ELEVATED CARBOHYDRATE-DEFICIENT TRANSFERRIN PREDICTS PROLONGED INTENSIVE CARE UNIT STAY IN TRAUMATIZED MEN

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Abstract — Carbohydrate-deficient transferrin (CDT) is reported to have a higher specificity in alcoholism than conventional markers. As the morbidity and mortality rates amongst chronic alcoholics are raised following trauma, the objective was to investigate if CDT could be used to predict prolonged intensive care unit (ICU) stay and an increased morbidity in patients with multiple injuries admitted to the ICU. In this prospective double-blind study, 66 traumatized male patients were transferred to the ICU following admission via the emergency room and operative management. Blood samples for CDT determination were taken upon admission to the emergency room, the ICU and on days 2 and 4 following admission. The patients were allocated a priori to two groups: high CDT group (CDT >20 U/l on admission to the emergency room) and low CDT group (CDT <20 U/l). CDT values were determined by microanion-exchange chromatography and radioimmunoassay. Thirty-six patients had an elevated CDT value on admission to the emergency room. The high CDT group had a significantly prolonged ICU stay (median high CDT group: 13 days; median low CDT group: 5 days). Major intercurrent complications, such as alcohol-withdrawal syndrome, tracheobronchitis, pneumonia, pancreatitis, sepsis, and congestive heart failure, were significantly increased in the high CDT group. The increased risk of pneumonia in the high CDT group may be related to the significantly increased period of mechanical ventilation. As high CDT values were associated with an increased risk of intercurrent complications and a prolonged ICU stay, it seems reasonable to use CDT as a marker in intensifying research work into preventing alcoholism-associated complications.

INTRODUCTION

Almost half of all trauma beds are occupied by patients who have been injured while under the influence of alcohol (Gentilello et al., 1995). The prevalence of chronic alcoholics among traumatized patients admitted to the intensive care unit (ICU) is reported to range from 23 to 68% (Hervé et al., 1986; Spies et al., 1996a). A subsequent intensive care stay may be complicated by the development of alcoholism-related complications. In ICU wards, the rate of morbidity and mortality is reported to be two to four times greater in chronic alcoholics (Jensen et al., 1988; Spies et al., 1996a). The incidence of infections, cardiopulmonary insufficiency, and alcohol-withdrawal syndrome has been noted to be increased in traumatized men admitted to the ICU (Spies et al., 1996a). Chronic alcoholics have been reported to have an altered immune status (Jerrells, 1993; Wang et al., 1994), which may play a role in the development of infections during ICU stay.

The occurrence of post-traumatic alcoholism-related complications illustrates the importance of the precise diagnosis of alcoholism. An alcohol-related history and completed questionnaires on alcoholism (Selzer et al., 1975; Ewing, 1984; American Psychiatric Association, 1987) are frequently unobtainable in cases of traumatized patients, owing to their injuries and subsequent intubation. Therefore, laboratory tests with sufficient sensitivity and specificity, such as carbohydrate-deficient transferrin (CDT), may assist in the diagnosis and the possible prevention of these complications. A regular intake of alcohol results in increased levels of transferrin isoforms (Stibler, 1991). These are deficient of carbohydrate and have an elevated isoelectric point. A chronic daily intake of more than 50 to 80 g of alcohol for

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longer than a week is reported to increase CDT levels. The half-life of CDT has been reported to be approximately 2 weeks (Stibler, 1991), but in intensive care patients it has been reported to be much shorter (Spies et al., 1995).

The objective of this study was to investigate whether an elevated CDT value on admission to the ICU can predict a prolonged ICU stay (primary outcome measure) and whether CDT is a predictor of intercurrent complications (secondary outcome measure).

SUBJECTS AND METHODS

Patients

This prospective double-blind controlled clinical trial comprised the study of 66 male traumatized patients following their admission to the emergency room and transfer to the ICU for further medical care. The inclusion criteria for admission to the ICU consisted of the necessity for mechanical ventilation or observation/therapy due to the risk of organ failure or rupture. Patients were included in the study according to the concept of deferred consent (Biros et al., 1995; Levine, 1995) i.e. patients or their relatives provided their written informed consent to participate in this institutionally approved study (Review Board: Ethical Committee of the Benjamin Franklin Medical School, Free University of Berlin). The study was conducted over a period of 18 months.

Basic patient characteristics were documented (Table 1); these included age, height, weight, Trauma Score and Injury Severity Score (TRISS) (Parr and Grande, 1993), and Acute Physiology and Chronic Health Evaluation score (APACHE II) (Knaus et al., 1985). Women and patients under 18 years of age were excluded from the study. Women were excluded because the prevalence of alcoholism in traumatized women is reported to be lower, whereas CDT values are reportedly higher (Stibler, 1991). The following were also excluded: patients who had received a blood transfusion or more than 2 l fluid replacement prior to admission and patients with liver cirrhosis (Child B or C, liver biopsy) or severe head injury requiring barbiturate coma or hypothermia. The patient's history was obtained from the patient or the relatives along with the results of alcoholism-related questionnaires, the CAGE Questionnaire and the short Michigan Alcoholism Screen Test (sMast) (Selzer et al., 1975; Ewing, 1984). A chronic alcoholic was defined according to the DSM-III-R criteria (American Psychiatric Association, 1987). Patients with a CAGE = 0, a sMAST ≤1 and a daily alcohol intake <20 g were considered as non-alcoholics, all others who failed to meet the above-mentioned criteria were characterized as social drinkers.

A total of 156 consecutive patients were seen in the emergency room. Thirty-eight patients or their relatives refused to give their consent to participate in this study. A further 19 patients received a fluid replacement of more than 2 l or a blood transfusion prior to CDT sampling in the emergency room, and were therefore excluded owing to the fact that CDT sensitivity and specificity may have been influenced (Spies et al., 1995). A further 27 patients were also excluded, because they were not admitted to the ICU, two patients because of liver cirrhosis (Child B and C) and four patients because of severe head injury with subsequent treatment for barbiturate coma or hypothermia.

Protocol and laboratory markers

Blood sampling was performed via an intraarterial pressure line on both admission to the emergency room and to the ICU, and also on days 2 and 4 following admission to the ICU. Conventional laboratory parameters, such as mean corpuscular volume (MCV), aspartate aminotransferase (AST), alanine aminotransferase (ALT) and γ-glutamyltransferase (GGT), were obtained in accordance with clinical routine. Blood-alcohol concentration (BAC) was drawn only on admission and was determined by gas chromatography. The blood for the CDT kit was drawn in a separate vacutainer (Vacutainer™, Becton Dickinson Inc., Meylan Cedex, France). The blood was immediately centrifuged at 3000 rpm for 10 min. Two serum samples were then cooled to −80°C. CDT samples were blinded by four digits. The samples were sent to Pharmacia AB Diagnostics (CDTect™, Freiburg, Germany and Uppsala, Sweden), where they were determined by microanion exchange chromatography and radioimmunoassay. The time required for obtaining the results of the CDT test is approximately 4 to 5 h. Once all the case report
forms had been concluded, the CDT values were made available to us by Pharmacia AB.

The normal range for CDT is up to 20 U/l for males. A value above 20 U/l CDT is defined as pathologically elevated (CDTect™). Therefore, patients were a priori assigned to the following groups: high CDT group, CDT >20 U/l on admission to the emergency room; and low CDT group, CDT ≤20 U/l.

Documentation

Fluid administration (crystalloids, colloids, albumin, blood transfusions) was recorded. Diagnoses, intensive care therapy (i.e. medication), operations, and the length of ICU stay were documented. Vital signs, laboratory markers and post-traumatic complications were also documented. Infections were determined with respect to the Centers for Disease Control (CDC) criteria (Garner et al., 1988). All patients with pneumonia had a new pulmonary infiltrate as revealed in X-rays of the chest, new onset of purulent sputum or change in character of sputum, and rales or dullness to percussion present on examination in an area corresponding with the infiltrate. In the high CDT group, 29/36 and in the low CDT group, 23/30, patients were treated with antibiotics on admission to the ICU (best estimate, 95% confidence interval [BE (95% CI)] = -3.9% (-16.0-23.8%), see Statistical analysis). All patients treated with antibiotics on admission to the ICU received cefotiam with the exception of five patients in the high CDT and six patients in the low CDT group, who had open skull fractures and cerebrospinal fluid leakage and were treated with ceftazidime and flucloxacillin [BE (95% CI) = -6.1% (-24.4-12.1%), see Statistical analysis], and also one patient in the low CDT group, with a cephalosporin allergy who was treated with ciprofloxacin. During ICU stay, the antimicrobial regime was adapted to the susceptibility of isolated organisms. When a patient developed pneumonia and no organism was isolated, cefotaxim and gentamicin were administered. Sepsis was defined according to the Society of Critical Care Medicine Consensus Conference (Members of the American College of Chest Physicians/Society of Critical Care Medicine, 1992). The differential diagnosis of the alcohol-withdrawal syndrome was performed by means of an accepted algorithm (Cassem, 1989).

A shortened 10-item scale, the revised Clinical Institute Withdrawal Assessment for alcohol scale (CIWA-Ar), for clinical quantification of the severity of the alcohol-withdrawal syndrome was used (Sullivan et al., 1989). Diagnosis was confirmed by a participating neurologist. Symptoms and therapeutic regimes were recorded in the study protocol. In subjects in whom the alcohol-withdrawal syndrome developed, therapy with flunitrazepam or with clonidine plus haloperidol was administered (Spies et al., 1996c).

Statistical analysis

All data were expressed as medians and ranges. The best estimate (BE) with its 95% confidence interval (95% CI) is given so as to compare the difference between the two groups’ proportions regarding the occurrence of complications and death (Gardner and Altman, 1992). Statistical analysis was performed by the Wilcoxon rank sum test for determining intergroup differences. A two-tailed $P < 0.05$ was considered significant.

RESULTS

According to the CDT values sampled on admission to the emergency room (Fig. 1), 36 patients were assigned to the high, and 30 patients...
Table 1. Basic patient characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>High CDT group (n = 36)</th>
<th>Low CDT group (n = 30)</th>
<th>Significance (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>34 (18–59)</td>
<td>37 (18–72)</td>
<td>0.41</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>180 (170–188)</td>
<td>180 (155–186)</td>
<td>0.31</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>76 (58–100)</td>
<td>80 (44–110)</td>
<td>0.81</td>
</tr>
<tr>
<td>APACHE II (on admission to ICU)</td>
<td>15 (2–28)</td>
<td>14 (6–50)</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Values are given as median with the range in parentheses. APACHE, Acute Physiology, Age and Chronic Health Evaluation score; ICU, intensive care unit.

to the low, CDT group. In cases where CDT was negative, the other parameters detected chronic alcoholics by GGT in 12% (95% CI: 4–27%), by MCV in 2% (95% CI: 0–13%), by ALT in 5% (95% CI: 1–16%), by AST in 12% (95% CI: 4–26%), and by CAGE and sMAST in 21% (95% CI: 11–38%). In contrast, in cases where CDT was positive, GGT did not detect chronic alcoholics in 33% (95% CI: 19–50%), MCV in 68% (95% CI: 52–82%), ALT in 39% (95% CI: 24–56%), AST in 17% (95% CI: 7–32%), and CAGE and sMAST in 0% (95% CI: 0–9%). Following admission to the emergency room, CDT values in the high CDT group declined. During ICU stay, CDT values did not differ significantly at any measurement point between the two groups (Fig. 1).

The two CDT-based groups did not differ with regards to basic patient characteristics, the Acute Physiology, Age and Chronic Health Evaluation score (APACHE II, Table 1) or the Trauma and Injury Severity Score (TRISS, Table 2) on admission. All patients had undergone blunt trauma, with the exception of two patients in each group with penetrating injuries. The patients’ type of trauma and the frequency of surgery prior to admission to the ICU did not differ significantly between groups (Table 2). However, when considering all operations prior to and following admission to the ICU, the frequency of surgery was significantly increased in the high CDT group.

Table 2. Trauma-related data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>High CDT group (n = 36)</th>
<th>Low CDT group (n = 30)</th>
<th>Significance (P) and BE (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRISS score</td>
<td>0.905 (0.0–0.998)</td>
<td>0.921 (0.0–1.000)</td>
<td>P = 0.62</td>
</tr>
<tr>
<td>Type of trauma</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>26/36</td>
<td>23/30</td>
<td>BE (95% CI) = −4.5% (−25.5–16.5%)</td>
</tr>
<tr>
<td>Facial</td>
<td>16/36</td>
<td>15/30</td>
<td>−5.6% (−29.7–18.5%)</td>
</tr>
<tr>
<td>Thoraco-abdominal</td>
<td>17/36</td>
<td>12/30</td>
<td>7.2% (−16.7–31.1%)</td>
</tr>
<tr>
<td>Skeletal</td>
<td>22/36</td>
<td>14/30</td>
<td>14.7% (−9.2–38.6%)</td>
</tr>
<tr>
<td>Surgery (prior to admission to ICU)</td>
<td>33/36</td>
<td>24/30</td>
<td>BE (95% CI) = 11.7% (−5.2–28.6%)</td>
</tr>
<tr>
<td>Type of surgery (prior to admission to ICU)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Craniotomy</td>
<td>2/36</td>
<td>4/30</td>
<td>BE (95% CI) = −7.7% (−22.0–6.6%)</td>
</tr>
<tr>
<td>Bowel resection</td>
<td>1/36</td>
<td>1/30</td>
<td>0.5% (−7.9–8.9%)</td>
</tr>
<tr>
<td>Osteosynthesis</td>
<td>19/36</td>
<td>14/30</td>
<td>6.1% (−18.0–30.2%)</td>
</tr>
<tr>
<td>Wound surgery</td>
<td>11/36</td>
<td>8/30</td>
<td>10.0% (−11.8–31.8%)</td>
</tr>
<tr>
<td>Type of surgery (following admission to ICU)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgical revision due to bleeding</td>
<td>4/36</td>
<td>0/30</td>
<td>BE (95% CI) = 11.1% (0.8–21.4%)</td>
</tr>
<tr>
<td>Osteosynthesis</td>
<td>28/36</td>
<td>5/30</td>
<td>61.0% (42.0–80.0%)</td>
</tr>
<tr>
<td>Total surgery prior to and following ICU admission</td>
<td>65/36</td>
<td>29/30</td>
<td>BE (95% CI) = 83.9% (76.8–90.7%)</td>
</tr>
</tbody>
</table>

Values are given as median with the range in parentheses and frequencies. BE (95% CI), best estimate (95% confidence interval); TRISS, Trauma and Injury Severity Score; ICU, intensive care unit.
CDT AS A PREDICTOR OF ICU STAY IN TRAUMATIZED MEN

Table 3. Alcoholism-related and laboratory data on admission to the emergency room

<table>
<thead>
<tr>
<th>Parameter</th>
<th>High CDT group (n = 36)</th>
<th>Low CDT group (n = 30)</th>
<th>Significance (P and BE (95% CI))</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of chronic alcoholics</td>
<td>32/36</td>
<td>9/30</td>
<td>BE (95% CI) = 58.8% (39.4–78.2%)</td>
</tr>
<tr>
<td>Daily ethanol consumption (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Last month</td>
<td>100 (0–280)</td>
<td>17 (0–260)</td>
<td>P &lt; 0.01</td>
</tr>
<tr>
<td>Last week</td>
<td>100 (0–280)</td>
<td>17 (0–260)</td>
<td>P &lt; 0.01</td>
</tr>
<tr>
<td>Last 2 days</td>
<td>100 (0–350)</td>
<td>30 (0–260)</td>
<td>P &lt; 0.01</td>
</tr>
<tr>
<td>CAGE score</td>
<td>3 (0–4)</td>
<td>0 (0–4)</td>
<td>P &lt; 0.01</td>
</tr>
<tr>
<td>sMAST score</td>
<td>5 (0–15)</td>
<td>1 (0–13)</td>
<td>P &lt; 0.01</td>
</tr>
<tr>
<td>BAC (mg/dl)</td>
<td>0.11 (0.0–2.84)</td>
<td>0.0 (0.0–1.03)</td>
<td>P &lt; 0.01</td>
</tr>
<tr>
<td>GGT (U/l)</td>
<td>29 (8–668)</td>
<td>18 (7–172)</td>
<td>P = 0.03</td>
</tr>
<tr>
<td>AST (U/l)</td>
<td>28 (8–212)</td>
<td>19 (8–339)</td>
<td>P = 0.04</td>
</tr>
<tr>
<td>ALT (U/l)</td>
<td>21 (5–317)</td>
<td>15 (4–407)</td>
<td>P = 0.02</td>
</tr>
<tr>
<td>MCV (fl)</td>
<td>92.7 (84.8–106.9)</td>
<td>90 (82–108.3)</td>
<td>P = 0.04</td>
</tr>
<tr>
<td>Hb (g/dl)</td>
<td>10.6 (7.1–15)</td>
<td>12.2 (6.8–15.8)</td>
<td>P = 0.13</td>
</tr>
<tr>
<td>Hct (l/l)</td>
<td>0.32 (0.20–0.63)</td>
<td>0.36 (0.17–0.47)</td>
<td>P = 0.22</td>
</tr>
</tbody>
</table>

Values are given as median with the range in parentheses and frequencies. BE (95% CI), best estimate (95% confidence interval); CDT, carbohydrate-deficient transferrin; CAGE, alcoholism-related questionnaire; sMAST, short Michigan Alcoholism Screening Test; BAC, blood-alcohol concentration; GGT, y-glutamyl transferase; AST, aspartate aminotransferase; ALT, alanine aminotransferase; MCV, mean corpuscular volume; Hb, haemoglobin; Hct, haematocrit.

(Table 2). There was, however, no significant difference in the frequency of polytraumatized patients between groups [high CDT group: 14/36, low CDT group: 10/30; BE (95% CI) = 5.6% (−17.5–28.7%)]. Mean arterial pressure did not differ between groups on admission to the trauma centre [high CDT group: median 88 mmHg (range 59–113 mmHg), low CDT group: 82 mmHg (54–132 mmHg), P = 0.88]. Haemoglobin and haematocrit values also did not differ between the high and low CDT groups on admission to the emergency room (Table 3). Apart from one patient in the low CDT group, who had coronary artery disease, none of the patients had relevant additional diagnoses (pulmonary, cardiac, hepatic or renal). The prevalence of smoking differed significantly between groups [high CDT group: 21/36; low CDT group: 9/30; BE (95% CI) = 28.3% (5.3–51.3%)]. Groups differed in terms of their alcoholism-related history, as well as BAC, GGT, MCV, and AST on admission to the emergency room (Table 3).

The median time frame between admission to the emergency room and to the ICU was 5 h (range 1–21 h) in the high CDT group and 4 h (range 1–17 h) in the low CDT group (P = 0.46). The ICU stay in the high CDT group was significantly prolonged, with a median prolongation of 8 days (Fig. 2). During ICU stay, there was a significant increase in the occurrence of the alcohol-withdrawal syndrome and infections such as tracheobronchitis, pneumonia, pancreatitis, sepsis, and congestive heart failure (Fig. 3). The frequency of intubation and mechanical ventilation did not differ significantly between groups [high CDT group: 29/36; low CDT group: 24/30; BE (95% CI) = 0.5% (−18.8–9.7%)]. Nevertheless, the
INTERCURRENT COMPLICATION RATE IN THE HIGH AND LOW CARBOHYDRATE-DEFICIENT TRANSFERRIN (CDT) GROUPS

High CDT group (pathologically elevated CDT >20 U/l on admission to the emergency room) and low CDT group (CDT within normal values ≤20 U/l). AWS, alcohol-withdrawal syndrome; URTI, upper respiratory tract infection; CHF, congestive heart failure; BE (95% CI), best estimate (95% confidence interval).

Period of mechanical ventilation was significantly prolonged in the high CDT group (high CDT group: median 5.5 days, range 0–31 days; low CDT group: median 2.0 days, range 0–21 days; P = 0.04). Both the incidence of bleeding episodes which required transfusions [high CDT group: 24/36; low CDT group: 12/30; BE (95% CI) = 26.7% (3.5–50.0%)] and surgical revision (see Table 2) were significantly increased in the high CDT group. The mortality rate did not significantly differ between groups [high CDT group: 3/36; low CDT group: 3/30; BE (95% CI) = −1.7% (−15.7–12.3%)].

DISCUSSION

Trumatized males with a pathologically elevated CDT value on admission to the emergency room had a significantly prolonged ICU stay. The median difference between groups was 8 days. This resulted in extra costs of approximately US$12,000 per patient with an elevated CDT value admitted to our hospital. An elevated CDT not induced by alcohol is extremely unusual (Stibler, 1991). The prevalence of chronic alcoholics in the high CDT group was significantly higher in comparison with the low CDT group. Thus, 89% of the patients in the high CDT group were chronic alcoholics. The ICU stay of traumatized chronic alcoholics has also previously been reported to be prolonged (Spies et al., 1996a).

Of the four patients with false positive CDT values, three patients were social drinkers who had acutely misused ethanol. In these patients, the median intake during the 2 days prior to admission was 120 g ethanol per day (range 80–180 g). Of the low CDT group 30% were chronic alcoholics. False negatives may be due to haemorrhage and volume replacement before admission to the ICU (Spies et al., 1995). Despite this, the haemoglobin and haematocrit values before admission to the emergency room did not differ between chronic alcoholics in the high CDT group and those in the low CDT group. Therefore, the present data provide no explanation of the false negative findings.

In the present study, the relevance of CDT compared to the conventional laboratory markers detecting high-risk patients revealed that these latter markers may add to the diagnosis of high alcohol consumption, particularly GGT and AST in cases where CDT is negative. Additional sensitivity gained by GGT and AST was 12%. This is in accordance with a previous study by Huseby et al. (1997), who showed that CDT and GGT had variant responses to alcohol consumption. The CAGE and sMAST were even superior to the other laboratory markers in cases where CDT was negative. However, it may prove difficult to perform these questionnaires on patients with multiple injuries, as they are usually already sedated, intubated, and ventilated on admission to the emergency room or to the ICU, before the onset of alcohol-withdrawal syndrome.

The incidence of the alcohol withdrawal syndrome significantly differed between the two CDT-based groups. According to DSM criteria, the alcohol-withdrawal syndrome develops in alcohol-dependent patients. Nonetheless, CDT is only a marker for alcoholism and cannot differ between patients who are alcohol-dependent and chronic misusers according to DSM criteria (Stibler, 1991; Spies et al., 1995). In the high CDT group, 16 patients were alcohol-dependent and 16 were chronic misusers, nine alcohol-dependent patients developed an alcohol-withdrawal syndrome. In the low CDT group, only nine patients were chronic alcoholics, and two patients developed an alcohol-withdrawal syndrome. Therefore, the sensitivity of CDT in alcohol-dependent patients was 16/18 = 89% (95% CI: 65–99%) and in chronic misusers 15/25 = 64% (95% CI: 43–82%). These findings
show that the CDT sensitivity did not differ significantly with respect to the withdrawal state, and this is in keeping with a previous study by Lesch et al. (1996).

It has previously been demonstrated that traumatized chronic alcoholics experience a median of 9 days prolonged ICU stay (Spies et al., 1996a). This was related to a threefold increased intercurrent complications rate (Spies et al., 1996a). In the present study, the differing incidences of the alcohol-withdrawal syndrome may account in part for the significantly prolonged ICU stay. In a different patient population (i.e. patients admitted to the ICU following digestive tract surgery who also developed the alcohol-withdrawal syndrome), the ICU stay was 13 to 14 days longer in comparison with other chronic alcoholics (Spies et al., 1996b).

The prolonged ICU stay is explained to a certain extent by the increased intercurrent infection rate in these patients. The incidences of tracheobronchitis and pneumonia were significantly increased in the high CDT group. The period of mechanical ventilation was also significantly prolonged. In the ICU (Rodriguez, 1994), pneumonia is the most common of the ‘hospital-acquired’ infections. The diagnosis of pneumonia was made using defined criteria for nosocomial infections (CDC, Malangoni et al., 1994). All patients in the current study had developed new or changing infiltrates, as revealed in chest X-rays. This has been shown to distinguish surgical ICU patients with pneumonia from those who have normal colonized respiratory tracts (Mock et al., 1988).

Craven et al. (1986) demonstrated that mechanical ventilation in a high-risk patient is in itself a risk factor for mortality due to pneumonia. Intubation of the trachea has been reported to result in a seven- to 10-fold increase in the occurrence of nosocomial pneumonia (Cross and Roup, 1981; Celis et al., 1988), which may partially explain the overall increased complication rate in the ICU patients investigated when compared to surgical wards (Tønnesen et al., 1992). On admission to the ICU, mechanical ventilatory support was required in most of the patients, due to traumatic injury. The frequency of intubation and mechanical ventilation did not, however, differ between the two CDT-based groups. However, the period of mechanical ventilation was prolonged in the high CDT group. The development of hospital-acquired pneumonia has been reported to be associated with a significant morbidity as demonstrated by an increase in mechanical ventilation and ICU stay (Rodriguez et al., 1991; Rodriguez, 1994). On the other hand, as the number of days on mechanical ventilation increases, the probability of hospital-acquired pneumonia also increases (Rodriguez et al., 1991; Rodriguez, 1994). This may be a result of the therapy used e.g. for the alcohol-withdrawal syndrome.

The severity of the pre-existing illness has also been demonstrated to be closely linked to the risk of developing nosocomial infections (Britt et al., 1978). Apart from one patient in the low CDT group, who had coronary artery disease, none of the other patients included had relevant pre-existing diseases. However, the prevalence of smoking significantly differed between the two groups. Therefore, it cannot be ruled out that the increased infection rate of the pulmonary tract may be due at least partly to the higher prevalence of smoking in the high CDT group.

Between the groups, the small but statistically significant difference in the incidence of sepsis and congestive heart failure may also be due to the fact that there was an increased frequency of chronic alcoholics in the high CDT group. Chronic alcoholics have an altered immune system (Jerrells, 1993; Wang et al., 1994). Therefore, the immune mechanisms for dealing with infections are probably compromised. In this context, it is interesting that the APACHE II (and also the more recent APACHE III score) does not consider chronic alcoholics as a separate risk group (Knaus et al., 1985, 1991). This might be the reason why the APACHE II score in the present study did not differ between groups on admission to the ICU, despite the fact that patients in the high CDT group experienced a prolonged ICU stay, resulting from an increased intercurrent complication rate. This is particularly interesting, as the incidence of bleeding episodes which required transfusions and even surgical revision during ICU stay was also increased in the high CDT group. Inhibition of platelet aggregation has been reported in chronic alcoholics (Rubin and Rand, 1994). During ICU stay, the statistically significant increased frequency of osteosynthesis was caused by wound healing complications in chronic alcoholics (Higgins and du Vivier, 1994), but this type of
surgery would also have been performed on a
normal ward had the patient been transferred there
earlier. This occurred in the low CDT group.

The heart is a major target in relation to the
damaging effects of excessive ethanol consump-
tion (Thomas et al., 1994). The effects of ethanol
on the vasculature, on cardiac metabolism, and on
local and circulating hormone levels, are all
suggested to play a role in the changes in the
heart that eventually lead to decompensation and
cardiac failure (Thomas et al., 1994). Tønnesen et
al. (1992) recently reported that the pre-operative
ejection fraction was decreased in chronic al-
coholics. Although the investigated traumatized
patients in the high CDT group had no history of
congestive heart failure, coronary artery disease or
myocardial infarction before admission to the
hospital, certain factors or possibilities cannot be
ruled out. The patients could already have had a
decreased ejection fraction, silent myocardial
ischaemia or exercise-induced heart failure on
admission.

In conclusion, this study showed that patho-
logically elevated CDT values on admission to the
emergency room were associated with an in-
creased post-traumatic morbidity and a prolonged
ICU stay. Owing to the ability of CDT to identify
patients at risk and as infections were significantly
more frequent in the high CDT group, CDT may
be used as a marker to detect patients at risk and to
intensify research work into changing the immune
status of these patients.

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