Comparison of systemic cytokine levels in patients with acute respiratory distress syndrome, severe pneumonia, and controls

Torsten T Bauer, Concepción Montón, Antoni Torres, Hernan Cabello, Xavier Fillela, Abel Maldonado, Jose-Maria Nicolás, Elisabet Zavala

Abstract

Background—The inflammatory response has been widely investigated in patients with acute respiratory distress syndrome (ARDS) and pneumonia. Studies investigating the diagnostic values of serum cytokine levels have yielded conflicting results and only little information is available for the differential diagnosis between ARDS and pneumonia.

Methods—Clinical and physiological data, serum concentrations of tumour necrosis factor (TNF-α), interleukin (IL)-1β and IL-6, and quantitative cultures of lower respiratory tract specimens were obtained from 46 patients with ARDS and 20 with severe pneumonia within 24 hours of the onset of the disease and from 10 control subjects with no inflammatory lung disease. Cytokine concentrations were compared between groups and determinants in addition to the diagnosis were tested.

Results—Serum TNF-α levels were significantly higher in ARDS patients (67 (57) pg/ml) than in patients with severe pneumonia (35 (20) pg/ml; p = 0.031) or controls (17 (8) pg/ml; p = 0.007). For IL-1β and IL-6 the observed differences were not statistically significant between patients with ARDS (IL-1β: 34 (65) pg/ml; IL-6: 712 (1058) pg/ml), those with severe pneumonia (IL-1β: 3 (4) pg/ml, p = 0.071; IL-6: 83 (1165) pg/ml, p = 1.0), and controls (IL-1β: 6 (11) pg/ml, p = 0.359; IL-6: 94 (110) pg/ml, p = 0.262). TNF-α (standardised coefficient β = 0.410, p<0.001) and IL-1β (standardised coefficient β = 0.311, p = 0.006) were most strongly associated with the degree of lung injury, even when the diagnostic group was included in the statistical model.

Conclusions—Serum TNF-α levels were higher in patients with ARDS than in those with severe pneumonia or in control subjects. Multivariate results suggest that the levels of systemic TNF-α and IL-1β reflect the severity of the lung injury rather than the diagnosis.

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Keywords: acute respiratory distress syndrome (ARDS); pneumonia; cytokines

Cytokines are widely recognised as mediators of an inflammatory response. While some cytokines promote inflammation by recruit-
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Clinical signs of congestive heart failure. In pulmonary artery catheter present or no wedge pressure quadrants on the chest radiograph, and (4) pulmonary infiltrates involving at least two pressure applied (PEEP), (3) generalised forms), in addition to hypotension (systolic rate >20/min or Pa CO2 <4.27 kPa, and leucocytosis (<36 or more of the following: temperature >38.3 °C or hypothermia ≤35.0°C, purulent secretions, or leucocytosis (≥12 000/mm³) or leucopenia (≤4000/mm³). According to the clinical condition of the patient, lower respiratory tract specimens were obtained either non-invasively by tracheobronchial aspirates (TBAS, standard sputum trap; Proctor, Barcelona, Spain) or bronchoscopically by protected specimen brush (PSB, Microbiology brush; Mill-Rose Laboratories Inc, Mentor, Ohio, USA) within the first 24 hours after onset of the disease. Fibreoptic bronchoscopy was performed without interrupting mechanical ventilation through the endotracheal tube using a special adapter. The fibreoptic bronchoscope (BF30, Olympus, New Hyde Park, New York, USA) was introduced without bronchial suctioning after adequate sedation and no local anaesthetics were administered. The setting of the ventilator was adapted appropriately during the procedure to ensure ventilation and oxygenation. The PSB was used as described by Wimberley and co-workers. Microbiological processing The PSB was aseptically cut into a sterile tube containing 1 ml of Ringer’s lactate and shaken for one minute. Serial dilutions (10⁴, 10³, 10²) from each PSB and TBAS sample were prepared in sterile normal saline. One hundred ml of each dilution was inoculated into the following agar media: 5% sheep blood, chocolate, MacConkey, blood charcoal yeast extract (BCYE-a), and Sabouraud-dextrose. All cultures were incubated at 37°C under aerobic and anaerobic conditions. Cultures were evaluated for growth 24 and 48 hours later and discarded five days later if negative, except for CDC and Wilkins-Chalgren media which were evaluated at seven days and Sabouraud medium which was evaluated at four weeks. Gram stains were performed on all samples. All microorganisms isolated were identified by standard laboratory methods. The following thresholds for quantitative cultures were used: PSB ≥10⁴ cfu/ml, TBAS ≥10³ cfu/ml, and the following microorganisms were considered

SEPTIC SHOCK

Septic shock was defined as a systemic inflammatory response to infection (presence of two or more of the following: temperature >38°C or <36°C, heart rate >90 beats/min, respiratory rate >20/min or Paco₂ <4.27 kPa, and leucocyte count >12 000/mm³ or >10% band forms), in addition to hypotension (systolic blood pressure <90 mm Hg or a reduction of 40 mm Hg from baseline in the absence of other causes). Other causes of shock such as hypovolaemia or cardiogenic shock were not considered.

PROTOCOL

The following demographic, clinical, and laboratory data were recorded on entry to the study: age, sex, cause of ICU admission, duration of mechanical ventilation before the study, use of corticosteroid medication (any intravenous administration during the 24 hours before sampling), prior antibiotic use (administered intravenously for more than 24 hours), blood analysis necessary for calculation of the simplified acute physiology score (SAPS II), lung injury score, arterial blood gas tensions, and outcome at ICU discharge or death. The chest radiograph on the day of the study was reviewed for each patient and the extent of pulmonary infiltrates was scored as bilateral, unilateral, or none.

Lower respiratory tract sampling

According to the clinical condition of the patients, lower respiratory tract specimens were obtained either non-invasively by tracheobronchial aspirates (TBAS, standard sputum trap; Proctor, Barcelona, Spain) or bronchoscopically by protected specimen brush (PSB, Microbiology brush; Mill-Rose Laboratories Inc, Mentor, Ohio, USA) within the first 24 hours after onset of the disease. Fibreoptic bronchoscopy was performed without interrupting mechanical ventilation through the endotracheal tube using a special adapter. The fibreoptic bronchoscope (BF30, Olympus, New Hyde Park, New York, USA) was introduced without bronchial suctioning after adequate sedation and no local anaesthetics were administered. The setting of the ventilator was adapted appropriately during the procedure to ensure ventilation and oxygenation. The PSB was used as described by Wimberley and co-workers. Microbiological processing The PSB was aseptically cut into a sterile tube containing 1 ml of Ringer’s lactate and shaken for one minute. Serial dilutions (10⁴, 10³, 10²) from each PSB and TBAS sample were prepared in sterile normal saline. One hundred ml of each dilution was inoculated into the following agar media: 5% sheep blood, chocolate, MacConkey, blood charcoal yeast extract (BCYE-a), and Sabouraud-dextrose. All cultures were incubated at 37°C under aerobic and anaerobic conditions. Cultures were evaluated for growth 24 and 48 hours later and discarded five days later if negative, except for CDC and Wilkins-Chalgren media which were evaluated at seven days and Sabouraud medium which was evaluated at four weeks. Gram stains were performed on all samples. All microorganisms isolated were identified by standard laboratory methods. The following thresholds for quantitative cultures were used: PSB ≥10⁴ cfu/ml, TBAS ≥10³ cfu/ml, and the following microorganisms were considered

DEFINITIONS AND STUDY GROUPS

Acute respiratory distress syndrome (ARDS) The following criteria for the diagnosis of ARDS were applied as defined by the American-European Consensus Conference: (1) acute onset of the syndrome, (2) PaO₂/FI O₂ ratio ≤ 200 with positive end expiratory pressure applied (PEEP), (3) generalised pulmonary infiltrates involving at least two quadrants on the chest radiograph, and (4) wedge pressure ≤18 mm Hg in patients with a pulmonary artery catheter present or no clinical signs of congestive heart failure. In addition, a score of ≥2.5 according to Murray and co-workers was required. Causes of ARDS were classified as direct (pneumonia, aspiration or thorax trauma) or indirect lung injury (extrapulmonary source of inflammation, sepsis or shock).

Severe pneumonia Pneumonia was suspected clinically in the presence of new infiltrates on the chest radiograph and two of the following criteria: fever ≥38.3°C or hypothermia ≤35.0°C, purulent secretions, or leucocytosis (≥12 000/mm³) or leucopenia (≤4000/mm³). According to the length of hospital stay the episode of pneumonia was classified as either community acquired (<72 h) or nosocomial (≥72 h). All patients were intubated and mechanically ventilated in the ICU, thus fulfilling the criteria for severe pneumonia.

Controls This group included only patients who met the following criteria: (1) intubated and mechanically ventilated, (2) absence of any clinical signs of infection, (3) absence of any of the criteria of the above two groups; (4) bronchoscopic examination indicated for other reasons such as tube malposition, minor haemoptysis, or visual inspection of the tracheobronchial tree.

Exclusion criteria Patients with positive serology for human immunodeficiency virus (HIV), cerebral injury, presence of immunosuppression, or coagulation disorders were excluded. In each case family members gave informed consent for the study and the study was approved by the ethical committee of our centre.

Cytokine assays
To determine blood concentrations of TNF-α, IL-1β, and IL-6, blood samples were collected in sterile tubes not containing anticoagulants during the first 24 hours after diagnosis, centrifuged at 3000 rpm for 10 minutes, and stored at −70°C until processing. The solid phase enzyme linked immunosorbent assay (ELISA) used was based on the quantitative immunometric sandwich enzyme immunoassay technique on a microtitre plate (EASIA: Enzyme Amplified Sensitivity Immunoassay, Medgenix Diagnostics SA, Fleurus, Belgium) which uses a murine monoclonal antibody specific for the cytokine to be analysed coated onto the microtitre plate to create the solid phase. The results were expressed as pg/ml of serum. The sensitivity of the technique allows the detection of levels as low as 3 pg/ml for TNF-α and 2 pg/ml for IL-1β and IL-6, respectively.

**STATISTICAL ANALYSIS**
For the comparison of serum cytokine concentrations between patients with ARDS, severe pneumonia, and controls without inflammatory lung disease receiving mechanical ventilation the t test was used for comparison of quantitative variables of the two groups. For the comparison of more than two groups an analysis of variance (ANOVA) with post hoc test was used for comparison of cell frequencies <5) was used to compare proportions.

Comparative evaluation of possible determinants of serum cytokine concentrations in this population by multivariate analysis was performed using a multiple linear regression in a stepwise forward model with cytokine levels (TNF-α, IL-1β, IL-6) as the dependent variable. The diagnosis was recorded (ARDS = 2, severe pneumonia = 1, controls = 0) and tested pairwise with the following severity parameters: extent of pulmonary infiltrates (bilateral = 2, unilateral = 1, none = 0), lung injury score, and the simplified acute physiology score (SAPS II).

The significance level of all analyses was 5%. Results are expressed as mean (SD) and 95% confidence intervals (CI) are given for all comparisons. All data were analysed and processed on SPSS version 8.01.

**Results**
Forty six patients with ARDS (32 men), 20 with severe pneumonia (17 men), and 10 controls (eight men) were included in the study. The cause of ARDS was direct lung injury in 26 cases (57%; aspiration (n = 5, 19%), community acquired pneumonia (n = 12, 46%), nosocomial pneumonia (n = 8, 31%), other (n = 1, 4%) and indirect in 20 cases (43%; sepsis (n = 14, 70%), other (n = 6, 30%). Severe pneumonia was nosocomial in 12 of the 20 patients (60%) and community acquired in eight; 10 of the 20 patients with severe pneumonia had unilateral pulmonary infiltrates and 10 had bilateral pulmonary infiltrates. The demographic characteristics are summarised in table 1. Patients with ARDS were significantly younger than patients with severe pneumonia (mean difference –9.8, 95% CI –8.1 to –1.6, had a higher SAPS II (mean difference 10.9, 95% CI 2.4 to 19.4; p = 0.007), and a higher lung injury score (mean difference 1.1, 95% CI 0.8 to 1.4; p<0.001). The total length of stay in the ICU was similar for the patients with ARDS and those with severe pneumonia, but significantly shorter for control patients than for those with ARDS (mean difference –11.5, 95% CI –23.0 to –0.04; p = 0.049). The causes of ICU admission varied between the diagnostic groups and most patients received antibiotic treatment on the day of the study. Patients with severe pneumonia had an intravenous dose of corticosteroid medication prior to blood sampling more frequently than those with ARDS (55% versus 26%; mean difference

<table>
<thead>
<tr>
<th>Variable</th>
<th>ARDS (n = 46)</th>
<th>Severe pneumonia (n = 20)</th>
<th>Controls (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>57.2 (15.2)</td>
<td>67.1 (6.4)</td>
<td>65.6 (6.4)</td>
</tr>
<tr>
<td>SAPS II</td>
<td>43.8 (13.7)</td>
<td>32.9 (9.9)</td>
<td>34.6 (14.3)</td>
</tr>
<tr>
<td>Lung injury score</td>
<td>2.9 (0.9)</td>
<td>1.8 (0.6)</td>
<td>0.9 (0.4)</td>
</tr>
<tr>
<td>Leucocyte count (mm³)</td>
<td>114 (47)</td>
<td>251 (102)</td>
<td>428 (102)</td>
</tr>
<tr>
<td>Duration of mechanical ventilation until the study (days)</td>
<td>146 (192)</td>
<td>103 (120)</td>
<td>89 (84)</td>
</tr>
<tr>
<td>Cause of ICU admission (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community acquired pneumonia</td>
<td>8 (17)</td>
<td>7 (35)</td>
<td>—</td>
</tr>
<tr>
<td>Nosocomial pneumonia</td>
<td>9 (20)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Exacerbation of COPD</td>
<td>2 (4)</td>
<td>3 (15)</td>
<td>4 (40)</td>
</tr>
<tr>
<td>Other respiratory disease</td>
<td>2 (4)</td>
<td>1 (5)</td>
<td>1 (10)</td>
</tr>
<tr>
<td>Severe sepsis or shock</td>
<td>14 (30)</td>
<td>15 (75)</td>
<td>—</td>
</tr>
<tr>
<td>Neurological</td>
<td>2 (4)</td>
<td>2 (10)</td>
<td>5 (50)</td>
</tr>
<tr>
<td>Trauma</td>
<td>2 (4)</td>
<td>2 (10)</td>
<td>—</td>
</tr>
<tr>
<td>Postoperative</td>
<td>15 (33)</td>
<td>4 (20)</td>
<td>—</td>
</tr>
<tr>
<td>Others</td>
<td>1 (5)</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

SAPS = simplified acute physiology score; Pao₂ = arterial oxygen tension; PinO₂ = fractional inspired oxygen concentration.

*Total greater than 100% due to multiple causes.
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29%, 95% CI 3.8 to 54.2; p = 0.0473). The percentage of patients who had received antibiotic treatment prior to sampling was similar in all groups (ARDS, 100%; severe pneumonia, 100%; controls, 80%; p = NS).

BACTERIOLOGY

In patients with ARDS the microorganisms recovered most frequently from respiratory specimens were Pseudomonas spp (n = 13), S aureus (coagulase negative, n = 17), and Candida spp (n = 16). In patients with severe pneumonia Pseudomonas spp (n = 8), S aureus (coagulase positive, n = 6), and S pneumoniae (n = 6) were among the most common pathogens. The microorganisms recovered from controls consisted predominantly of non-pathogenic microorganisms such as Candida spp (n = 4) and Strep viridans (n = 3), and in four cases the samples were sterile.

When only potentially pathogenic microorganisms were taken into account the recovery was 20/46 (44%) in patients with ARDS, 11/20 (55%) in patients with severe pneumonia, and 2/10 (20%) in controls. In control patients these were Pseudomonas spp and Proteus mirabilis, respectively. With potentially pathogenic microorganisms above the defined threshold these figures were 13/46 (28%) in ARDS patients, 10/20 (50%) in patients with severe pneumonia, and 11/20 (55%) in patients with severe pneumonia, and 1/10 (10%) in controls.

CYTOKINE LEVELS

TNF-α and IL-6 were detected in all patients with ARDS and severe pneumonia and in nine of the 10 control patients. IL-1β was detectable in 44 of 46 patients with ARDS (96%), nine of 20 patients with severe pneumonia (45%), and in five of the 10 controls.

The raw data and mean levels of all three cytokines for the three groups are shown in fig 1. Serum concentrations of TNF-α were significantly higher in ARDS patients (67 (57) pg/ml) than in patients with severe pneumonia (35 (20) pg/ml; mean difference 32.2, 95% CI 2.3 to 62.3; p = 0.031) or controls (17 (8) pg/ml; mean difference 52.3, 95% CI 11.2 to 89.3; p = 0.007). The serum concentration of IL-1β showed a large variation within groups and the differences observed were therefore statistically not significant when patients with ARDS (34 (65) pg/ml) were compared with those with severe pneumonia (3 (4) pg/ml; mean difference 31.8, 95% CI -1.9 to 65.5; p = 0.071) and controls (6 (11) pg/ml; mean difference 28.2, 95% CI -15.7 to 72.2; p = 0.356). IL-6 concentrations also showed a large interindividual variation and were not significantly different between ARDS patients (712 (1058) pg/ml), those with severe pneumonia (834 (1165) pg/ml; mean difference -124.6, 95% CI -795.5 to 546.3; p = 1.0), or controls (94 (110) pg/ml; mean difference 618.0, 95% CI -256.0 to 1491.9; p = 0.262).

The serum concentrations of cytokines in patients with ARDS were not significantly different when patients with an indirect cause were compared with those with a direct cause of ARDS (TNF-α: 67 (53) versus 67 (60) pg/ml, mean difference -0.74, 95% CI -35.1 to 33.6; p = 0.965; IL-1β: 22 (29) versus 44 (82) pg/ml; mean difference 22.3, 95% CI -61.2 to 16.9; p = 0.256; IL-6: 643 (1068) versus 765 (1068) pg/ml, mean difference -122.4, 95% CI -762.6 to 517.9; p = 0.702).

MULTIVARIATE ANALYSIS

The results of the multiple regression analyses are summarised in table 2. The serum concentrations of TNF-α and IL-1β were most strongly associated with the degree of lung injury as measured by the lung injury score, even when the diagnostic group was included in the statistical model. The extent of pulmonary infiltrates was not better associated with the serum level of TNF-α and IL-1β than in the diagnostic group. When the SAPS II score was also entered into the model in the diagnostic group it improved only the approximation of TNF-α serum levels but not those of IL-1β. IL-6 levels were inconsistent. The diagnostic
ARDS = acute respiratory distress syndrome; TNF-α = tumour necrosis factor α; IL = interleukin; SAPS = simplified acute physiology score.

Results are presented as standardised coefficients (β) with p values in parentheses.

*Parameter not selected in the stepwise forward linear regression model.

Table 3  Mean (SD) cytokine levels of survivors and non-survivors for all patients and for patients with ARDS, severe pneumonia, and control group

<table>
<thead>
<tr>
<th></th>
<th>Survivors</th>
<th>Non-survivors</th>
<th>p value (mean difference, 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>50 (45)</td>
<td>25 (65)</td>
<td>0.834 (~2.4, ~25.6 to 20.7)</td>
</tr>
<tr>
<td>IL-1β</td>
<td>21 (44)</td>
<td>20 (63)</td>
<td>0.770 (3.7, ~21.2 to 28.5)</td>
</tr>
<tr>
<td>IL-6</td>
<td>468 (776)</td>
<td>471 (716)</td>
<td>0.185 (~323.3, ~766.5 to 120.0)</td>
</tr>
<tr>
<td>ARDS</td>
<td>80 (51)</td>
<td>62 (59)</td>
<td>0.323 (18.5, ~18.8 to 59.9)</td>
</tr>
<tr>
<td>IL-1β</td>
<td>51 (94)</td>
<td>28 (80)</td>
<td>0.270 (23.8, ~19.1 to 66.7)</td>
</tr>
<tr>
<td>IL-6</td>
<td>666 (904)</td>
<td>731 (1125)</td>
<td>0.854 (~64.7, ~770.5 to 641.1)</td>
</tr>
<tr>
<td>Severe pneumonia</td>
<td>34 (25)</td>
<td>35 (15)</td>
<td>0.956 (~0.5, ~19.4 to 18.4)</td>
</tr>
<tr>
<td>IL-1β</td>
<td>3 (4)</td>
<td>2 (4)</td>
<td>0.793 (~0.5, ~3.4 to 4.4)</td>
</tr>
<tr>
<td>IL-6</td>
<td>464 (823)</td>
<td>1210 (1371)</td>
<td>0.158 (~745.1, ~1807.6 to 317.4)</td>
</tr>
<tr>
<td>Controls</td>
<td>18 (10)</td>
<td>14 (3)</td>
<td>0.603 (3.2, ~11.6 to 17.0)</td>
</tr>
<tr>
<td>IL-1β</td>
<td>5 (12)</td>
<td>8 (11)</td>
<td>0.786 (~2.2, ~20.6 to 16.2)</td>
</tr>
<tr>
<td>IL-6</td>
<td>100 (132)</td>
<td>87 (28)</td>
<td>0.634 (39.3, ~84.4 to 163.0)</td>
</tr>
</tbody>
</table>

ARDS = acute respiratory distress syndrome; TNF-α = tumour necrosis factor α; IL = interleukin.

Discussion

The results of this study show that serum concentrations of TNF-α are significantly higher in patients with ARDS than in those with pneumonia (p < 0.03) or controls (p = 0.007). In the context of ARDS, TNF-α is mainly produced by monocytes and macrophages but may also be released by lymphocytes or mast cells. It triggers the release of other inflammatory mediators and stimulates recruitment of polymorphonuclear neutrophils from the vascular compartment. The role of TNF-α in patients with ARDS is not fully understood. Persistent high levels of this cytokine caused by extrapulmonary sources of infection such as sepsis may, on the one hand, induce fever and increased capillary permeability in the lung which is part of the pathogenesis of ARDS. On the other hand, ARDS may be induced by direct lung injury such as aspiration and serum TNF-α levels would only reflect the systemic response to the initial local challenge. However, in our study we did not find any differences in serum TNF-α concentrations in patients with direct or indirect lung injury. Although Gattinoni and co-workers recently established differences in pulmonary mechanics, the inflammatory response in the serum does not seem to be helpful for differentiating between patients with these two aetiologies of ARDS.

In patients with pneumonia the lung is the site of the initial inflammatory response to respiratory pathogens and there is clear indication that TNF-α is a key mediator. In contrast to ARDS there is evidence from animal studies that the inflammatory response in pneumonia, as measured by TNF-α release, is initially confined to the compartment of the lung and systemically circulating cytokines may not be present. In subjects with unilateral pneumonia, Dehoux and co-workers found higher TNF-α levels in the BAL fluid of the involved lung than in the non-involved lung. However, with increasing severity circulating cytokines may also be present in the serum of patients with pneumonia. Detectable levels of TNF-α in serum have been reported in patients with community acquired or severe pneumonia. In our study all patients with severe pneumonia had detectable TNF-α levels, thus confirming TNF-α as a severity marker in pneumonia.

In the multivariate analyses the lung injury score was the factor which agreed most closely with TNF-α serum levels. Two major factors may have contributed to these results. Firstly, in some cases a positive differential diagnosis between ARDS and severe pneumonia with bilateral pulmonary infiltates cannot always be easily established. This problem has also been recognised by the American-European Con-
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sensus Conference on ARDS which states that pulmonary infection may be considered to be ARDS if the physiological criteria are met.21 Furthermore, direct lung injury due to pulmonary infection is a common aetiology of ARDS.22 Although in this study every attempt was made to keep these two clinical entities apart, a diagnostic overlap cannot be entirely ruled out. Secondly, systemically circulating TNF-α might have little or no discriminating potential between ARDS and severe pneumonia. Schütte and co-workers also acknowledged this diagnostic overlap and analysed an intermediate group of patients with ARDS and signs of pulmonary infection separately from those with a clear aetiology.23 However, even then they could not find any differences in systemic TNF-α release on the first day of the disease between patients with pneumonia and those with ARDS. In our study serum TNF-α concentrations were higher in patients with ARDS but the degree of lung injury was clearly a better predictor of TNF-α levels. This measurement includes the radiological extent of the infiltrates but also takes into account additional measurements such as the Pao2/Fio2 ratio, the level of positive end expiratory pressure (PEEP), and the pulmonary compliance.20 This supports the view that the level of circulating TNF-α increases with the degree of lung injury, which can be similar in patients with ARDS and severe pneumonia, but it does not help to clarify the aetiology of the lung injury.23 24 TNF-α and IL-1β have similar effects on cellular functions and are usually classified together, according to their position in the inflammatory cascade, as proximal cytokines.20 Their association with the severity markers tested in the multivariable analysis was found to be similar (table 2).

In this study interpretation of the serum IL-6 concentrations was difficult because the results showed a large variation and the multivariable testing yielded inconsistent results (table 2). IL-6 is located more distally in the inflammatory cascade (distal cytokine) and its main physiological effects differ from those of TNF-α and IL-1β. The systemic effects of IL-6 include induction of fever, production of acute phase proteins in the liver such as C reactive protein, and regulation of the immune response. This might explain, at least in part, why serum levels of IL-6, unlike those of TNF-α and IL-1β, were also associated with the SAPS II score.

Various attempts have been made to associate the cytokine concentrations with the prognosis but most studies have failed to establish a clear relationship between the two, at least during the early stages of the disease. In a very selected population of patients with ARDS Meduri and co-workers found significantly higher levels of cytokines in non-survivors during the early course of the disease but the prognostic value improved when the time course of these inflammatory response was taken into account.21 25 Since cytokines were only measured in our study at the onset of the disease, this might explain why neither univariate nor multivariate analysis supported any prognostic value for serum cytokine levels.

Three possible limitations of this study should be addressed. Firstly, the use of corticosteroids is known to interfere with serum cytokine levels. Meduri and co-workers found that corticosteroid rescue treatment led to an improvement in the lung inflammatory response in patients with ARDS and, in particular, decreased levels of cytokines in plasma.20 Although we recorded the prior use of intravenous corticosteroids, we did not investigate the actual and cumulative doses. Secondly, the prognostic properties of serum cytokine levels were not a primary or secondary objective of this study and the data introduced should be interpreted with caution. Thirdly, cytokines are part of an inflammatory cascade and biological effects are difficult to interpret without appreciation of the entire network of the inflammatory response. However, since one objective of this study was to investigate the possible discriminatory potential of cytokines, we focused in this report on pro-inflammatory cytokines which may be present in most clinical settings.

In conclusion, we found increased levels of TNF-α in patients with ARDS compared with patients with severe pneumonia or intravenous corticosteroids without inflammatory lung disease. However, this reflects the extent of pulmonary inflammatory disease rather than a diagnostic entity. Serum levels of IL-1β also increased with the extent of lung injury but were not significantly different between the diagnostic groups.

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