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Disturbances of electrolytes and blood chemistry in acute alcohol intoxication

Markus Rauchenzauner[1], **Jordan Kountchev**[1], **Hanno Ulmer**[2], **Christoph Pechlaner**[1], **Romuald Bellmann**[1], **Christian J. Wiedermann**[1], and **Michael Joannidis**[1]

[1] Department of General Internal Medicine, Medical University Innsbruck, Innsbruck, Austria
[2] Institute of Biostatistics, Medical University Innsbruck, Innsbruck, Austria

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Elektrolytstörungen und laborchemische Veränderungen bei akuter Alkoholvergiftung

Zusammenfassung. Über einen Zeitraum von sechs Monaten wurden Prävalenzraten von Elektrolytstörung sowie laborchemischen Veränderung bei Patienten bestimmt, die mit der Diagnose Alkoholvergiftung in die Notfallaufnahme der Universitätsklinik für Innere Medizin in Innsbruck in den Jahren 2000/2001 eingeliefert wurden. Weiters wurde die Wertigkeit der Routineparameter MCV und GGT für die Diagnose von chronischem Alkoholabusus evaluiert.

Die am häufigsten festgestellten Elektrolytstörungen waren Hypernatriämie (41%), Hyperchlorämie (21%), Hypermagnesiämie (17%) und Hypokalzämie (15%), während Hypokaliämie (5%) sowie Hypophosphatämie (3.4%) relativ selten auftraten.

Die auffälligsten biochemischen Veränderungen sind vereinbar mit Zeichen der Leberzellschädigung (erhöhte Gamma-Glutamyltransferase (GGT), Glutamin-Oxalazetat-Transaminase und Laktatdehydrogenase) sowie Pankreatitis (erhöhte Serum-Amylase und -Lipase) und Muskelzellschädigung (erhöhte Kreatinkinase), eine signifikante Rhabdomyolyse trat nur in 2 Fällen auf. Auffällige Blutbildveränderungen bestanden in Leukozytose (23%), Thrombopenie (14%) und Anämie (12%). C-reaktives Protein war dabei nur geringfügig erhöht.

Mittels logistischer Regression wurden männliches Geschlecht sowie Intoxikationsgrad (Blutalkoholspiegel) als wesentliche Risikofaktoren für das Bestehen von chronischem Alkoholabusus identifiziert. Bei der Suche nach einem geeigneten Routineparameter für die Diagnosestellung von chronischem Alkoholmissbrauch bei Akutpatienten erwiesen sich GGT und mittleres korpuskuläres Erythrozyenvolumen (MCV) als gleichwertig. Die Kombination von Blutalkoholwerten ≥3‰ und erhöhtem GGT bzw. MCV kann als hoch prädiktiv für das Vorhandensein von chronischem Alkoholmissbrauch angesehen werden.

Schlüsselwörter: Hypernatriämie, mittleres korpuskuläres Erythrozyenvolumen (MCV), Gamma-Glutamyltransferase (GGT), chronischer Alkoholabusus, Prävalenz.

Summary. Prevalence of electrolyte disturbances and biochemical changes were determined in patients admitted to the emergency room of the Department of Internal Medicine in Innsbruck, Austria during a six-month period. The value of biochemical parameters for the detection of chronic alcohol abuse was also investigated.

The most frequent electrolyte disturbances found were hypernatremia (41%), hyperchloremia (21%), hypermagnesemia (17%) and hypocalcemia (15%), whereas hypokalemia and hypophosphatemia were observed quite rarely (5% and 3.4%, respectively).

The most frequent biochemical changes observed were consistent with signs of cellular toxicity i.e. increased liver enzymes (elevated gamma-glutamyltransferase (GGT), aspartate aminotransferase, alanine aminotransferase and lactic dehydrogenase) as well as signs of pancreatitis (elevated serum lipase and amylase) and muscle damage (elevated creatine kinase). The most frequent changes in blood counts were leucocytosis (23%), thrombocytopenia (14%), and anemia (12%). C-reactive protein showed only minimal elevation.

Male sex and level of blood alcohol were detected as major risk factors for the diagnosis of chronic alcohol abuse in the patient sample investigated. When testing the value of routinely measured parameters for predicting the presence of chronic alcohol abuse, GGT and mean corpuscular volume of red blood cells (MCV) appeared to be of equal value. A combination of elevated blood alcohol with an increase in either of these markers may be interpreted as high risk for chronic alcohol abuse in this particular group of patients.

Key words: Hypernatremia, mean corpuscular volume (MCV), gamma-glutamyltransferase (GGT), chronic alcohol abuse, prevalence.

Introduction

Alcoholism is one of the most important and serious addictions with regard to social, economic and medical consequences [1, 2].

To provide prompt and efficient therapy for patients admitted to an emergency room (ER) for acute alcohol intoxication it is necessary to know about the prevalences of the main disturbances in electrolytes and biochemical parameters. The most frequent disturbances of electrolytes reported in association with alcoholism are hypophosphatemia and hypomagnesemia followed in decreasing order by hypokalemia, hypocalcemia and hyponatremia [3]. However, there is little information on acute disturbances of these electrolytes in relation to different degrees of alcohol intoxication, and even less information on disturbances of biochemical parameters in acute alcohol intoxication.

In addition, when deciding about further treatment of patients with alcohol intoxication it is important to distinguish between acute and chronic alcohol abuse, so that early measures against symptoms of withdrawal can be established [4]. Alcohol addiction often fails to be noticed in injured patients [5] or patients admitted for acute diseases such as pneumonia. Since these patients are likely to develop symptoms of withdrawal, such as alcoholic delirium, early diagnosis of chronic alcohol abuse and appropriate measures to reduce serious complications are required [6].

General application of reported findings must be made with caution as they are strongly influenced by regional peculiarities [7]. The present study investigated the spectrum of alcohol intoxication in our local situation in Innsbruck, Austria. We performed a prospective analysis of patients admitted for alcohol intoxication to the medical ER of the university hospital in Innsbruck, which also serves as the primary hospital for the town's 130,000 inhabitants.

The main aim of the study was to investigate the relation of blood-alcohol levels to prevalence of disturbances of major electrolytes, blood count and blood chemistry in patients with acute alcohol intoxication admitted to the ER.

The second aim was to compare the predictive value of mean corpuscular volume (MCV) of erythrocytes with that of gamma-glutamyltransferase (GGT), another easily determined and established parameter, as screening parameters for the diagnosis of chronic alcohol abuse in this group of patients.

Patients and methods

Patients' characteristics

The study was designed as a prospective cohort study. All patients admitted for alcohol intoxication to the ER of the Department of Internal Medicine in Innsbruck, Austria in a six-month period from October 2000 to March 2001 were evaluated. Acute alcohol intoxication (ICD 10 F10.0) was diagnosed when patients showed disturbances in the level of consciousness (e.g. stupor, coma), cognition, affect or behaviour (aggression, lability of mood, impaired attention), as well as clinical signs of intoxication (slurred speech, nystagmus, flushed face, conjunctival injection) in the presence of an elevated blood-alcohol level of >0.5‰ after exclusion of every other medical reason for the symptoms observed. Patients with detectable concomitant intoxication with other substances were excluded from the study. If a patient was admitted with alcohol intoxication more than once during the study period, only the first admission was evaluated. Electrolytes, biochemical parameters, liver-function parameters and blood count were determined routinely in all patients.

Patients were categorized as being severely or moderately intoxicated, according to their measured blood-alcohol levels. In contrast to the WHO definition, severe alcohol intoxication was defined as a blood alcohol concentration of > 3‰ in our study. In addition, patients were grouped into acute and chronic alcohol abuse. Since our patients were frequently unable to answer questionnaires in the ER, we decided to define chronic alcohol abuse either on the basis of a patient's history (i.e. previous diagnosis of chronic alcohol abuse or diagnosis of alcohol-related diseases such as alcohol hepatitis, liver cirrhosis or esophageal varicosis) or on the basis of two or more admissions to the ER for acute alcohol intoxication.

We also determined the sensitivities and specificities of GGT and MCV in diagnosis of chronic alcohol abuse defined by the criteria mentioned above.

The study was performed in compliance with the guidelines of the local ethics committee.

Laboratory methods (normal range in parenthesis)

Urea (10–50 mg/dl) and glucose (70–110 mg/dl) were measured using enzyme tests [8], creatinine (0.7–1.4 mg/dl) with the Jaffe method, sodium (135–145 mmol/l), potassium (3.4–4.6 mmol/l) and chloride (98–108 mmol/l) with ion-selective electrodes, calcium (2.1–2.65 mg/dl), magnesium (0.6–0.95 mg/dl) and phosphorus (0.8–1.6 mmol/l) with photometry. Activities of aspartate aminotransferase (AST, SGOT; 2–18 U/l) and alanine aminotransferase (ALT, SGPT; 4–22 U/l) were determined under optimized conditions. GGT (5–28 U/l in men, 6–19 U/l in women) was measured with the method of Persijn and van der Slik [9]. Serum amylase (28–100 U/l) and lipase (40–190 U/l) were determined with enzymatic tests, alkaline phosphatase (60–170 U/l) with the method of the German Association of Clinical Chemistry (GACC), cholinesterase (3.5–8.5 kU/l) with butyrylchinoline, and lactic dehydrogenase (LDH; 120–240 U/l) with an optimized UV test. Creatine kinase (CK; 10–100 U/l) was measured in accordance with recommendations of the GACC.

Table 1. Baseline characteristics of patients in study

Demographic and clinical characteristics	
Alcohol-intoxicated patients included into study	121
Mean age	46.5 years (range 19–77)
Mean blood-alcohol concentration	3.19‰ (range 0.5–6.59)
Men	95
Women	26
Acute alcohol intoxication	46
Chronic alcohol abuse	75
Moderate alcohol intoxication	55
Severe alcohol intoxication	66

Table 2. Distribution of different degrees of alcohol intoxication

Blood-alcohol concentration (‰)	Patients	(%)
0–0.99	4	(3.3%)
1–1.99	10	(8.3%)
2–2.99	41	(33.8%)
3–3.99	44	(36.4%)
4–4.99	13	(10.7%)
> 5	9	(7.4%)

Table 3. Risk ratios and significance of blood-alcohol level, sex and mean corpuscular volume of erythrocytes (MCV) in the diagnosis of chronic alcohol abuse, determined using stepwise logistic regression

	Risk factor	p Value	95% Confidence interval	
			lower limit	upper limit
Alcohol	1.457	0.049	1.005	2.121
Male sex	4.952	0.002	1.769	13.861
MCV	1.113	0.009	1.027	1.206

C-reactive protein (CRP, < 0.7 mg/dl) was measured with the immuno-turbidometric method, blood-alcohol concentration with photometry.

Leukocytes (4–10 G/l), erythrocytes (4.4–5.9 T/l in men; 3.8–5.2 T/l in women) and thrombocytes (150–350 G/l) were determined with a Coulter counter; hemoglobin (133–177 g/l in men; 117–157 g/l in women) with photometry (cyanmethemoglobin measurement). Hematocrit (0.40–0.52 l/l in men; 0.35–0.47 l/l in women), mean cell hemoglobin (MCH; 27–32 pg) and MCV (77–96 fl) were calculated.

Statistical analysis

Data obtained were analysed using SPSS for Windows (SPSS Inc.). We used descriptive statistics and the nonparametric Mann-Whitney U-test, Spearman´s correlation and chi-square tests. Stepwise logistic regression was used for assessing the predictive value of age, sex, MCV, GGT and blood-alcohol concentration for the diagnosis of chronic alcohol abuse as defined above. A p-value < 0.05 was considered statistically significant.

Results

Total study population

Epidemiological data

A total of 161 patients met the criteria of acute alcohol intoxication during the study period. Thirty patients were excluded because of detectable mixed intoxication (positive drug-screening for benzodiazepines, tricyclic antidepressant, opiates, etc.). Ten patients came twice to our ER within the observation period; in these cases we included only the first admission.

Finally, 121 patients were included in our study. Projected on a total number of 6909 patients admitted to our ER in this six-month period means a 1.8 % prevalence of alcohol intoxication (Table 1). 21.5% of our patients were women, 78.5% were men. The mean age of the patients was 46.5 years (range 19–77), mean blood-alcohol concentration 3.2‰ (range 0.5–6.59). The frequencies of different degrees of alcohol intoxication are shown in Table 2. Of these 121 patients, 54.5% presented with severe alcohol intoxication (> 3‰), which represents a prevalence of 1% among all patients admitted to the ER. Seventy-four patients (61%) were diagnosed with chronic alcohol abuse, which means a prevalence of 1.1% in our medical ER population. Liver cirrhosis was additionally diagnosed in 14 patients (13.2%), alcoholic hepatic steatosis in six (5%) and non-alcoholic hepatic steatosis in three (2.5%). Stepwise multiple regression revealed a significant correlation between male sex and blood-alcohol concentration but not between age and the diagnosis of chronic alcohol abuse. Risk ratios, confidence intervals and p-values are shown in Table 3.

Electrolytes

Alterations in serum sodium levels were the most frequently observed electrolyte changes in our patients, hypernatremia was much more common than hyponatremia (41.3% vs. 2.5%, respectively). The second most frequent electrolyte disturbance was hyperchloremia, which was found in 20.9% of the patients. Other disturbances in electrolyte homeostasis were hypermagnesemia (16.7%), hypocalcemia (15.1%) and hyperphosphatemia (9.4%). The clinical relevant disturbances hypokalemia and hypophosphatemia occurred less frequently, with prevalences of 5% and 3.5%, respectively (Fig. 1, Table 5). Only 1.4% of the patients presented with elevated serum potassium.

Significant correlations were found between sodium and chloride ($r = 0.676$, $p < 0.001$), magnesium and chloride ($r = 0.459$, $p < 0.01$), and magnesium and sodium ($r = 0.338$, $p < 0.05$).

Blood count

The most frequent changes in blood count were elevated MCH (40.8%), elevated MCV (30.6%), reduced erythrocyte count (33.3%), decreased hematocrit (23.3%) and leucocytosis (23.1%), followed by thrombocytopenia (14.1%) and reduced hemoglobin (11.7%) (Fig. 2, Table 5).

Table 4. Sensitivity and specificity of increased gamma-glutamyltransferase (GGT) and mean corpuscular volume (MCV) in the diagnosis of chronic alcohol abuse for all patients and in subgroups with severe (≥ 3‰) or moderate intoxication (< 3‰)

	Sensitivity (%)		Specificity (%)	
	GGT	MCV > 96 fl	GGT	MCV > 96 fl
All patients	57.6	33.3	60.5	73.9
≥ 3‰	61	43.5	56.2	66.7
< 3‰	52	17.2	63.6	80

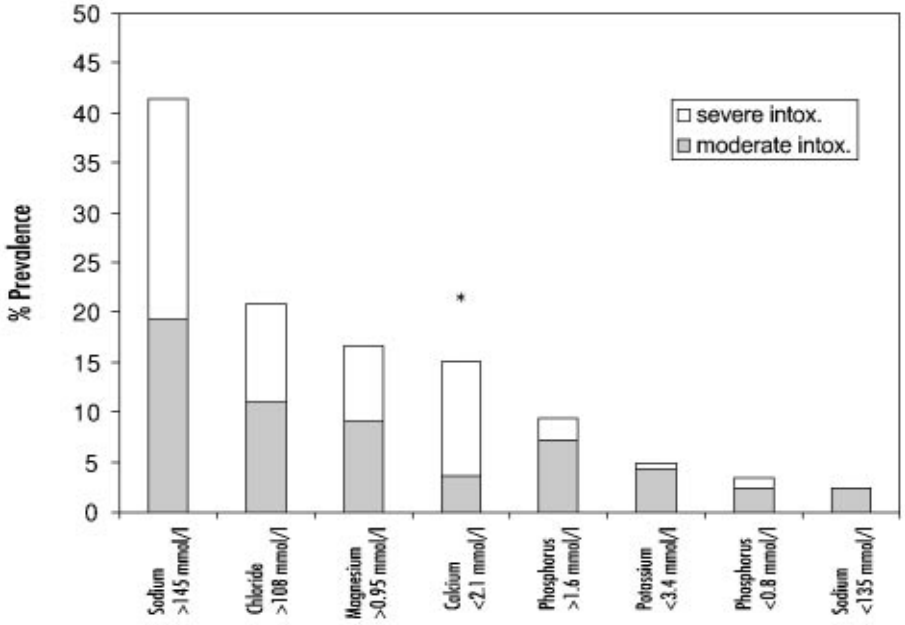

Fig. 1. Frequency of main electrolyte disturbances, measured in the emergency room, in patients with alcohol intoxication (values given as percent; *severe intox*. blood-alcohol levels ≥ 3‰; *moderate intox*. blood-alcohol levels < 3‰). * Statistically significant differences between patients with severe and moderate intoxication, $p < 0.05$, chi-square test

Biochemical parameters

The following disturbances of biochemical parameters were observed, listed in decreasing frequency (Fig. 3, Table 5):

Elevated serum activities of gamma-glutamyltransferase (56.3%), aspartate aminotransferase (38.9%), creatine kinase (33.6%) and lactic dehydrogenase (34%); low serum creatinine levels (21%), elevated alkaline phosphatase (19.7%), increased levels of alanine aminotransferase (17.8%), serum amylase (15.3%) and lipase (12.5%); reduced cholinesterase (10.2%) and serum-urea (8%).

Glucose was elevated in 42.2% of our patients, CRP in only 20% (Table 5).

Patients with severe alcohol intoxication (blood-alcohol levels ≥3‰)

Significant differences in electrolyte homeostasis between subgroups were found for hypocalcemia only (22.5% in severe intoxication vs. 6.8% in moderate intoxication, $p = 0.035$, Fig. 1, Table 5).

Comparison of blood counts between severely and moderately intoxicated patients showed significant differences for thrombocytopenia (20.4% vs. 7.3%, $p = 0.049$, Fig. 2), elevated MCH (50% vs. 29.1%, $p = 0.016$) and elevated MCV (40.3% vs. 18.5%, $p = 0.038$).

Significant differences between severely and moderately intoxicated patients were also found for the prevalences of elevated levels of CK (43.8% vs. 21.2%, $p = 0.048$), LDH (43.4% vs. 22.7%, $p = 0.024$), serum amylase (28.6% vs. 3.2%, $p = 0.003$) and lipase (23.8% vs. 3.7%, $p = 0.037$) (Fig. 3).

Markers of chronic alcohol abuse

Based on the criteria used in this study (case history containing the diagnosis of chronic alcohol abuse or diagnosis of alcohol-related diseases, or at least two admissions to the ER for acute alcohol intoxication), 74 of 121 patients (i.e. 61%) admitted for alcohol intoxication suffered from chronic alcohol abuse.

Elevated GGT levels (> 19 U/l in women and > 28 U/l in men) as a marker of chronic alcohol abuse showed a sensitivity of 57.6%. The specificity reached 60.5%. An increase in sensitivity was observed with a blood-alcohol concentration above 3‰ (Table 4).

MCV correlated significantly with the diagnosis of chronic alcohol abuse and was the only biochemical parameter that was robust in stepwise logistic regression (Table 3). An MCV above 96 fl was associated with increased risk of chronic alcohol abuse (risk ratio = 1.12; $p = 0.007$; CI 95% = 1.031–1.216). Calculated sensitivity and specificity of MCV > 96 fl for the diagnosis of chronic alcohol abuse were 33.3% and 73.9%, respectively (Table 4).

Discussion

Over a study period of six months, 121 alcohol-intoxicated patients with a mean blood-alcohol concentration of 3.19‰ (range 0.5–6.59) were treated in the medical ER in Innsbruck. We found a prevalence of 1.8% for acute alcohol intoxication and 1.1% for chronic alcohol abuse in nearly 7000 patients admitted to the ER during the study. These numbers are in accordance with the prevalence of alcohol dependence calculated for the Austrian adult population [1]. About 20% of the study population were women, which correlates perfectly with the ratios of male to

Table 5. Median, range and percentage of patients showing laboratory values above or below the normal range

	All patients				< 3‰				≥ 3‰			
	median	range	% above normal	% below normal	median	range	% above normal	% below normal	median	range	% above normal	% below normal
Sodium	145.0	131–154	41.3	2.5	144.0	131–151	38.2	5.5	145.0	135–154	43.9	0.0
Potassium	3.9	3.1–6.5	1.7	5.0	3.8	3.2–6.5	3.6	9.1	3.9	3.1–4.5	0.0	1.5
Calcium	2.2	1.95–2.45	0.0	15.1	2.6	1.97–2.45	0.0	6.8	2.2	1.95–2.41	0.0	22.5
Chloride	106.0	94–114	20.9	4.4	106.0	94–111	22.0	12.0	105.0	95–114	20.0	1.5
Magnesium	0.9	0.46–1.02	16.7	2.4	0.9	0.49–1.02	18.2	4.6	0.8	0.65–1	15.0	0.0
Phosphorus	1.2	0.5–1.9	9.4	3.5	1.3	0.5–1.9	15.0	5.0	1.2	0.66–1.84	4.4	2.2
AST	14.0	6–256	38.9	0.0	12.0	6–256	30.0	0.0	17.0	7.0–91	46.0	0.0
ALT	12.0	1–145	17.8	1.0	10.5	2–145	15.2	0.0	13.5	1.0–79	20.0	1.8
GGT	27.0	3–675	56.3	1.0	27.0	3–521	40.0	1.8	36.0	6–675	47.7	0.0
AP	109.0	68–301	19.7	1.7	106.0	68–301	12.9	3.2	126.5	71–288	26.7	0.0
CHE	5.2	1.65–10.4	16.3	10.2	5.1	1.65–10.2	14.8	11.1	5.2	2.56–10.4	18.2	9.1
LDH	208.0	141–621	33.0	0.0	179.0	141–621	20.9	0.0	224.0	145–610	42.6	0.0
Amylase	62.0	38–146	15.3	0.0	62.8	38–110	3.2	0.0	66.0	39–146	28.6	0.0
Lipase	86.0	21–607	12.5	20.8	85.0	24–215	3.7	14.6	102.0	21–607	23.8	14.3
Glucose	107.0	71–234	42.2	0.0	107.0	71–231	43.6	0.0	106.5	71–234	39.4	0.0
Urea	18.5	4.8–63.3	0.9	8.0	20.8	5.1–63.3	1.8	6.0	16.1	4.8–41.8	0.0	9.7
Creatinine	0.8	0.47–1.86	1.7	21.0	0.9	0.54–1.86	1.9	13.2	0.8	0.47–1.8	1.5	27.3
CK	72.0	14–1130	33.6	0.0	67.0	14–421	19.6	0.0	79.0	16–1130	45.8	0.0
CRP	n.a.	<0.7–3.29	20.4	na	n.a.	<0.7–3.17	20.7	n.a	n.a.	<0.7–3.29	20.0	na
Leukocytes	7.6	4.2–19.5	23.1	0.0	8.3	4.2–19.5	30.9	0.0	7.3	4.3–15.8	15.2	0.0
Erythrocytes	4.5	3–5.74	12.4	33.3	4.5	3–5.74	10.9	25.5	4.4	3.01–5.49	13.9	40.0
Hemoglobin	143.0	103–177	3.3	11.7	143.0	103–177	0.0	12.7	142.0	109–171	1.5	10.8
Htk	0.4	0.309–0.516	0.8	23.3	0.4	0.309–0.516	0.0	20.0	0.4	0.327–0.512	1.5	26.2
Thrombocytes	236.4	33–680	6.6	14.1	248.0	87–680	7.3	7.3	227.0	33–628	6.2	20.0
MCH	31.9	25.2–37.5	40.8	1.7	31.5	25.2–37.5	29.1	3.6	32.1	28–37.1	50.0	0.0

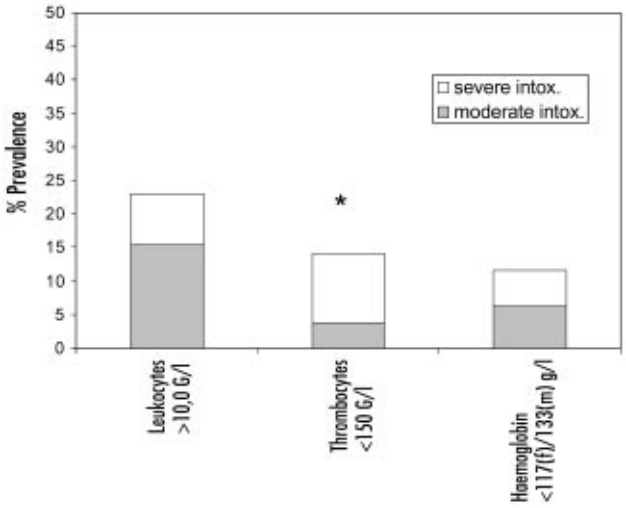

Fig. 2. Frequency of disturbances of blood count, measured in the emergency room, in patients with alcohol intoxication (values given as percent); *severe intox*. blood-alcohol levels ≥3‰; *moderate intox*. blood-alcohol levels <3‰. *Statistically significant differences between patients with severe and moderate intoxication ($p < 0.05$, chi-square test)

female problem drinking and alcohol dependence (range 3:1–5:1) in Austria and Germany [1, 10]. Although the inequality in sex distribution of patients in our study may have had an impact on our results, we could not find any significant differences when analysing separately for men and women. Since we used sex-related cut-off values, the results for men and women were finally pooled when calculating prevalences of disturbances in electrolytes, blood chemistry and blood count.

We investigated the frequency of electrolyte disturbances in our patients. Compared with other authors' studies of patients suffering from alcohol abuse [11–17], prevalences found in our study showed a very different pattern. However, we studied only acutely intoxicated patients and therefore comparison with studies that included alcohol-dependent patients without acute intoxication might be limited.

Alcoholism is usually reported to be associated with reduced serum-electrolyte concentrations, i.e. hypophosphatemia, hypomagnesemia, hypokalemia, hypocalcemia and hyponatremia (listed in decreasing frequency) [3].

Nevertheless, the most frequent electrolyte disturbance found in our study was hypernatremia, with a prevalence of 41.3%. This high frequency may be explained by the particular circumstances of the study. We investigated acutely intoxicated patients in the ER who were probably still in the phase of increasing blood-alcohol levels, leading to suppression of antidiuretic-hormone release from the pituitary gland and consequent polyuria [18]. The result would be a mild hypernatremia associated with lack of fluid intake due to intoxication. Unfortunately we did not measure osmolality to verify this assumption. However, increased osmolality was described by Ryb and co-workers in trauma patients who were currently alcohol dependent [5]. The sensitivity of increased osmolality for the diagnosis of current alcohol dependency was reported to be around 74%. The only study which investigated alcohol users in a similar setting, an ER in Finland [15], also found an increased prevalence of hypernatremia, but with a lower prevalence of about 15%. On the other hand, hyponatremia, which has been detected at high rates between 20 and 40% by other authors [12, 17], was rare in our study and only present in patients with moderate alcohol intoxication. The study by Elisaf and co-workers [12] was not performed in ER patients but in patients admitted to a general ward. Wrenn and co-workers selected only patients with alcoholic ketoacidosis [17]. It may be assumed that hyponatremia develops during a later phase of alcohol intoxication, when suppression of ADH has subsided and substitution of free water (e.g. glucose infusion) has occurred.

Chloride was elevated in 20.9% of our patients. As observed in other situations of disturbed fluid and electrolyte homeostasis, changes in serum chloride mostly parallel changes in sodium concentrations [19]. This assumption is further supported by the highly significant correlation between serum sodium and chloride in our patients. Thus, we consider the same mechanisms responsible for both hyperchloremia and hypernatremia.

The third most frequent electrolyte disturbance found in our study was hypermagnesemia. Investigations of the short-term effects of alcohol ingestion found an increase in serum-magnesium levels six hours after alcohol ingestion; this was attributed to transient hypoparathyroidism induced by alcohol ingestion [20]. The same mechanism could be hypothesized for our patients. Hypermagnesemia may also reflect hypertonic dehydration, which would explain the highly significant correlation between magnesium, sodium and chloride. Hypermagnesemia in acutely intoxicated patients could also result from renal insufficiency or intake of antacids. Interestingly, we did not find significant degrees of renal insufficiency; however, previous intake of antacids could not be ruled out.

Hypocalcemia was observed in about 15% of our patients, occurring about three times as often in severely intoxicated patients as in moderately intoxicated ones. The prevalence of hypocalcemia was comparable with that reported elsewhere [11, 12, 17]. Since the diagnosis of chronic alcohol abuse correlated strongly with severe alcohol intoxication, which in its turn was a major risk factor for chronic alcohol abuse, hypocalcemia in this group may be traced back to malnutrition and lack of vitamin D [21].

The prevalence of hyperphosphatemia, the fifth most frequent electrolyte disturbance observed in our study, was comparable with that reported in other studies [14, 16]. Metabolic acidosis, especially alcoholic ketoacidosis, presumably plays a pathogenic role in this condition [11, 17].

Lastly, hypokalemia and hypophosphatemia were present in <5% of our patients, which again is discrepant with the findings of other publications reporting hypophosphatemia in about 25–30% of admitted patients and hypokalemia in 8–22% [11, 14–17]. We could not find a conclusive explanation for our observation; however, it may be assumed that hypophosphatemia and hypokalemia develop during a later stage of alcohol intoxication, especially when treatment with glucose has been commenced

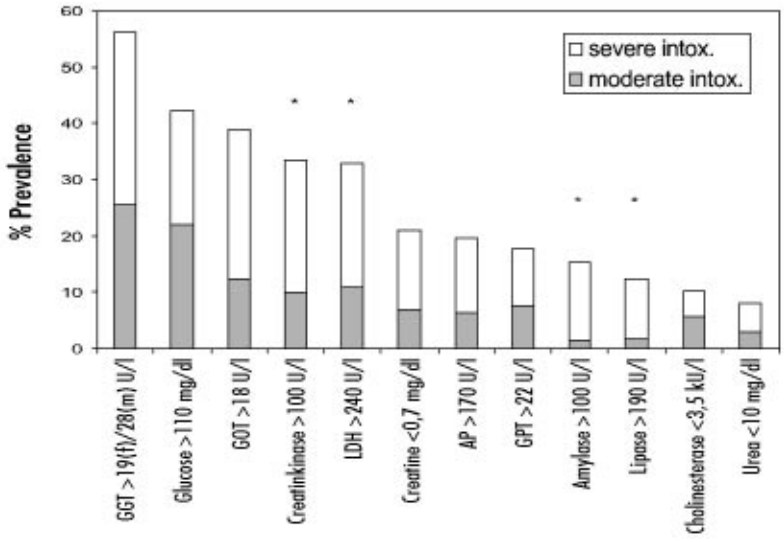

Fig. 3. Disturbances of biochemical parameters measured in patients with acute alcohol intoxication (values given as percent); *severe intox*. blood-alcohol levels ≥ 3‰; *moderate intox*. blood-alcohol levels < 3‰. * Statistically significant differences between patients with severe and moderate intoxication ($p < 0.05$, chi-square test)

after admission. This assumption is supported by observations in ER patients with alcoholic ketoacidosis and hyperphosphatemia, who all showed a rapid decline, even to hypophosphatemic values, within 8–24 hours after admission [17].

Hyperglycemia occurred in > 40% of our patients, but was usually mild with only four patients showing blood-glucose levels above 180 mg/dl. It is also remarkable that hypoglycemia, often discussed as a potential danger in acute alcohol intoxication, could not be detected in any of our patients. Recent publications also suggest that in this setting hypoglycemia is less common than originally proposed [22, 23].

Changes in biochemical parameters were dominated by increased liver-function parameters, with GGT elevation being the most frequent. Elevated aminotransferases (AST, ALT) and LDH were also prominent. These changes were much more frequent in patients with severe alcohol intoxication, indicating acute liver cell damage. The increased alkaline phosphatase found in 18.3% of our patients may be attributed to cholestasis but could also reflect lack of vitamin D as a result of malnutrition [21].

Elevated serum amylase and lipase indicating pancreatitis were found mainly in patients with severe alcohol intoxication (26.7%). A probable explanation for these disturbances may be the high frequency of alcohol-induced pancreatitis seen in patients with chronic alcohol abuse as well as with severe alcohol intoxication [24].

Increased serum levels of LDH and CK were significantly correlated with the degree of alcohol intoxication. Elevation of these parameters is most probably due to toxic cell damage caused by alcohol. Increased serum CK most probably indicates muscle damage. However, significant rhabdomyolysis with CK values of 1027 and 1130 U/l was found in only two patients, who presented with very high blood-alcohol levels of 5.5 and 6.6‰, respectively. This is a low rate compared with the rate reported by Martin and co-workers [25], who found rhabdomyolysis associated with alcohol intoxication at a prevalence of about 5%.

Finally, changes in blood count were analysed. The most frequent finding was leukocytosis, which was associated with only mild elevations of CRP and may be considered as a sign of volume depletion and demargination from physical stress rather than of infection. Thrombocytopenia was found mainly in patients with severe alcohol intoxication. Considering the relatively high frequency of liver disease in our patients, this was not an unexpected finding. Anemia was not very frequent and was usually mild.

We were also interested in the question of how many patients admitted for acute alcohol intoxication might be suffering from chronic alcohol abuse, which is associated with a significant complication rate [6, 10]. It is well known that such patients need more observation and have to be monitored even more carefully for development of symptoms of withdrawal, as these are associated with high rates of mortality. Chronic alcohol abuse increases the risk of intraoperative mortality [26]. There are also several alcohol-associated diseases such as pneumonia, liver cirrhosis and esophageal varicosis that require special therapies and medications [10]. Various tests have been developed for the detection of chronic alcohol abuse. Most of them are questionnaires such as CAGE or AUDIT [27–29]. However, these questionnaires cannot be used routinely on admission of patients with acute alcohol intoxication because of the patients' mental impairment. For this reason we tested the reliability of biochemical markers in diagnosing alcohol dependency. Since many of our patients were lost for follow-up or unwilling to answer questionnaires later on, our diagnosis of chronic alcohol abuse was based on clinical charts or earlier diagnoses associated with alcohol abuse or on repeated admissions secondary to alcohol intoxication.

Though this method most probably underestimates the rate of alcohol dependency in our patients, we still detected a prevalence > 61% for chronic alcohol abuse, which is in accordance with the literature [1]. Logistic regression showed that in the ER the degree of alcohol intoxication and the male sex were the main risk factors for chronic alcohol abuse.

The most common biochemical markers used for the diagnosis of chronic alcoholism are MCV and GGT, which are known to have moderate sensitivity and specificity [30]. In a large study of 1202 patients, Yersin and co-workers [31] found a sensitivity of 27% and a specificity of 91% for MCV; for GGT the respective values were 69% and 65%. Reynaud and co-workers [32] found a sensitivity of 24% and a specificity of 96% for MCV; for GGT the respective values were 42% and 76%. The results obtained in our study are within these reported ranges (Table 4). Although we found MCV, but not GGT, to be significantly correlated with the diagnosis of chronic alcohol abuse, the sensitivity of this marker (using the upper normal range of 96 fl) for detecting chronic alcohol abuse was quite low at 33%. The sensitivity could be improved by including male sex and a higher degree of alcohol intoxication (Tables 3 and 4). Thus, a blood alcohol level of > 3‰ in combination with elevated MCV or GGT may be considered high risk for chronic alcohol abuse. It is well known that the sex of the patient influences both GGT and MCV as markers of alcohol consumption. For example, in women GGT shows lower sensitivity but higher specificity [33]. Although this may have played a role in the results obtained, we could not reliably analyse the data separately for women because of their low numbers in our study.

In summary, the present study shows that in patients admitted to the ER for acute alcohol intoxication the pattern of electrolytes significantly differs from that seen in chronic alcohol abuse or in patients treated on a general ward, with hypernatremia being the predominant disturbance. This further indicates that hyperosmolar dehydration is the most frequent disturbance in acute alcohol intoxication and suggests that volume substitution is one of the most important first measures. Biochemical changes are dominated by increased serum enzyme levels as the result of toxic cellular damage of liver and muscles, and both MCV and GGT are effective for the detection of high risk drinking, especially when taking blood-alcohol levels and the sex of the patient into account.

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Correspondence: Michael Joannidis, M.D., Universitätsklinik für Innere Medizin, Anichstrasse 35, 6020 Innsbruck, Austria, E-mail: Michael.Joannidis@uibk.ac.at