Epidemiology of acute pediatric poisonings complicated by cardiogenic shock – a 6-year study in a clinical toxicology unit

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ABSTRACT

Background. Acute pediatric poisonings represent an emergency pathology that associates a significant risk of adverse outcome or death. The increased incidence reported by antitoxic centers is a public health problem and requires implementing prevention strategies.

Material and method. The six-years study targets children diagnosed with acute poisoning complicated by cardiogenic shock in a pediatric toxicology unit, performing a descriptive analysis of the epidemiological characteristics of the group.

Aim. To provide statistical data that can represent the basis of preventive measures carried out by health services.

Results. The incidence of severe intentional poisonings complicated by cardiogenic shock is almost twice as high as accidental ones. A strong correlation was identified between intentional poisonings and adolescent girls.

Conclusions. The detailed epidemiological data allows targeted intervention measures to prevent suicide attempts and decrease the incidence of accidental exposures among the pediatric population.

Keywords: pediatric poisoning, epidemiology, cardiogenic shock, prevention

INTRODUCTION

Acute poisonings are a permanent cause of morbidity and mortality in the pediatric population. According to data counted in the US National Poisoning System in 2017, approximately 60% of toxic exposures were recorded in patients under 20. The increase in the incidence of accidental poisonings among children has been correlated with the increase in prescription drugs for adults, especially opioids, anti-addictive medication, for ADHD, cardiovascular or sedative-hypnotic agents (1,2).

Accidental poisonings are a common pathology among the pediatric population, while intentional exposures are becoming prevalent in adolescents and young people (3).

Young children show a particular innate curiosity to explore the environment with all the senses, thus being prone to ingest various substances with toxic potential. Age-specific neurological acquisitions do not allow them to be aware of the potential danger they are exposed to, being attracted to colorful objects such as containers of household prod-
ucts, fruits or toxic plants or medicines. Preschoolers tend to copy the behavior of adults, including by administering pharmaceuticals. The association of these exploratory mechanisms characteristic of children is the cause of the increased incidence of accidental exposures in this age group (4).

Very young children are underweight, have limited physiological reserves and poorly developed metabolic pathways, making them more susceptible to post-exposure lesions, including small amounts of toxic. Even in less severe exposures, in the case of ingestion of pharmaceutical products by children, is decided their hospitalization, causing high costs to the health system (5).

The literature identifies differences among adolescents in choosing toxic agents according to gender, probably due to their exploratory behavior and social norms. Boys are prone to addictive behaviors through substance abuse and self-medication, while girls are at increased risk for suicidal behavior. Research on drug intakes has identified differences in the toxicant metabolism depending on the patient's gender. Thus, girls show more side effects than boys, possibly due to their weaker representation in clinical trials and therefore, the lack of knowledge of the specific dose of each gender (6,7).

After analyzing the cases of toxic exposures registered by the American poison centers, it was concluded that only 10% of the children under the age of 6 need specialized care in a medical unit. The detailed knowledge of the epidemiological characteristics, corroborated with the possibility of remote evaluation of the case in an antitoxic center by trained medical staff, leads to efficient management of the case and substantial savings of the health system. With the help of these telephone services, toxicologists, based on epidemiological criteria taken from the patient or relatives, estimate the severity of the case and especially identify those who do not require medical care. The collected demographic data associated with the information regarding the presumed toxic substance, the intention and the developed symptomatology allow the distinction between real intoxications and only toxic exposures (8).

The American Toxic Exposure Surveillance System (TESS) has identified several epidemiological parameters that characterize a toxic exposed patient. These can be quantified and allow a cost-effective approach to the case: the patient's sex and age, the intention of exposure and its chronic or acute nature, etiology, route of exposure and quantity of the toxicant. Data on the developed symptomatology and specific or empirical therapeutic measures applied at the exposure site are also helpful for the effective management of the case. Toxicologists may further establish that the toxic substance claimed by the patient or relatives does not represent a toxic agent or has low toxicity (1,9).

Epidemiological data underlie the introduction of public health measures to reduce the overall harm caused by toxic agents. For example, in the United Kingdom, reducing the size of extralarge Paracetamol vials, sold without a prescription, has not led to a further significant decrease in the number of cases of acute paracetamol poisoning, but has reduced cases of large amounts ingestions, usually complicated by liver failure and death (1,7).

Another public health measure, based on the increasing risk of morbidity and mortality reported by epidemiological studies, is the withdrawal of certain drugs from the pharmaceutical market. One such example is the withdrawal from the United Kingdom of the drug Co-proxamol, a combination of paracetamol and opioids, when epidemiological data indicated an increase in the incidence of mortality following ingestion of high doses, intentional or unintentional (1,10,11).

The toxicity index is a valuable parameter in assessing the toxic potential of a substance. Its determination is made by comparing the prescription rate with the incidence of mortality given by the respective agent (12).

**AIM**

The study aims to provide statistical data that can represent the basis of prevention strategies developed by health services to reduce mortality and morbidity associated with acute pediatric poisoning.

**MATERIAL AND METHOD**

The study presented in this paper is observational, descriptive and retrospective, conducted over six years, October 2014 - October 2020, in the Department of Toxicology - Intensive Care of the Emergency Clinical Hospital for Children “Grigore Alexandrescu”. The department is a separate clinical toxicology unit in a tertiary hospital. The group consisted of 1396 patients hospitalized in the Department of Toxicology with the diagnosis of severe acute poisoning with cardiotoxic agents. From these, were selected those cases that associated signs of cardiogenic shock, summing a sample of 62 patients.

The criteria for including patients in the group were:
- age between 0 and 18 years
- confirmation of the diagnosis of acute poisoning with cardiotoxic agents and which have associated signs of cardiogenic shock
- absence of pre-existing heart disease
hospitalization registered during the analyzed period, October 2014 - October 2020. The criteria for excluding patients from the group were:

- over 18 years of age,
- confirmation of the diagnosis of acute intoxication with cardiotropic and/or vasculotropic agents, but which showed only altered mental status due to the direct action of the toxicant without other manifestations associated with the shock,
- known to have heart disease prior to toxic exposure
- hospitalization occurred outside the analyzed time interval.

We analyzed the clinical observation files of hospitalized patients diagnosed with severe acute poisoning with cardiotoxic agents, and from these, we selected those who met the clinical shock criteria. For the selected sample, we recorded in individual files their anamnestic, epidemiological, clinical - biological parameters, the therapeutic methods approached and the evolution.

Each of the 62 patients included in the study group presented at least one of the following diagnostic criteria for cardiogenic shock: weak or absent pulse in the major arteries, capillary recoloration time over 2 seconds, low blood pressure (according to age), cold, cyanotic or marbled extremities, diuresis decrease below 1 ml/kgc/hour, mental status alteration (2).

The collected data were processed using the IBM SPSS program. The results obtained were represented in percentages, frequencies, standard deviations, variants, means and medians, depending on the situation (13).

**Medical ethics issues**

Being a descriptive and retrospective study, we used the informed consent expressed by the parents at the time of admission of the minor patients. The stages of compiling the study group as well as the analysis of the clinical observation files were performed following the medical legislation in force regarding the confidentiality of the data provided and the informed consent.

**RESULTS**

**Prevalence of cardiogenic shock in acute pediatric poisoning**

During the six years studied, 63,078 hospitalizations were registered in the Pediatrics Department, with an average of 9010 cases per year. Of these, 7,666 cases were admitted to the Toxicology - Intensive Care Unit, with an average of 1100 per year (figure 1). It should be noted that the year 2020 was under the influence of the COVID-19 pandemic, so the number of hospitalizations was reduced by half.

During the six years analyzed, 1396 acute poisoning cases had a cardiotoxic substance as an etiological agent; the average of these patients with severe outcome potential, including cardiogenic shock, was 199.4 cases per year.

After extensive investigation of severe or potentially severe cases, we identified 62 patients with at least one of the signs of cardiogenic shock. Thus, considering that 7666 cases of acute poisoning were registered in the Department of Toxicology, the prevalence of cardiogenic shock in 2014 - 2020 is 0.8%.

![Figure 1](image-url)

**FIGURE 1.** Distribution of acute poisoning cases from the total number of hospitalizations in the Department of Pediatrics from 2014 to 2020
Analysis of demographic characteristics

Analyzing the group of 62 patients included in the study, we found a discrepancy in the cases’ distribution by gender, so that most acute poisonings were recorded among girls in a percentage of 75.81% compared to boys of only 24.19%, with a ratio of 3.13:1 (Figure 2).

The age of the selected patients ranged from 2 months and a half to 18 years (Figure 3).

We divided the cases into three age categories, and the histogram of the distribution by age groups of cardiogenic shock showed two peaks of incidence, at 0-5 years (n = 16, 25.81%) and 13-18 years (n = 38, 61.29%). The number of cases in the 6-12 age group is significantly lower (n = 8, 12.9%).

The mean age in the studied group was 10.92 years, with a standard deviation of 5.64.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Frequency</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>10</td>
<td>4</td>
<td>8</td>
<td>9</td>
<td>7</td>
<td>62</td>
</tr>
<tr>
<td>Percent</td>
<td>1.6</td>
<td>4.8</td>
<td>4.8</td>
<td>9.7</td>
<td>1.6</td>
<td>3.2</td>
<td>4.8</td>
<td>1.6</td>
<td>1.6</td>
<td>3.2</td>
<td>1.6</td>
<td>16.1</td>
<td>6.5</td>
<td>12.9</td>
<td>14.5</td>
<td>11.3</td>
<td>100</td>
</tr>
</tbody>
</table>
Regarding residency of the patients, we registered a higher number of cases in urban areas (36) than rural areas (26), in a percentage of 58.06% versus 41.94%.

Analyzing the distribution of the patients by age groups, considering the gender and the residency, a predominance of females is observed, especially in rural areas in the age group 13-18 years, where the percentage is 94.4%. In the 6-10 age group, the distribution is equal between the genders, regardless of the residency. The only category where boys represent the majority (75%) is among young children from rural areas, 0-5 years old. Acute poisonings among adolescents (13-18 years) are equally common regardless of whether they come from urban or rural areas (n = 17, 44.7% of the group).

The distribution of cases according to age and gender shows homogeneity of distribution in males. The average age of the boys in the group is 7.93 years, with a standard deviation of 5.73 and a dispersion index of 32.78. Regarding girls, the appearance of the age distribution curve is similar to that of the entire study group. The average age of girls is 11.87 years with a standard deviation of 5.33 and a dispersion index of 28.37, lower than that of boys.

**TABLE 2. Distribution of patients according to their residency, gender and age categories**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Rural</th>
<th></th>
<th></th>
<th>Urban</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>F</td>
<td></td>
<td>M</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. of cases</td>
<td>% from category</td>
<td>% from sample</td>
<td>No. of cases</td>
<td>% from category</td>
<td>% from sample</td>
</tr>
<tr>
<td>0-5</td>
<td>3</td>
<td>75.0</td>
<td>18.8</td>
<td>1</td>
<td>25.0</td>
<td>6.2</td>
</tr>
<tr>
<td>6-10</td>
<td>2</td>
<td>50.0</td>
<td>25.0</td>
<td>2</td>
<td>50.0</td>
<td>25.0</td>
</tr>
<tr>
<td>13-18</td>
<td>1</td>
<td>5.6</td>
<td>2.6</td>
<td>17</td>
<td>94.4</td>
<td>44.7</td>
</tr>
</tbody>
</table>
Analysis of intention

FIGURE 7. Distribution of patients according to the intention of exposure

In the studied group, the incidence of intentional poisonings (n = 41, 66.13%) is almost twice as high as accidental ones (n = 21, 33.87%).

Analyzing the intention of exposure according to age and gender, it can be noticed that all poisonings are accidental in the age group 0-5 years, regardless of gender, the distribution being similar in girls and boys (56.2% versus 43.8%). In the 13-18 age group, however, all 38 registered cases are intentional, with an absolute dominance among girls (n = 34, 89.5%) compared to boys, represented in a percentage of only 10.5%.

DISCUSSIONS

The extensive literature review associated with this research has highlighted a significant shortage of recent scientific articles, mainly targeting cases of cardiogenic shock from acute pediatric poisonings. The presented study analyzes the latest epidemiological data from a clinical toxicology unit, consisting of one of the most extensive research, as it evaluates acute pediatric poisonings over six years.

During the analyzed period, 7,666 pediatric cases with the diagnosis of acute poisoning were registered, among them the prevalence of cardiogenic shock being quantified at 0.8%. A similar prevalence is found in another scientific paper by Petran et al., which following a statistical study conducted in the period 2000-2005 in the Department of Toxicology of SCUC “Grigore Alexandrescu” reported a prevalence of 0.71% cases of shock cardiogenic out of a total of 5560 cases of acute intoxication recorded (14). Thus, there is a slightly increased prevalence of acute pediatric poisoning severe cases, a trend that is maintained in other recent international reports (5,8,10).

Compared with existing data in the literature, Thanacoody et al. identify an incidence of over 100,000 cases of acute poisoning, regardless of age, assessed in the emergency departments of the United Kingdom, considering that the population of the UK is 3.5 fold larger compared to Romania (1).

Following the age analysis of the patients included in the group, acute poisonings were identified in all ages, their distribution being inhomogeneous. Thus, two peaks of incidence were noted, in young children 0-5 years and adolescents aged 13-18 years. The youngest patient studied was a two and a half months old infant admitted to the clinic with the diagnosis of acute methemoglobinemia due to severe acute nitrite poisoning, after receiving the formula prepared with well water. Actually, he was the only infant included in the group.

Most cases in the group analyzed in this study were recorded at 13 years (10 cases, representing a percentage of 16.1). The 6-10 age group was less represented, but the incidence increases towards adolescence. The increased frequency of cases in young children overlaps with the observations reported in the literature and is due to their feature of exploring the environment, thus being exposed to various toxins (10,11). The second peak of the incidence correlates with the increased number of cases of intentional poisoning for suicidal purposes among adolescents (15).

Litovitz et al. report 1.5 million toxic exposures in US antitoxic centers among patients under 19. The peak incidence was registered in the 1-2 years age group and children younger than 4 years accounted for 46% of cases (16).

Recent studies also signal an increase in the incidence of suicide attempts among adolescents, but the underlying causes that led to this behavior are

<table>
<thead>
<tr>
<th>Table 3. Distribution of intention by sex by age groups</th>
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<tbody>
<tr>
<td>Age (years)</td>
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<tr>
<td></td>
</tr>
<tr>
<td>No. cases</td>
</tr>
<tr>
<td>0-5</td>
</tr>
<tr>
<td>6-10</td>
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<tr>
<td>13-18</td>
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</table>
not well documented. Specific correlations have been identified with adolescents' risky behavior, with unlimited access and intense exchange of information between them and with the practice of self-medication (5,8,17). A particular case is a 15-year-old girl with intentional cardiotoxic poisoning as a suicide attempt, in the context of a 17-week pregnancy. During the hospitalization, the patient benefited from the medical care of a multidisciplinary team consisting of an emergency physician, toxicologist, obstetrician, pediatrician and anesthetist. Both the fetus and the mother survived the event, but there are no data on their subsequent evolution. According to literature reports, Czeizel et al. draw attention that this combination of diagnoses is common enough to require a national system to monitor the evolution of live-born babies regarding fetotoxicity and the teratogenic effect of toxic intrauterine exposure (10,15,18).

A research published in 2020 by Beauchamp et al. performs an exhaustive analysis of the correlation between the gender of pediatric poisoned patients and their age. A percentage of 59.2% of girls from the entire studied group is reported. Also, most cases (67.1%) were between 13 and 18 years old (19). A similar percentage is identified in the present study - 61.29% (figure 2). 73.7% of the total exposures analyzed by the American team were voluntary intoxications with pharmaceuticals, a finding that overlaps with most recent epidemiological studies, including the current one in which a percentage of 66.13% is identified (19).

There is a strong correlation between intentional poisoning and females in the 13-18 age group. The gender of the patients thus becomes a moderator of the suicidal behavior, the girls having an overwhelming predisposition to overdoses. The percentage identified in the present study, of 75.81% (figure 2), reinforces the findings presented in the literature (17,20,21).

The 2019 annual report of the American Association of National Antitoxic Centers, published in late 2020, states a 42.8% incidence of toxic exposures in children under 5, regardless of gender or the severity of side effects. It also records the same trend of male predominance in young children, a distribution that reverses as they progress to adolescence and adulthood, where girls become the majority (22).

Assessing gender-specific differences across age groups in the pediatric population can highlight how the patient's gender and age interaction can modulate risk factors, clinical features, and therapeutic approaches (20).

CONCLUSIONS

The study performs a detailed analysis of epidemiological data of pediatric patients diagnosed with acute intoxication complicated by cardiogenic shock in a pediatric toxicology unit. The research identified some correlations between the demographic characteristics of the studied cases, the results being presented in the context of a shortage of scientific materials regarding severe acute poisonings in the pediatric population. Detailed data may represent the basis of prevention strategies developed by national public health services. This facilitates the implementation of targeted educational and administrative measures at the population level to avoid or improve children’s adverse effects secondary to toxic exposures.

REFERENCES


