MOTHBALL POISONING

NICOLA BATES discusses mothball ingestion, a condition not particularly common in emergency units, but one which can be difficult to manage because the active ingredient is often unknown.

Mothballs are not as commonly used as they were in the past, but there are still available. Last year NPIS (London) received 76 enquiries concerning mothballs, that is more than one a week.

Several different chemicals are used as moth repellents. Mothballs usually contain either paradichlorobenzene (also known as p-dichlorobenzene, PDCB and 1,4-dichlorobenzene) or naphthalene; the latter being the more toxic of the two. Some mothballs contain camphor, but these are not generally available in the UK. Mothballs are used to protect clothing and other fabrics from attack by moths. The compounds do not actually repel moths but act as an insecticide and kill both the adults and larvae when a high enough concentration is reached in a closed container. Mothballs are also sometimes used in the garden to repel domestic pets and other animals. Some products are sold as air fresheners and moth repellents combined, these will usually be paradichlorobenzene. This compound is also available in some toilet fresheners in the form of solid rim blocks and channel blocks.

By the very nature of the product the packaging is often not available and this can make determination of the active ingredient very difficult. However, it is important to know which type of mothball is involved in order to determine the appropriate management. Physical appearance is not helpful. All these compounds are white or colourless crystalline solids. They are described as having an aromatic or even more unhelpfully, a mothball-like odour. Fortunately, there are several relatively simple tests that can be employed to distinguish the different types of mothballs (see Table 1). The easiest involves placing the suspect mothball in a glass of water and then in a saturated salt solution. A saturated solution is one in which no further solid (the salt in this case) can dissolve and some remains undissolved at the bottom of the container. If the mothball floats in the saturated salt solution but sinks in water it is naphthalene. If it sinks in both liquids it is paradichlorobenzene. Camphor, in contrast, floats in water.

Another potential problem with mothballs is determining the dose ingested. Mothballs generally weigh about 3.5-4.5 g but they decrease in size with age as the moth repellent compound slowly evaporates.

PARADICHLOROBENZENE

The toxicity of paradichlorobenzene is difficult to assess since there is little substantiated evidence in the literature, but it is generally thought to be of low toxicity. Paradichlorobenzene on the skin or in the eye may cause irritation. It is also irritant to the gastrointestinal tract and may cause nausea, vomiting and diarrhoea. Paradichlorobenzene is considered to be mildly toxic to the liver. Isolated cases of gastrointestinal erosion, liver damage and pulmonary oedema (Tatsuno et al 1978) and of jaundice, methaemoglobinaemia and haemolysis (Hallowell 1959) have been reported. However, in the latter case the presence of naphthalene was not excluded. These are rare cases; in most circumstances ingestion of paradichlorobenzene causes only gastrointestinal irritation.

Gastric decontamination is not required following ingestion of paradichlorobenzene. Clear fluids may be given, but fatty foods...
including milk should be avoided since these may enhance absorption of paradichlorobenzene (although the clinical significance of this is unclear because systemic toxicity from ingestion of paradichlorobenzene is uncommon). Treatment thereafter is symptomatic and supportive with fluid replacement if necessary. Observation in hospital is unlikely to be required following ingestion of mothballs containing paradichlorobenzene.

**NAPHTHALENE**

Naphthalene is more toxic than paradichlorobenzene. Poisoning has arisen from the wearing of nappies or clothes that have been stored with naphthalene mothballs (Schafer 1951, Valaes et al 1963, Grigor et al 1966, Santucci and Shah 2000). In addition, naphthalene is a fat-soluble compound and dermal absorption is enhanced with the use of baby oil. However, naphthalene poisoning in children is obviously less of a problem now, with the widespread use of disposable nappies and reduced use of mothballs.

Naphthalene is irritant to the skin and hypersensitivity may cause dermatitis. The metabolites, naphthol and naphthoquinone, have haemolytic activity but naphthalene itself is a non-haemolytic compound. Patients with a hereditary deficiency of glucose-6-phosphate dehydrogenase (G6PD) are particularly susceptible to the haemolytic effects of naphthalene metabolites. G6PD deficiency is an inherited, X-chromosome linked condition, which exists in a number of forms. It is more commonly found among people of African, South Indian, Oriental and Mediterranean origin, but not exclusively. It is characterised by a tendency to develop haemolysis when subjected to oxidative stresses (e.g. drugs and other toxins, or severe illness). Although this tendency may have been discovered in some people by previous adverse experiences, or by testing, this information may not always be available in an emergency situation. There are several reports in the literature of naphthalene-induced haemolysis in children.

In a study of 24 children (aged less than eight years) admitted to hospital with haemolysis (confirmed by blood smear) 14 had been exposed to naphthalene. Of these children, six had eaten mothballs, one had eaten naphthalene flakes, five had been playing in a room where naphthalene products were present and two had been wearing clothes stored in naphthalene. Of these 14 children, 12 presented with dark urine, jaundice and pallor, either alone or in combination. The other two presented with vomiting, diarrhoea and lethargy. Eleven of these patients required blood transfusions. When tested for G6PD deficiency at the time of presentation 58 per cent of these children had ‘normal’ activity. However, when tested after recovery all were found to have reduced G6PD activity. The remaining children in this study all had infection-association haemolysis; they were all G6PD deficient. None of these children were known to be G6PD deficient prior to attendance (Santucci and Shah 2000).

Ingestion or inhalation of naphthalene may cause headache, confusion, excitement, malaise, profuse sweating, nausea, vomiting and abdominal pain. Irritation of the urinary bladder may occur due to naphthalene metabolites, resulting in dysuria and black/brown urine. This should not be confused with the haemolytic reaction. Urine may have the odour of naphthalene. Convulsions, coma, jaundice and deranged liver function may also occur. Haemoglobinuria, albuminuria, urinary casts and acute renal failure have also been reported. Methaemoglobinemia occurs occasionally following exposure to naphthalene.

In susceptible patients, particularly those with G6PD deficiency, acute intravascular haemolysis can occur up to five, but usually three days later. There may be anaemia with leucocytosis, Heinz body formation and basophilic stippling. Erythrocytes may be abnormally thin (called target cells), small (microcytosis) and vary in size (anisocytosis), shape (poikilocytosis), haemoglobin content (polychromasia) and staining (polychromatophilia). Spherocytosis with fragmentation and distortion of erythrocytes may also occur.

There are few cases of intentional ingestion of naphthalene mothballs. Most cases involve accidental ingestion in children. However, an adult who died five days after intentional ingestion of 40 naphthalene mothballs developed tachycardia, acidosis, respiratory depression, renal
failure, elevated liver enzymes and cerebral oedema. On post-mortem examination 25 mothballs were found in the stomach (Kurz 1987).

In an illustrative case, a boy aged two years and eight months, of Afro-Caribbean descent was observed in hospital overnight after ingestion of one naphthalene mothball. He remained asymptomatic and was discharged home. However, he returned two days later having become progressively unwell with pyrexia, pallor, jaundice and lethargy. On examination he looked unwell with obvious jaundice. His haemoglobin was low with a large number of nucleated red cells present and bilirubin was elevated. His G6PD concentration was found to be low at 1.08 U/ml (normal range 1.6-3.9). He was given a transfusion of packed cells and was discharged on iron and folic acid supplements two days later (Bates 1997).

Chronic inhalational abuse of naphthalene has caused behavioural changes, nausea, vomiting, jaundice, hepatomegaly, elevated liver enzymes, ascites, pitting pedal oedema, and death from liver toxicity (Pysher et al 1984).

TREATMENT

Gastric decontamination should be considered following ingestion of naphthalene in those patients with G6PD deficiency or those who have a high risk of having this condition. This is usually males from the appropriate ethnic groups: those of African, Mediterranean, Middle Eastern or South East Asian descent. Determining the ethnic group of any individual who has been exposed to naphthalene is integral to a full risk assessment. It is also important to determine if the patient is known to be G6PD deficient, however, this information will not always be immediately available.

Activated charcoal is of no proven benefit for naphthalene and a gastric lavage or nasogastric aspiration may be unsuccessful because of the size of mothballs. Whole bowel irrigation may be considered, particularly following ingestion of multiple mothballs. All patients should be observed for at least four hours post-ingestion. Fatty foods including milk should be avoided because they may enhance absorption and so increase the risk of systemic effects. Severe cases may require blood transfusions and haemodialysis may be necessary in renal failure. Treatment is essentially symptomatic and supportive. Haemoglobinuria should be managed conventionally with alkalinisation of urine if necessary.

Methaemoglobin is rare following naphthalene exposure and the usual treatment for methaemoglobinemia is methylene blue (also known as methylthioninium chloride). However, G6PD deficiency results in low levels of NADPH and this is required in order for methylene blue to be effective. In addition, patients with G6PD deficiency are susceptible to haemolytic anaemia induced by methylene blue itself. However, patients with this deficiency have variable activity of the G6PD enzyme and exhibit different levels of disease, and methylene blue is classed only as a moderate haemolytic agent. Its use may therefore be considered in patients with G6PD deficiency although...
Further doses should not be given (Wright et al 1999). Routine use of methylene blue following exposure to naphthalene is not recommended (Chun et al 1998) and it should only be considered in patients with a methaemoglobin concentration >30 per cent. Where methylene blue therapy fails exchange transfusion is the treatment of choice (Wright et al 1999).

LABORATORY INVESTIGATION
Laboratory investigations should be made to check for evidence of haemolysis including full blood count, examination of erythrocyte morphology, haemoglobin and haemacrit. This is only likely to be required in patients with G6PD deficiency or those with a high risk of having the disease. The liver and renal function should be monitored.

SCREENING FOR G6PD DEFICIENCY
Results of a screen for G6PD deficiency during an acute haemolytic crisis may be misleading and diagnosis may be difficult in such circumstances. This is because during a haemolytic crisis the older erythrocytes are destroyed and are replaced by young erythrocytes. These cells have a higher G6PD activity and because they are present in greater numbers than they would be normally, G6PD activity may be elevated into the normal range (Melzer-Lange and Walsh-Kelly 1989). G6PD activity tested during a haemolytic crisis may be ‘normal’ and a repeat test following recovery may show reduced activity (Santucci and Shah 2000).

Methylene blue dosage: As a 1 per cent solution (10 mg/ml) give 1-2 mg/kg IV over five minutes and repeat after one hour if there is no response. IV injection of methylene blue can be painful and a bolus dose of 15-30 ml of fluid immediately following injection may reduce local pain. If the patient remains asymptomatic and the decision is made to discharge, then the patient or their parent/carer should be warned of the risk of delayed effects and advised to return if necessary.

CAMPHOR
If the mothball is from abroad it may contain camphor. Camphor is prepared synthetically or obtained from the plant Cinnamomum camphora. Camphor has been used medicinally for centuries. It acts as a counter-irritant, rubefacient and mild analgesic and is used in liniments for the relief of fibrositis, neuralgia and similar conditions. Camphor has carminative properties and it has been used as a mild expectorant and to relieve gripping. It has also been used as a circulatory and respiratory stimulant but this use is considered hazardous. Exposure to camphor in the UK is likely to be due to a source other than mothballs. Most commonly it is due to ingestion of a vapour rub.

Symptoms of camphor toxicity usually appear rapidly after ingestion, and because of the usual combination of vomiting, drowsiness and convulsions there is a high risk of secondary complications, such as aspiration of stomach contents. The majority of cases of camphor toxicity are in the older literature reflecting the previously widen use and availability of camphor-containing products. Camphor is rapidly absorbed and metabolised, so the clinical course of an intoxication can be relatively short if the acute phase is adequately managed and complications avoided.

A review of 182 cases (patient age unspecified) of camphor ingestion reported to two poison centres between 1980-1983 found that the 101 cases who ingested less

Box 2: Summary of clinical features from the different compounds used in mothballs

<table>
<thead>
<tr>
<th>Compound</th>
<th>Clinical effects</th>
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<tbody>
<tr>
<td>Paradichlorobenzene</td>
<td>Usually only causes gastrointestinal irritation.</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>Gastrointestinal irritation, liver and renal damage, CNS effects (such as confusion, excitement, sweating) and then haemolysis (three to five days later), particularly in G6PD deficient individuals.</td>
</tr>
<tr>
<td>Camphor</td>
<td>Gastrointestinal irritation, and CNS effects particularly convulsions.</td>
</tr>
</tbody>
</table>

References
Hallowell M (1959) Acute haemolytic anaemia following the ingestion of paradichlorobenzene. Archives of Disease in Childhood 34, 74-75.


than 2 mg/kg remained asymptomatic. 90 per cent of the patients ingesting over 2 mg/kg remained asymptomatic. 4 per cent developed minor symptoms (mean dose 15 mg/kg), and 6 per cent developed major symptoms (mean dose 152 mg/kg). There were no deaths in this series. A review of the literature found that the mean dose ingested by patients with major symptoms was 124 mg/kg, with the mean dose in fatal cases being 199 mg/kg. On the basis of this analysis the authors suggested that patients ingesting less than 10 mg/kg of camphor and displaying no symptoms required no treatment (Geller et al 1984). Fatal doses in children have ranged from 0.7-1.0 g (Committee on Drugs 1994).

Camphor usually causes rapid onset of effects with salivation, nausea and vomiting. Abdominal pain, and coffee-ground vomiting have been reported. Peripheral circulatory shock has been seen in association with severe vomiting and dehydration (Vasey and Karayannopoulos 1972). Tachycardia and hypotension may occur (Koppel et al 1988). There may also be leucocytosis, albuminuria and changes in renal function. There have been reports of respiratory depression, apnoea and collapsed lung secondary to aspiration of stomach contents following camphor ingestion. Respiratory arrest been reported (Aronow and Spigiel 1976).

Neurological effects including hyper-excitability, irritability, confusion, hallucinations, restlessness, anxiety and agitation and coma may occur. Convulsions (tonic-clonic and grand-mal) are very common following exposure to camphor. Convulsions have also been reported from dermal exposure to camphor, particularly in cases of repeated, widespread dermal application. They may also occur following application to abraded or burnt skin or in individuals who have previous histories of epilepsy or febrile convulsions.

Activated charcoal may be administered for camphor ingestion. Gastric lavage or nasogastric aspiration may be unsuccessful because of the size of mothballs. Observation until at least 6 hours after ingestion is recommended.

Camphor can cause severe vomiting and it is important to ensure adequate hydration. Clear fluids should be given. Fatty foods, including milk should be avoided as they will enhance absorption. Diazepam should be used to control convulsions; phenobarbital may be used if necessary. The airway should be protected to prevent aspiration of stomach contents during convulsions. Monitor liver and renal function.

Charcoal haemoperfusion, amberlite haemoperfusion and lipid dialysis have all been shown to remove camphor from the serum (Mascie-Taylor et al 1981, Koppel et al 1988, Kopelman et al 1979, Ginn et al 1968, Antman et al 1978), and may be considered in severe cases.

CONCLUSIONS

Mothball ingestion is not particularly common but can be difficult to manage because the active ingredient is often unknown. There are three main compounds used paradichlorobenzene, naphthalene and less commonly, camphor (see Table 2). There are simple tests to distinguish the different types but in some cases no other mothballs will be available as the patient may have eaten them all. In such cases the patient will have to be observed for the onset of any initial effects and then advised to return if any other delayed effects that could be related to naphthalene-induced haemolysis develop. Where the patient is at risk of haemolysis and the mothball is known or suspected of containing naphthalene, observation in hospital may be considered, depending on the circumstances. Treatment of poisoning for all types of mothballs is supportive.