Successful treatment of cardiogenic shock with an intra-aortic balloon pump following aluminium phosphide poisoning

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Aluminium phosphide (AIP) is a highly toxic pesticide that inhibits cytochrome oxidase c and causes oxidative stress. Death results from refractory cardiogenic shock due to myocardial dysfunction. There is very little information regarding extracorporeal life support in severe AIP poisoning. Although several therapies are available, none are curative. We report on the use of an intra-aortic balloon pump (IABP) in a 24-year-old woman brought to our hospital after an intentional ingestion of a tablet of AIP (3 g), which caused refractory AIP-induced cardiogenic shock and acute respiratory distress syndrome (ARDS). The patient underwent gastric lavage with potassium permanganate, received sodium bicarbonate intravenously, and was admitted to the intensive care unit. Echocardiography at 36 h post ingestion showed a left ventricular ejection fraction (LVEF) of <20%. An IABP was inserted and the patient’s vital signs stabilised. After eight days, the IABP was removed and on day 20, the patient’s LVEF increased to 50%. IABP was successfully used and may improve future prognoses for severely poisoned AIP patients with refractory cardiogenic shock. We encourage clinical toxicologists to examine this new treatment.

KEY WORDS: emergency medical treatment; extracorporeal life support; phosphine gas poisoning
and was given intravenous sodium bicarbonate (NaHCO$_3$) 44 mEq every 15 min. The patient was then admitted to our Centre (about three hours post-ingestion of AlP). Vital signs on arrival were: blood pressure 100/70 mm Hg; pulse 130 bpm; respiratory rate 18 per minute; and body temperature 37 °C with an oxygen saturation of 96 %. Electrocardiography (ECG) revealed sinus tachycardia with no ST-T changes, but serial ECGs showed non-specific ST and T-wave changes and interventricular conduction delay (Figure 1). Serial vital signs and laboratory data are shown in Table 1. The patient was admitted to the intensive care unit (ICU) and received intravenous crystalloid fluid (normal saline; 150 mL h$^{-1}$ until her thirst was resolved), vasopressors (dopamine; 10 µg kg$^{-1}$ min$^{-1}$, and norepinephrine; 4 µg min$^{-1}$), digoxin 0.5 mg stat followed by 0.25 mg q6h for 24 h and 0.25 mg daily, afterwards, glucagon 4 mg h$^{-1}$, magnesium sulphate 2 g stat followed by 1 g q6h, sodium bicarbonate (until correction of metabolic acidosis), vitamin C 500 mg per day, vitamin E 100 IU per day, heparin 5000 IU BID and N-acetylcysteine 300 mg kg$^{-1}$ through 24 h in three divided doses. About 24 h later, the patient experienced tachypnea (respiratory rate 45 per minute) and her O$_2$ saturation dropped to 70 %.

The patient also complained of retrosternal discomfort and was therefore intubated and placed on mechanical ventilation with the following parameters: synchronised intermittent mandatory ventilation (SIMV) mode of fractional inspired oxygen (FiO$_2$) was 50 %, tidal volume was 350 mL, and positive end-expiratory pressure (PEEP) was 7 mm H$_2$O. However, her O$_2$ saturation remained at 88-92 % and gasometry showed an arterial oxygen pressure (PaO$_2$) level of 50 mm Hg. A chest X-ray confirmed acute respiratory distress syndrome (ARDS) (Figure 2). ARDS was defined as diminished PaO$_2$ to FiO$_2$ ratio (P to F ratio smaller than 200). Thirty-six hours after admission, bedside echocardiography showed a left ventricular ejection fraction (LVEF) of less than 20 %, global hypokinesia of the left ventricle and mitral valve regurgitation (MR) and an IABP was inserted by a cardiac surgeon. The patient had no contraindications to the use of an IABP (e.g., sepsis, aortic aneurysms, peripheral vascular diseases, neurological deficits, aortic dissection, etc.).

On the third day of ICU admission, ventilator acquired pneumonia (VAP) occurred and the patient’s temperature increased to 38.5 °C. Meropenem (1 g three times per day), amikacin (500 mg BID), and vancomycin (1 g BID) were administered. On day
Table 1 Clinical and paraclinical findings of our case of AlP poisoning

<table>
<thead>
<tr>
<th>Laboratory tests / time after ingestion</th>
<th>12 h</th>
<th>24 h</th>
<th>day 5</th>
<th>day 8</th>
<th>day 10</th>
<th>day 18</th>
<th>day 26</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood pressure (mm Hg)</td>
<td>100/70</td>
<td>90/60</td>
<td>80/50</td>
<td>105/65</td>
<td>110/70</td>
<td>105/80</td>
<td>120/70</td>
</tr>
<tr>
<td>Pulse rate (bpm)</td>
<td>130</td>
<td>160</td>
<td>150</td>
<td>110</td>
<td>86</td>
<td>90</td>
<td>103</td>
</tr>
<tr>
<td>Respiratory rate (pm)</td>
<td>20</td>
<td>30</td>
<td>45</td>
<td>SIMV</td>
<td>SIMV</td>
<td>SIMV</td>
<td>20</td>
</tr>
<tr>
<td>O₂ saturation (%)</td>
<td>94</td>
<td>86</td>
<td>70</td>
<td>91</td>
<td>100</td>
<td>100</td>
<td>96</td>
</tr>
<tr>
<td>pH</td>
<td>7.48</td>
<td>7.30</td>
<td>6.90</td>
<td>7.47</td>
<td>7.49</td>
<td>7.38</td>
<td>-</td>
</tr>
<tr>
<td>PaCO₂ (mm Hg)</td>
<td>17.6</td>
<td>19.9</td>
<td>69</td>
<td>45</td>
<td>34.8</td>
<td>43.9</td>
<td>-</td>
</tr>
<tr>
<td>PaO₂ (mmHg)</td>
<td>58</td>
<td>52</td>
<td>50</td>
<td>56</td>
<td>60</td>
<td>62</td>
<td>65</td>
</tr>
<tr>
<td>Serum HCO₃ (mmol L⁻¹)</td>
<td>13.1</td>
<td>10</td>
<td>15.4</td>
<td>32.9</td>
<td>28.2</td>
<td>26.5</td>
<td>-</td>
</tr>
<tr>
<td>WBC (10⁵ µL)</td>
<td>16.5</td>
<td>-</td>
<td>23</td>
<td>-</td>
<td>23</td>
<td>22.6</td>
<td>14.1</td>
</tr>
<tr>
<td>Hb (g dL⁻¹)</td>
<td>13.7</td>
<td>-</td>
<td>14.4</td>
<td>-</td>
<td>8.4</td>
<td>8.7</td>
<td>9</td>
</tr>
<tr>
<td>Platelet count (10³ µL)</td>
<td>232</td>
<td>-</td>
<td>194</td>
<td>-</td>
<td>81</td>
<td>131</td>
<td>267</td>
</tr>
<tr>
<td>Na (meq L⁻¹)</td>
<td>140</td>
<td>-</td>
<td>139</td>
<td>144</td>
<td>139</td>
<td>136</td>
<td>138</td>
</tr>
<tr>
<td>K (meq L⁻¹)</td>
<td>4</td>
<td>-</td>
<td>3.9</td>
<td>2.6</td>
<td>4.6</td>
<td>4.4</td>
<td>4.1</td>
</tr>
<tr>
<td>Prothrombin time (s)</td>
<td>12.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>15.6</td>
<td>14.4</td>
<td>-</td>
</tr>
<tr>
<td>Creatinine (mg dL⁻¹)</td>
<td>0.6</td>
<td>-</td>
<td>-</td>
<td>0.8</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
</tr>
<tr>
<td>Glucose (mg dL⁻¹)</td>
<td>145</td>
<td>-</td>
<td>485</td>
<td>45</td>
<td>169</td>
<td>155</td>
<td>135</td>
</tr>
<tr>
<td>Creatine phosphokinase (IU L⁻¹)</td>
<td>219</td>
<td>-</td>
<td>648</td>
<td>203</td>
<td>-</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>AST* (IU L⁻¹)</td>
<td>52</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>72</td>
<td>43</td>
<td>45</td>
</tr>
<tr>
<td>ALT** (IU L⁻¹)</td>
<td>75</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>273</td>
<td>216</td>
<td>89</td>
</tr>
</tbody>
</table>

SIMV - synchronised intermittent mandatory ventilation
*Aspartate aminotransferase
**Alanine aminotransferase

Figure 1 Electrocardiography of AlP poisoned case. Electrocardiography (ECG) revealed sinus tachycardia with no ST-T changes; but serial ECGs showed non-specific ST and T-wave changes and interventricular conduction delay.

four, sudden complete cardiac arrest occurred; however, fortunately, the patient responded to resuscitation. After stabilization of vital signs, the IABP was removed (8 days after insertion). Repeated echocardiography on day 20 of admission showed an LVEF of 50 %.

Surprisingly, our patient exhibited thrombocytopenia, hypokalaemia, and variations in haemoglobin between the second and the eighth day of admission (Table 1), maybe due to receiving heparin. The administered antibiotics were the other possible causes of acute thrombocytopenia (21, 22). Hypokalaemia in our patient was probably due to the administration of sodium bicarbonate to correct acidosis, although there is evidence that AlP can affect potassium levels in cases of poisoning (9, 23). Variations in haemoglobin were probably due to haemolysis induced by the IABP as an external device. Mean corpuscular volume amounts have been reported to be at maximum levels
due to the release of unmaturated red blood cells into circulation from bone marrow hyperactivity (24).

The patient’s medication (vasopressors, calcium gluconate, magnesium sulphate, hydrocortisone, vitamin C, and vitamin E) was tapered gradually. After consultation with a psychologist, the patient was discharged on day 27 in good condition and normal vital signs and laboratory tests. A follow-up visit about two months later revealed that the patient was asymptomatic with no evidence of ongoing toxicity or sequelae.

DISCUSSION

Cardiogenic shock is defined as systolic blood pressure <90 mm Hg or 30 mm Hg below the baseline during organ dysfunction (25). It is a kind of shock in which the failure of the cardiac ventricle causes inadequate circulation. It is defined by tissue hypoperfusion and hypotension and is a largely irreversible and fatal condition (26). Cardiogenic shock is commonly caused by damage to the heart muscle such as myocardial infarction, arrhythmias, cardiomyopathy, etc. Some cases of drug poisoning, such as those by β₁ adrenergic receptor antagonists (e.g. atenolol, propranolol) and calcium channel blockers, also lead to profound hypotension and cardiogenic shock; similar to those that occur with aluminium phosphide (27-29). Cardiogenic shock could also be approached by procedures such as administration of positive inotropic agents or glucagon (11, 30) and enhancing pumping capabilities, which should cause a positive inotropic and chronotropic effect by stimulating adenosine monophosphate.

Pumping can also be improved by using an IABP, a left ventricular assist device that enhances the perfusion of coronary arteries. During an IABP procedure, a balloon is inserted via the femoral artery and placed below the left subclavian and above the renal arteries (31). It is generally used in patients with heart failure waiting for heart transplantation, further revascularization, and shock. At the end of a systole, pumping the balloon causes an increase in aortic blood pressure and increases cardiac output and coronary perfusion as well as improves central nervous system perfusion.

There have been several cases of intoxication where an IABP was applied (27-29), all of which involved refractory cardiogenic shock. Janion et al. (32) reported successful treatment of combined massive drug intoxication using mechanical ventilation and IABP, concluding that combined mechanical and pharmacological treatment may even prevent multi-organ insufficiency.

The use of an IABP for the treatment of AlP was first reported by Chacko et al. (33) in 2008, in a 25-year-old female who suffered from severe toxicity after ingesting 10 tablets of AlP. Unfortunately, it was unsuccessful. A successful treatment of AlP with an IABP was first reported by Siddaiah et al. (12) in 2009, in a 22-year old female who, suffering with cardiogenic shock due to AlP poisoning, was treated with an IABP until the effects of AlP resolved. There are no other reports in the literature on IABP in the treatment of AlP poisoning and the case presented here was the second successful one in this regard.

Our use of an IABP for treating AlP-induced cardiogenic shock yielded success in a patient who otherwise appeared to have a very poor prognosis due to refractory hypotension and ARDS (34, 35). Given our success in the case reported here, it is reasonable to question why IABP has not been used more often. We assume that this most likely relates to the unavailability of a cardiac surgeon in Iranian referral toxicological centres and probably other countries where AlP poisoning is common. Furthermore, to improve outcomes, AlP-poisoned patients need extensive ICU care after insertion of an IABP and, due to the high rate of poisoned patients in the aforementioned countries, the lack of ICU beds is another limitation that should be considered.

IABP has also been used in severe LV dysfunction in other toxic myocarditis cases (27-30), as IABP...
generally reduces afterload and improves coronary artery perfusion. Despite many proposed therapies, patients with severe AIP poisoning continue to die of cardiogenic shock. We recommend the use of this treatment in other cases of refractory cardiogenic shock from AIP poisoning and encourage clinical toxicologists to report on their experiences.

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Sažetak

Primjena intra-aortne balonske pumpe pri kardiogenom šoku uzrokovanim trovanjem aluminijevim fosfidiom

Aluminijev fosfid (AlP) visoko je toksičan pesticid koji inhibira citokrom c oksidazu i uzrokuje oksidacijski stres. Smrt nastupa nakon refraktornog kardiogenog šoka uslijed miokardijalne disfunkcije. Vrlo je malo literature o izvantelesnim sredstvima održavanja na životu nakon otrovanja AlP-om. Iako postoji određeni broj terapija, nijedna ne vodi do potpunoga izlječenja. Prikazan je slučaj uporabe intra-aortne balonske pumpe (IABP) kod 24-godišnje žene otrovane namjernim uzimanjem AlP-a (3 g), što je uzrokovalo refraktorni kardiogeni šok i akutni respiratorni distres sindrom (ARDS). Pacijentici je želudac ispran kalijevim permanganatom, intravenozno je primila natrijev bikarbonat te je zbrinuta u jedinici za intenzivnu skrb. Ehokardiografija 36 h nakon uzimanja tablete AlP-a pokazala je ejekcijsku frakciju lijevog ventrikula (LVEF) od < 20 %. Nakon umetanja IABP-a vitalni su se znakovi su se poboljšali. Pumpa je uklonjena nakon osam dana, a dvadesetoga dana LVEF je iznosio 50 %. Naši rezultati pokazuju da bi primjena IABP-a mogla poboljšati prognoze pacijenata s refraktornim kardiogenim šokom uslijed teškog otrovanja s AlP-om. Stoga preporučujemo kliničkim toksikolozima da razmotre ovaj novi tretman.

KLJUČNE RIJEČI: hitni medicinski tretman; izvantelesna sredstva održavanja na životu; otrovanje pesticidom

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