Indies [29]), Asia (India [30, 31], Thailand [32], Indonesia [3]), Africa (Egypt [33, 34], Nigeria [35, 36], South Africa [37]), Australia [38] and New Zealand [39, 40]. Leptospirosis is characterized by great clinical variability, ranging from a mild flu-like illness to life-threatening multi-organ failure. There are no established criteria for early identification of the severe forms of leptospirosis, but prompt recognition of severe cases, followed by appropriate timely intervention may contribute to improved morbidity and mortality. Several studies attempted to identify prognostic factors associated with mortality, but different authors have reached different conclusions. Dupont demonstrated that dyspnea, oliguria, low white blood cell count, repolarization abnormalities on electrocardiogram, and alveolar infiltrates on chest radiographs were independently associated with mortality [29], whereas Esen et al. [20] demonstrated that patients with altered mental status and hyperkalemia on hospital admission are at high risk for mortality and should be followed up in an ICU. A prospective cohort study by Panaphut et al. [32] suggested that oliguria, hyperkalemia, pulmonary rales or hypotension on admission are associated with high mortality, a study by Marotto et al. [25] identified hemodynamic disturbance, renal dysfunction and hyperkalemia as variables associated with mortality. In addition, a large recent study from India by Pappachan et al. [41] used logistic regression and identified pulmonary and central nervous system involvement as significant predictors of death, whereas a large recent study from Indonesia [3] identified pulmonary involvement as a strong independent predictor of mortality. Despite differences between studies, most authors agree that intensive care and early intervention should be provided for patients who present with risk factors and in cases where there is high index of clinical suspicion for leptospirosis, but diagnosis has not been confirmed by the laboratory.

Mortality in leptospirosis has been reported to be up to 55% in different studies, but varies depending on case mix and severity of organ dysfunction. In a study from Brazil by Vieira [42], where all 35 patients presented with ARF, required mechanical ventilation and developed multi-organ failure, mortality was 51%. [42]. In another study from India, all 60 leptospirosis patients who were admitted to the ICU had evidence of severe sepsis, 46 of 60 had multiple organ dysfunction, 26 of 60 required ventilatory support, and mortality was 52% [30]. In contrast, although only patients with severe leptospirosis were admitted to the ICU in our study, mortality was lower (3 of 10 patients, 30%) compared to previous reports.
4.2. SOFA Score and Other Severity Scoring Systems. Currently available outcome prediction models include the APACHE II (Acute Physiology and Chronic Health Evaluation II), SAPS II (Simplified Acute Physiology Score II) and MPM (Mortality Probability Models). These systems calculate a prediction based on values recorded within the first 24 hours after ICU admission. The APACHE-II score estimates ICU mortality based on clinical signs and laboratory values, but also takes into account both acute and chronic patient diseases. The SAPS II is a severity of disease classification system, and it is mostly used to describe morbidity and outcome. Because of the need to evaluate changes in patient status over time, two scoring systems were developed, the Multiple Organ Dysfunction Score (MODS) and the Sequential Organ Failure Assessment (SOFA) scores [7, 43], which are calculated on admission and every 24 hours until patient death or discharge from the ICU.

The MODS was developed based on a literature review of all studies related to multiple organ dysfunction published between 1969 and 1993, to determine which characteristics had been used to define organ failure. The SOFA score was created during a consensus conference organized by the European Society of Intensive Care and Emergency Medicine. Both scores calculate a summary value for the degree of dysfunction for six organs (respiratory, hematologic, cardiovascular, liver, renal and central nervous system). For SOFA score, this evaluation includes PO2/FiO2 ratio, levels of serum creatinine, levels of serum bilirubin, platelet count, assessment of neurologic status (Glasgow Coma Scale) and assessment of the cardiovascular system (doses of adrenergic agents administered for hypotension). The main difference between the MODS and the SOFA is in the evaluation of cardiovascular function. In MODS, the cardiovascular assessment is based on the pressure adjusted heart-rate (PAR), defined as the product of the heart rate (HR) multiplied by the ratio of the right atrial pressure (RAP) to the mean arterial pressure (MAP), whereas the SOFA score is calculated based on mean arterial pressure and the need for vasopressors.

Results from many clinical studies show that the MODS and the SOFA score correlate well with outcome in terms of mortality [44], and also correlate with the APACHE II score. Of note, compared to the APACHE II score, both MODS and SOFA score were better predictors of mortality in the subgroup of patients with shock. With regards to the SOFA score, although this was not created for use as predictor of mortality, SOFA score changes over time have been associated with ICU mortality. In each 24-hour period, the most abnormal value for each parameter was used in the calculation of the SOFA score [7].

4.3. Leptospirosis in the ICU: Our Results. The findings of our study come in line with the results of a retrospective study by Ittyachen [31] on 104 cases with clinical suspicion of severe leptospirosis. In this study, leptospirosis was serologically confirmed in 53 (50.7%) cases, and mortality was 26.8% in the sero-negative group versus 3.8% in the sero-positive group. The discordance between observed mortality and SOFA-predicted mortality in our study could be attributed to statistical error due to our small number of patients or errors in calculating mortality predicted by SOFA score. Other plausible explanations include real differences between our leptospirosis ICU patient population and the SOFA reference population [43] or greater potential for organ recovery when organ dysfunction is caused by leptospirosis. Admission SOFA scores were high in both survivors and non-survivors. SOFA scores declined during the first 5 ICU days due to restoration of platelet count and hemodynamic stabilization in all patients. However, improvement was more pronounced in survivors. Over time, SOFA scores continued to improve, due to gradual restoration of respiratory, renal and hepatic function in survivors, whereas SOFA scores remained high until death in non-survivors. However, the results of this small, retrospective study should be interpreted with caution, because the retrospective nature of our study and the small sample size are major shortcomings of this work.

5. Conclusion

Leptospirosis is a severe disease that can progress to multi-organ failure requiring ICU care, with high predicted mortality. Although SOFA score can be used as a tool to assess disease severity in leptospirosis, our limited data suggest that SOFA and other commonly used severity scores may not be good predictors of mortality. Our findings suggest that we should be optimistic in cases of severe leptospirosis with multiple organ failure, as in this series critically ill leptospirosis patients with high disease severity scores had a good outcome. Prospective multi-center studies with large numbers of patients are needed to validate our findings.

References

[7] J. L. Vincent, A. de Mendonca, F. Cottancine et al., “Use of the SOFA score to assess the incidence of organ dysfunction/failure in intensive care units: results of a multicenter,


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