Acute Alcohol Intoxication Characteristics in Children

Mailis Tönisson1,2,*, Vallo Tillmann3,4, Anne Kuudeberg1, Delia Lepik1 and Marika Väli1,2

1Department of Pathological Anatomy and Forensic Medicine, University of Tartu, Biomedicalum, Ravila 19, Tartu, Estonia, 2Estonian Forensic Science Institute, Tallinn, Estonia, 3Department of Paediatrics, University of Tartu, Tartu, Estonia and 4Tartu University Children’s Clinic, Tartu, Estonia

*Corresponding author: Tel: +372-737-4286; Fax: +372-737-4282; E-mail: mailis.tonisson@ut.ee

(Received 3 April 2012; first review notified 9 May 2012; in revised form 1 April 2013; accepted 2 April 2013)

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 ($r_s = 0.16$) and speech ($r_s = 0.13$) ($P < 0.0001$). 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 $1.19 \pm 0.13$ ($P < 0.001$) 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, 85.9% of 13–16-year-old adolescents in Estonia had consumed alcohol in their lifetime (Markina and Šahverdov-Žarkovski, 2007). Since the frequency and amount of alcohol consumption has gradually increased, medical personnel at hospitals have to be prepared for an increase in the corresponding workload. Clinical signs and symptoms of acute alcohol intoxication (AAI) have been well studied in adults, and the Diagnostic and Statistical Manual of Mental Disorders (DSM IV) for the diagnosis of AeAI is used in everyday work (Diagnostic and Statistical Manual of Mental Disorders IV, 2000) (note that throughout this paper we use the term ‘intoxication’ to mean alcoholization and not to the behavioural state associated with alcohol). A set of clinical signs—disturbed consciousness and memory, slurred speech, imbalance, aggressiveness or euphoria—may be an indicator of AAI. Somnolence, stupor, disorientation and disturbance of balance are common and well recognized symptoms of the depression of the central nervous system (CNS) related to alcohol intoxication. Many studies describe good correlations between CNS symptoms and the blood alcohol concentration (BAC) in adults (McKnight et al., 1997; Zoethout et al., 2011), but there is insufficient information about similar studies in children (Laminpää, 1994). The measurement of the clinical signs such as pulse, frequency of breath, blood pressure and body temperature is a simple way, but these signs are not specific to the estimation of drunkenness. Some studies have found that the pulse of intoxicated people is often accelerated (Ryan and Howes, 2002; Brunelle et al., 2004), but can also occur occasionally slower than normal (Brvar and Bunc, 2009). Blood pressure can express a similar tendency—from hypotension in very rare cases (Wilson and Waring, 2007) to hypertension (Spencer and Hutchison, 1999; Reims et al., 2004). The frequency of breathing is related to the intoxication level and lactate level in plasma—an increased lactate level leads to acidosis and this in turn to an increased breathing rate. Body temperature is often influenced by the outside temperature: the hazard to cooling is greater in cold weather. Although there are a lot of studies related to different aspects of AAI in children, few have looked at the clinical signs and symptoms of AAI (Weinberg and Wyatt, 2006; Bouthoorn et al., 2011a,b). These studies mainly describe serious alcohol intoxications in children without the comparable groups of mildly or moderately intoxicated children. In the emergency department the paediatrician on call should diagnose and treat the AAI as soon as possible. Assessment of the intoxication level by clinical signs can help to determine treatment tactics, but routine measurement of the serum alcohol concentration (SAC) in alcohol intoxication cases takes time. The clinical assessment of drunken children is not an easy task as there are no objective criteria to determine the alcohol intoxication level: it is often subjective and depends on the experience of the on-call physician.

The clinical signs have been compared with alcohol concentrations in different biological fluids such as serum, plasma or blood in adults by most authors (Dubowski, 1980; Wright, 1991; Vonghia et al., 2008), but there are only few such studies in children (Bouthoorn et al., 2011a,b). Alcohol
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 chemical tests and hormones have been reported by authors in other papers (Tõnisson 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/l was considered mild alcohol intoxication; 1.51–2.50 mg/l moderate intoxication and >2.50 mg/l 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 amphetamine, 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, confused speech was a frequent sign \((n = 103)\), followed by difficulty 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>
</tr>
</thead>
<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 ((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>
</tr>
</tbody>
</table>
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 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 SAC, 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
ratio of girls to boys was similar to that in other studies (Marchi et al., 2003; McIntosh et al., 2004) where generally more boys were involved. The mean age of the children in our study was similar to that in other studies (Weinberg and Wyatt, 2006; Schöberl et al., 2008), except that we encountered significantly fewer 16-year-old adolescents. Some studies showed the different pattern of gender and age in AAI children where the ratio of boys to girls was quite equal and the mean age was over 15 years (Kuzelova et al., 2009; van Hooft et al., 2010; Bouthoorn et al., 2011a,b).

CNS disturbance signs were correlated with the SAC in the children, but the correlation was stronger with the BAC. The disturbed conscious and balance problems in the children were similar to those seen in adults with AAI as alcohol induces the inhibition of CNS and the disturbance of coordination, memory, consciousness and speech. Reduced consciousness was also the most common clinical finding by other studies (Weinberg and Wyatt, 2006; Bouthoorn et al., 2011a,b), but the second important sign was hypothermia (Madsen, 1990). In our study slurred speech was not a useful sign to determine the severity of AAI in children because it was common at every level of AAI. Although slurred speech is not common in chronic intoxicated adults even with a high BAC (Sobell et al., 1982; Pisoni and Martin, 1989), it is common in children with AAI. Change in muscle tone was unpredictable in some children as alcohol usually produces a decrease in muscle tone, but there were eight children with increased muscle tone, possibly due to aggressiveness.

However, in our study we did not find statistically significant differences in body temperatures between seasons. Ethanol itself enhances the decline in body temperature by the dilatation of the peripheral blood vessels, and therefore, body temperature can slightly decrease. Seasonal differences in body temperature can occur in areas with large temperature differences as in Estonia, but children in our study were mostly hospitalized from inside rooms. The few who were found outside were discovered and studied in the summer.

Estimation of AAI clinical signs and BAC together in the everyday work in hospitals is especially important for the early detection and intervention of hazardous drinking habit in young people (Touquet and Harris, 2012). Comparing BAC and estimated AAI levels by the clinical signs, we found that doctors often clinically estimated the severity of intoxication in children as one or even two stages more severe than that indicated by the SAC.

There were also 15 children in whom the BAC was in the mild group (0.20–1.50 mg/g) but who were clinically assessed as severe AAI by the paediatrician, i.e. the doctor estimated the severity of AAI two stages more severe than determined biochemically. Most of these children were younger than 14 years and the leading sign was strongly disturbed balance. The younger children probably had not used alcohol before and therefore were probably very sensitive to alcohol. This is due to the child’s many organ systems such as endocrine system, liver function and others. The body of a younger child contains more body water than in older children and adults and as alcohol disperses easily in body water, the SAC in children may even be relatively low, but there are remarkable clinical signs of AAI due to the direct effect of alcohol on CNS. The clinical signs of AAI can develop and diminish more rapidly in younger children due to the differences in the alcohol metabolism rate, which in children is twice higher rate found in adults (Leung, 1986; Donovan, 2009).

In our study all the children were Caucasians, but generally the ethnicity of the subjects should be taken into consideration because in some Asians low activity of enzyme aldehyde dehydrogenase has been found (Crabb et al., 1989; Thomasson et al., 1991).

Many authors have studied the ratio between the SAC and BAC in adults (Rainey, 1993; Labianca, 2002; Barnhill et al., 2007). The results of these studies can be used in legal cases, especially in those related to traffic incidents. Ethanol is spread well in body water, and its concentration in serum is higher than in blood because the water content of the serum is higher than in the whole blood. The ratio between the SAC and BAC in adults has been found from 1.04:1 to 1.26 with an average of 1.14–1.15:1 (Rainey, 1993; Charlebois et al., 1996). We found that the average SAC:BAC ratio in children was a bit higher (1.19:1) than seen in adults, probably from the lower haematocrit of the blood, with no difference between age groups or gender of the children.

One of our major limitations was that we did not use a standardized method to determine the level of AAI by clinical signs and did not perform inter-rater reliability testing. However, all the on-call doctors in this study have graduated from the only medical faculty in Estonia and their medical training in paediatrics has been similar. Therefore, we presume that there can be no major differences in the evaluation of a child admitted to the hospital, and the severity of AAI should be comparable. In our study there were few patients with mild AAI. This was because they did not need hospitalization. There were also difficulties in the generalization of the results due to a scarce representation of 16-year-old adolescents.

CONCLUSIONS

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.

Acknowledgements — Thanks are due to Tartu University Children’s Clinic, Tallinn Children’s Hospital and Estonian Forensic Science Institute for their cooperation in collecting data.

Funding — The study was funded by the Estonian Science Foundation (grants no. 6592 and 8256) and by the Basic Funding Grant from the University of Tartu (PARPA).

Conflict of interest statement. None declared.

REFERENCES


European School Survey Project on Alcohol and Other Drugs. (2003)