Acute Alcohol Intoxication Characteristics in Children

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Abstract — Aims: To describe clinical, mental and physical signs in children with different severity acute alcohol intoxication (AAI) determined either by serum alcohol concentration (SAC) or by blood alcohol concentration (BAC) to study the diagnostic performance characteristics of clinical assessment and to establish the ratio of SAC:BAC in children. Methods: Data were analysed from 256 children aged 8.4–17.9 years who were hospitalized at Estonia’s two children’s hospitals over a 3-year period. In each case, the on-call paediatrician completed a special form about the clinical, mental (consciousness, balance and speech) and physical (muscle tone, blood pressure, pulse and body temperature) signs of AAI. Blood samples were drawn for measurements of SAC and BAC. Diagnostic performance characteristics (sensitivity, specificity, efficiency) of the clinical assessments and the SAC:BAC ratio were calculated. Results: The most correctly described signs in children in different SAC groups were consciousness (r = 0.16) and speech (r = 0.13) (P < 0.0001). The severity of alteration of consciousness and degrees of disturbance in balance and speech were positively correlated with SAC (P < 0.001). The clinical judgment matched better with AAI determined by SAC rather than by BAC with the mean efficiency. The mean ratio between SAC and BAC was 1.19 ± 0.13 (P < 0.001) in children. Conclusion: The level of consciousness is the leading sign in the clinical evaluation of children with AAI and correlates well with SAC. The severity of AAI judged by clinical assessment matched better with AAI severity stages determined by SAC than by BAC. For legal cases where BAC is required, the SAC:BAC ratio of 1.19:1 should be used in children regardless of their gender or age.

INTRODUCTION

Ethanol is the most commonly abused drug in Western countries. Increasing alcohol consumption is accompanied by the growing problem of alcohol intake by children and adolescents (Woolfenden et al., 2002; Meyer et al., 2008; Schöberl et al., 2008). Among a teenage population evaluated in Australia, 29% of the subjects reported drinking to the point of drunkenness (Australian Institute of Family Studies, 2000). In the European School Survey Project on Alcohol and Other Drugs, 7% of all males between 15 and 16 years of age and 2% of all females interviewed reported ten or more episodes of drunkenness in the previous year (European School Survey Project on Alcohol and Other Drugs, 2003). A similar study showed that the average age at initial alcohol consumption was 11.3 years in girls and 10.7 years in boys. On average, showed that the average age at initial alcohol consumption was 11.3 years in girls and 10.7 years in boys. 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concentration is often measured in serum or plasma in hospitals; however, in legal cases serum or plasma ethanol concentrations have to be converted into BAC. Therefore, the correlations between the clinical signs of AAI and SAC or BAC are often not comparable, as the SAC is usually slightly higher than the BAC. The SAC-to-BAC ratio in adults is between 1.12:1 and 1.18:1, as reviewed by Barnhill et al. (2007). To our knowledge, no such information is available for children.

The aim of this study was to investigate the prevalence of different clinical signs in different alcohol intoxication severity groups, compare the different AAI levels with the SAC or BAC and to calculate the ratio of alcohol concentrations between serum and blood in children hospitalized with AAI.

**METHODS**

All the under 18-year-old children hospitalized with AAI at Estonia’s two main children’s hospitals (Tartu University Children’s Clinic and Tallinn Children’s Hospital) over a 3-year period (December 2005 to December 2008) were included in the study. From the study period we analysed 417 children and adolescents who were hospitalized at these two hospitals with suspected AAI. Twenty children were excluded because their SAC was below 20 mg/dl. Three children with narcotic intoxication, confirmed by a rapid urine test, were also excluded. A further 138 children were omitted from the study group because they refused testing, mistakes were made when drawing blood, biochemical tests had not been carried out or the medical form had not been completed.

Data from the remaining 256 children were used in the analysis: 76 children from Tartu University Children’s Clinic and 180 from Tallinn Children’s Hospital. Their mean age was 14.2 (in a range of 8.4–17.9 years). There were 148 boys, (male-to-female ratio was 1.37:1). Due to the legal criteria where criminal responsibility starts from the age of 14 years, children were divided into two age groups—8.0–13.9 years and 14.0–17.9 years. In the younger children group, there were 64 boys and 51 girls, in the elder children group 84 boys and 57 girls. Children up to 11 years were at the primary school level and children older than 11 years were at the secondary school level. All children in the study groups were Caucasians.

According to the severity of drunkenness, the subjects were divided into three groups using two different methods: first, according to the clinical signs and symptoms estimated by the on-call paediatrician and secondly, according to the SAC as a gold standard in hospitals. Upon hospitalization, an anonymous encoded medical assessment form was filled in by the on-call paediatrician to confirm the drunkenness of the child. Alcohol intoxication was diagnosed using the Diagnostic and Statistical Manual of Mental Disorders (DSM IV), and criteria were used to complete the medical assessment form. This form included data about the child’s mental status (consciousness, balance, speech and behaviour). Consciousness was assessed on a scale from normal (1 point) to severely aggravated (4 points): clear consciousness, disorientation, somnolence, stupor or coma (estimated on the Glasgow Coma Scale); balance on a scale of normal, imbalanced or unable to stand (lying); speech on a scale of normal, rushed, fast, confused (slurred) or unable to speak, and behaviour on a scale of normal, restful, passive, euphoria, aggressiveness or impossible assess. Physical status (muscle tone, body temperature, blood pressure and pulse), consumption of alcohol (the time passed since the drinking started, the amount of consumed alcohol and the first or recurrent episode of AAI) and the time of the assessment were reported. Muscle tone was assessed on a scale of normal, decreased or increased (with or without tremors, spasms or convulsions). The amount of reported consumed alcohol was registered as the number of standard drinks. If the child consumed different types of alcohol products or consumed these with other subjects, these parameters were taken into consideration in the calculation. According to the clinical signs and the children’s general conditions, the on-call paediatrician was asked to estimate subjectively the severity of AAI as mild, moderate or severe, using instructions introduced to him/her before the study. For example, mild imbalance, slow speech or euphoria indicated the mild form; significant imbalance, slurred speech, disturbed consciousness or memory, the moderate form; the inability to stand or severe imbalance, disturbed memory, inability to speak or coma, the severe form of AAI. Blood samples were drawn for measurements of serum and blood alcohol, levels of plasma cortisol and sex hormones and concentrations of glucose, lactate, sodium and potassium. The results for clinical chemistry and hormones have been reported by authors in other papers (Tönisson et al., 2010, 2011). Urine samples were also collected in order to exclude the use of narcotics. Children with ethanol concentrations below 20 mg/dl in serum or 0.20 mg/g in blood were excluded, as the alcohol concentration below these levels could be physiologically obtained from meals, and they were considered not to have consumed alcohol (or all of the blood alcohol had been eliminated by the time of measurement). Children with SAC above 20 mg/dl were included into the study as this ethanol level is likely to be achieved by alcohol consumption. According to the SAC, the subjects were divided into three groups: (a) mild alcohol intoxication group with a SAC of 20–150 mg/dl; (b) moderate alcohol intoxication group with a SAC of 151–250 mg/dl and (c) severe alcohol intoxication group with a SAC of >250 mg/dl. The BACs were then studied to compare clinical signs in groups of different levels of drunkenness as estimated by paediatricians. A BAC of 0.20–1.50 mg/g was considered mild alcohol intoxication; 1.51–2.50 mg/g moderate intoxication and >2.50 mg/g severe intoxication.

The SAC was determined using the enzymatic method by TDxFLx (Abbott Diagnostics) in both hospitals. Blood was drawn into sodium fluoride-potassium oxalate vacutainer tubes. The BAC was measured using headspace gas chromatography (TurboMatrix 40 Headspace Sampler and Clarus 500) with two columns at the Estonian Forensic Science Institute. Its laboratories form part of the Labquality quality control programme. A urine screening test (Multiscreen 10 MTD, Biomedical Diagnostics) for narcotics was used to detect amphetamines, methamphetamine, ecstasy, opioids (morphine/heroin), methadone, cannabis (Δ-tetrahydrocannabinol), cocaine, benzodiazepines, barbiturates and tricyclic antidepressants. Children were screened for illicit drugs, but not all narcotics are detectable by this urine test, and therefore, it is possible that some drunken children had been using alcohol together with some illegal drugs not screened (e.g. synthetic cannabinoids).

We then assessed the diagnostic performance characteristics, i.e. sensitivity, specificity and efficiency (Frank Wians, 2009) of the clinical judgement by clinician against the gold standard, i.e. groups defined either by SAC or by BAC.
Statistical analysis was performed using the Statistical 10.0 statistical program and descriptive statistics were used to analyse the children’s general data. Spearman Rank Order Correlations ($r_s$) were used to assess bivariate relationships. A $P$-value of <0.05 was considered statistically significant.

The study was approved by the Ethics Review Committee on Human Research of the University of Tartu and procedures were followed in accordance with the Helsinki Declaration of 1975 as revised in 1983.

RESULTS

Clinical signs of alcohol intoxication

The consciousness level ranged from normal to coma—somnolence was the most common clinical sign ($n = 92$), followed by a normal conscious level ($n = 71$) and disorientation ($n = 51$). Coma, estimated as 8 points or less (5 to 8) by the Glasgow Coma Scale, was reported in 12 children. Normal balance was reported in 12 children and an imbalanced state in 124 (48.4%); 120 (46.9%) were unable to stand. On the speech scale rushed speech was a frequent sign ($n = 103$), followed by confused speech ($n = 64$) and an inability to speak ($n = 60$). The most correctly described signs in children in the different SAC groups were consciousness ($r_s = 0.16$) and speech ($r_s = 0.13$). The correlation between estimated drunkenness level and signs was $P < 0.0001$. Passive behaviour was the most common sign of the AAI children ($n = 70$; 27.3%) followed by restful behaviour ($n = 60$) and impossible assess ($n = 50$).

Muscle tone had decreased in 119 children and increased in 8. Mean body temperature, pulse and blood pressure were not statistically different between the different alcohol concentration groups. The mean temperature was similar from October to March (mean 35.6 ± 0.65 degrees) and from April to September (mean 35.6 ± 0.64) but was not statistically significant ($P > 0.05$). The mean heart rate was 83.9 ± 15.2 beats per minute (in the range of 47–132); systolic blood pressure was 108.7 ± 14.3 mmHg (in the range of 71–153) and diastolic blood pressure was 65.3 ± 12.1 mmHg (in the range of 35–110). The most commonly observed AAI signs in different alcohol intoxication levels in children are given in Table 1.

Overall, children started to consume alcohol 3 h and 16 min (ranging from 30 min to 9 h) before the hospitalization and the main type of consumed beverage was strong alcohol such as spirit cocktails, brandy or vodka (63.2%) followed by light alcohol (21.3%) or both types of beverages. The mean amount of consumed alcohol was four standard drinks ranging from 0.25 to 16 drinks, and 38.9% of children reported that this AAI was their first.

The clinical signs did not differ between boys and girls or between the age groups.

Comparison of drunkenness level by clinical signs with serum and BACs

The distribution of subjects by levels of AAI estimated by the clinical signs and SAC or BAC is given in Table 2. A moderate alcohol intoxication was the most common level assessed by the clinical signs ($n = 117$; 45.7%) followed by severe intoxication ($n = 79$; 30.9%). The coincidence of the assessed signs and the SAC was 30.1% ($n = 77$) in the moderate alcohol intoxication group and 9.8% ($n = 25$) in the severe. There was the shift from a higher SAC to lower BAC in all AAI groups, and the correlation between the serum and blood alcohol concentrations was very good ($r_s = 0.93$; $P < 0.0001$) (Fig. 1). The mean ratio SAC:BAC was 1.19:1 ± 0.13, from 1.17:1 in the mild AAI group to 1.19:1 in the moderate and severe AAI groups. The mean ratio was not significantly different between boys and girls, nor between the different age groups. The most noticeable difference was in the severe intoxication by the signs group, with a 20–150 mg/dl (or mild) SAC and a 0.20–1.50 mg/dl BAC. The children in this group were seven boys aged 11–14 years and one 16-year-old girl: their balance was disturbed, muscle tone had decreased, they exhibited somnolence and stupor, their memory failed and body temperature was between 34.8–36.2°C. Additionally, seven boys aged 11–14 years were in the 20–150 mg/dl SAC group were moved to the mild BAC group. In total, 14 younger children were classified as being severely alcohol intoxicated by the signs. One 16-year-old girl in this group was mistakenly not assessed for narcotic drugs.

<table>
<thead>
<tr>
<th>Alcohol intoxication level</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
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<tbody>
<tr>
<td>Serum alcohol concentration</td>
<td>Passive ($n = 18$; 7.03%), somnolence ($n = 21$; 8.20%), slow speech ($n = 21$; 8.20%), imbalance ($n = 25$; 9.77%)</td>
<td>Passive ($n = 43$; 16.80%), somnolence ($n = 62$; 24.21%), slow speech ($n = 72$; 28.13%), impossible assess balance ($n = 78$; 30.47%)</td>
<td>Impossible assess behaviour ($n = 11$; 4.30%), disorientation ($n = 10$; 3.91%), unable to speak ($n = 16$; 6.25%), impossible assess balance ($n = 24$; 9.38)</td>
</tr>
<tr>
<td>Blood alcohol concentration</td>
<td>Restful behaviour ($n = 27$; 10.55%), clear consciousness ($n = 37$; 14.45%), slow speech ($n = 44$; 17.19%), imbalance ($n = 50$; 19.53%)</td>
<td>Restful behaviour ($n = 41$; 16.02%), somnolence ($n = 51$; 19.92%), slow speech ($n = 48$; 18.75%), impossible assess balance ($n = 77$; 30.08%)</td>
<td>Impossible assess behaviour ($n = 7$; 2.73%), coma ($n = 4$; 1.56%), unable to speak ($n = 9$; 3.52%), impossible assess balance ($n = 10$; 3.91%)</td>
</tr>
<tr>
<td>Alcohol intoxication level by signs</td>
<td>Normal behaviour ($n = 9$; 3.52%), clear consciousness ($n = 23$; 8.98%), slow speech ($n = 11$; 4.30%), imbalance ($n = 17$; 6.64%)</td>
<td>Restful behaviour ($n = 39$; 15.23%), somnolence ($n = 41$; 16.02%), slow speech ($n = 65$; 25.39%), imbalance ($n = 72$; 28.13%)</td>
<td>Impossible assess behaviour ($n = 35$; 13.67%), somnolence ($n = 40$; 15.63%), unable to speak ($n = 43$; 16.80%), impossible assess balance ($n = 65$; 25.39%)</td>
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Two children with frequent experience of consuming alcohol (16-year-old boys) were in a mild state of drunkenness by the signs, but in the severe SAC group. One of them was in the moderate alcohol intoxication group by the BAC. The main sign of alcohol intoxication they exhibited was disturbance of balance.

Age did not correlate significantly with the AAI stage, BAC or SAC levels, except in the younger children group where the SAC correlated positively with age ($r_s = 0.23; P = 0.013$).

**Diagnostic performance characteristics of clinical assessment**

Comparing the clinical signs of AAI with the SAC, the physicians were most accurate in diagnosing the clinical signs in terms of mild intoxication, with a sensitivity of 26.5%, specificity of 92% and efficiency of 77.6%. Moderate alcohol intoxication was diagnosed with a sensitivity of 57%, specificity of 46.1% and efficiency of 54.5%; severe drunkenness with a sensitivity of 64.1, specificity of 70.6% and efficiency of 69.5%. Thus, the average efficiency to diagnose the right AAI severity group, determined by the SAC, and using clinical judgement by a physician, was 67.7%. These data also show that clinically, doctors estimated the severity of drunkenness to be one level more severe than our definition according to the SAC.

Comparing the clinical signs of AAI with the BAC, mild intoxication was diagnosed with a sensitivity of 23.0%, specificity of 94.9% and efficiency of 66.8%. Moderate alcohol intoxication was identified with a sensitivity of 51.2%, specificity of 46.1% and efficiency of 48.9%; severe intoxication with a sensitivity of 73.0%, specificity of 67.3% and efficiency of 67.7%. Thus, the average efficiency to diagnose the right AAI severity group, determined by the BAC, using clinical judgement by a physician, was 61.1%. Thus, comparing the diagnostic characteristics of clinical judgement between AAI groups determined biochemically, it is clear that the clinical judgement matched better with AAI determined by the SAC rather than by the BAC.

**DISCUSSION**

The consumption of alcohol among children is a growing problem in many countries, including Estonia, and therefore, our study involved a relatively large number of children: 256 intoxicated minors admitted to two hospitals over 3 years. The
The severity of alteration of consciousness correlated well with the SAC and should be the leading sign in the clinical evaluation of children with AAI. Disturbances of speech and balance added further information about AAI. The variation of AAI signs could be confirmed by measuring the SAC as the ‘AAI gold standard’ in hospitals. For legal cases where BAC is required, the SAC:BAC ratio of 1.19 should be used in children regardless of their gender or age.

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Conflict of interest statement. None declared.

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CONCLUSIONS