

Accidental hanging injuries in children: recognition and management

ABSTRACT

Accidental hanging is rare in childhood but is often fatal. Window blind cords pose a particular and unique risk to young children in the UK, accounting for one to two deaths annually. These accidents are frequently associated with non-adherence to the safety instructions provided by the manufacturers. Early discovery of the child and initiation of effective cardiopulmonary resuscitation at the site of the incident are likely to improve the outcome. Prolonged suspension, children who are pulseless at first contact by the emergency paramedic responder, and patients with prolonged periods of remaining in asystole before return of spontaneous circulation after starting cardiopulmonary resuscitation are unlikely to have intact neurological survival. Management in the hospital includes early airway protection by intubation, maintenance of normal oxygen saturation, normothermia, active control of clinical and sub-clinical seizures, and strict electrolyte and glucose regulation. Child safeguarding concerns should be considered when children have asphyxial injuries, and other signs of child physical abuse should be actively looked for. There is a need for stronger legislation in the UK to prevent some of these accidents, especially those relating to window blind cords.

Accidental hanging in children occurs when there is asphyxiation following constriction of the neck and its contents by a ligature, usually when a child left unsupervised becomes entangled during play or exploration.

Hanging injuries are a subtype of strangulation injuries, and this article focuses primarily on hanging injuries. Hanging injuries are rare in young children and are usually accidental in nature. They are more frequent in younger children, who explore their environment while being unaware of the potential dangers that may be posed by common household objects which are often considered to be potentially harmless by the parents. Hanging injuries present a challenge to clinicians, and early intervention and appropriate management are likely to be associated with a better outcome (Sep and Thies, 2007).

This article provides an overview of the available literature and management of children presenting with accidental strangulation. There are no randomized controlled trials or high quality systematic reviews on the subject. PubMed, Google and Google Scholar literature

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searches were undertaken using the MESH and key words: accidental hanging, window blind cords, cycle helmets causing strangulation, children, intravenous drip set causing strangulation, accidental strangulation children. Media reports such as BBC news items were also used to maximize search strategies as some of these cases would not be published in a biomedical journal for logistic and medicolegal reasons, especially when death occurred.

Epidemiology

Every year in the UK one or two children aged between 16 and 36 months die from accidental strangulation (BBC News, 2004; Royal Society for the Prevention of Accidents, 2016). The number of near-miss events is unknown as there is no formal mechanism for recording or reporting them.

Mortality rates from accidental hanging are high in very young children. A Spanish study of records available from medical examiner's office over a 10-year period (1991–2001) reported 44 accidental strangulations of children aged between 0 and 14 years, with hanging accounting for around one third of all fatalities (Celis et al, 2004). Nouma et al (2016) reported that of all the fatal injuries occurring in the playground ($n=107$), 50% occurred as a result of asphyxia secondary to hanging. A study from the Netherlands showed a third of patients with accidental fatal injuries in the playground were aged less than 5 years, and 80% were under 10 years of age (Sep and Thies, 2007). A retrospective study in the USA using existing death certificates of children aged between 1 month to 8 years, documented 183 fatal window cord hangings over a 14-year period (1981–95); 93% of the cases occurred in patients aged ≤ 3 years (Rauchschwalbe and Mann, 1997).

Different modes of strangulation injuries

Depending on the environment different potential strangulation hazards exist. These include:

Home

Hazards include window blind cords (Masand, 2010; Paul and Bhadoria, 2010; Datta and Cyriac, 2013), telephone cords, necklaces or religious ties (Altmann and Nolan, 1995; Paul and Bhadoria, 2010; Ben Dhiab et al, 2014), cords in toys (Altmann and Nolan, 1995), loops on lift-up bed (BBC News, 2016), railings of a balcony (Muthukrishnan et al, 2012), bunk beds (McFaull et al, 2012), homemade hammock (by slinging a sari from a rafter) (Kumar et al, 2011), indigenously made rocking cradle (Saha et al, 2010) and human hair causing an accidental ligature effect (Kindley and Todd, 1978; Milkovich et al, 2005).

Hospital or medical equipment

Strangulation has been reported to be caused by apnoea monitoring leads (Emery et al, 1992), electrocardiogram monitoring leads, intravenous infusion tubing (Garros et al, 2003) and gastric feeding tubes (Woodham et al, 2016).

Community, playground or school

These hazards can include bicycle helmet straps (Byard et al, 2011), toilet cloth towel rolls (Le and Macnab, 2001), clothing, e.g. pullover (Ben Dhiab et al, 2014), sweater, scarf, belt or tights (Kumral et al, 2014), the choking game (causing self-strangulation) (Re et al, 2015), rope swing (Altmann and Nolan, 1995; Kumral et al, 2014), motor vehicle window (Strauss et al, 1997).

Window blind cords pose a particular risk to children living in the UK, and each year one or two young children die from accidental strangulation by a window blind cord (Datta and Cyriac, 2013). This risk is modifiable by following the 'make it safe' leaflet published by the British Blind and Shutter Association in collaboration with the Royal Society for the Prevention of Accidents, giving advice to eliminate the risk associated with hazardous looped window blind cords. In continental Europe external window blinds are generally used, while in the USA, cordless blinds are used (Paul and Bhadoria, 2010; Datta and Cyriac, 2013). *Table 1* highlights studies where a window blind cord was involved in accidental hanging of young children.

Pathophysiology

The pathophysiological processes occurring when a young child undergoes accidental hanging are often different from what happens to adults following a hanging incident. Young children are less likely to be able to free themselves because of their larger head:body ratio, reduced cognitive recognition of the dangerous event and less developed muscular control and strength than adults (Datta and Cyriac, 2013).

The proposed mechanism of injury is that obstruction or compression of cervical blood vessels leads to cerebral hypoxia and ischaemia (Sep and Thies, 2007; Deasy et al, 2011). The jugular veins are superficial, and susceptible to trauma and compression. Obstruction of the jugular vessels leads to venous pooling, then hypoxia and unconsciousness. As a consequence, the body loses muscle tone and becomes flaccid, which further tightens the ligature around the neck, causing complete carotid arterial obstruction. There is complete loss of airway as the base of the tongue is pushed towards the roof of the pharynx; the resulting cerebral hypoxia finally causes death (Salim et al, 2006). Another mechanism of injury or death results from the vagal reflex secondary to the external pressure and stretching of the carotid sinus; this triggers extreme bradycardia leading to cardiac arrest (Salim et al, 2006; Gandhi et al, 2011).

Cervical spine fracture is uncommon in younger children; the risk rising with increasing age, the dropped height and suspension time. The classic 'hangman's fracture' caused by an unstable fracture of the second cervical vertebra leading to spinal cord injury, asphyxiation

Table 1. Articles highlighting outcome of accidental hanging from window blind cords

Reference	No of children	Ages of children	Outcome
Rehn et al (2016)	3	Not available	Three out of eight children died, not clear of aetiology
Ben Dhiab et al (2014)	1	4 years	Died
Datta and Cyriac (2013)	1	22 months	Survived
Deasy et al (2011)	2	Not available	Outcome not clear
Masand (2010)	5	22 months 23 months 2 years 2 years 2 years	Survived Died Died Died Died
Paul and Bhadoria (2010)	1	31 months	Survived
BBC (2004)	1	23 months	Died
Rauchschwalbe and Mann (1997)	114	1 month–8 years	All died (retrospective review of death certificates)
Altmann and Nolan (1995)	3	16–21 months	All died
Yee (1990)	2	Not available	1 survived 1 died

and ultimately death is rare in children, but it is important to consider this injury during the secondary survey after successful resuscitation and stabilization (Salim et al, 2006; Deasy et al, 2011).

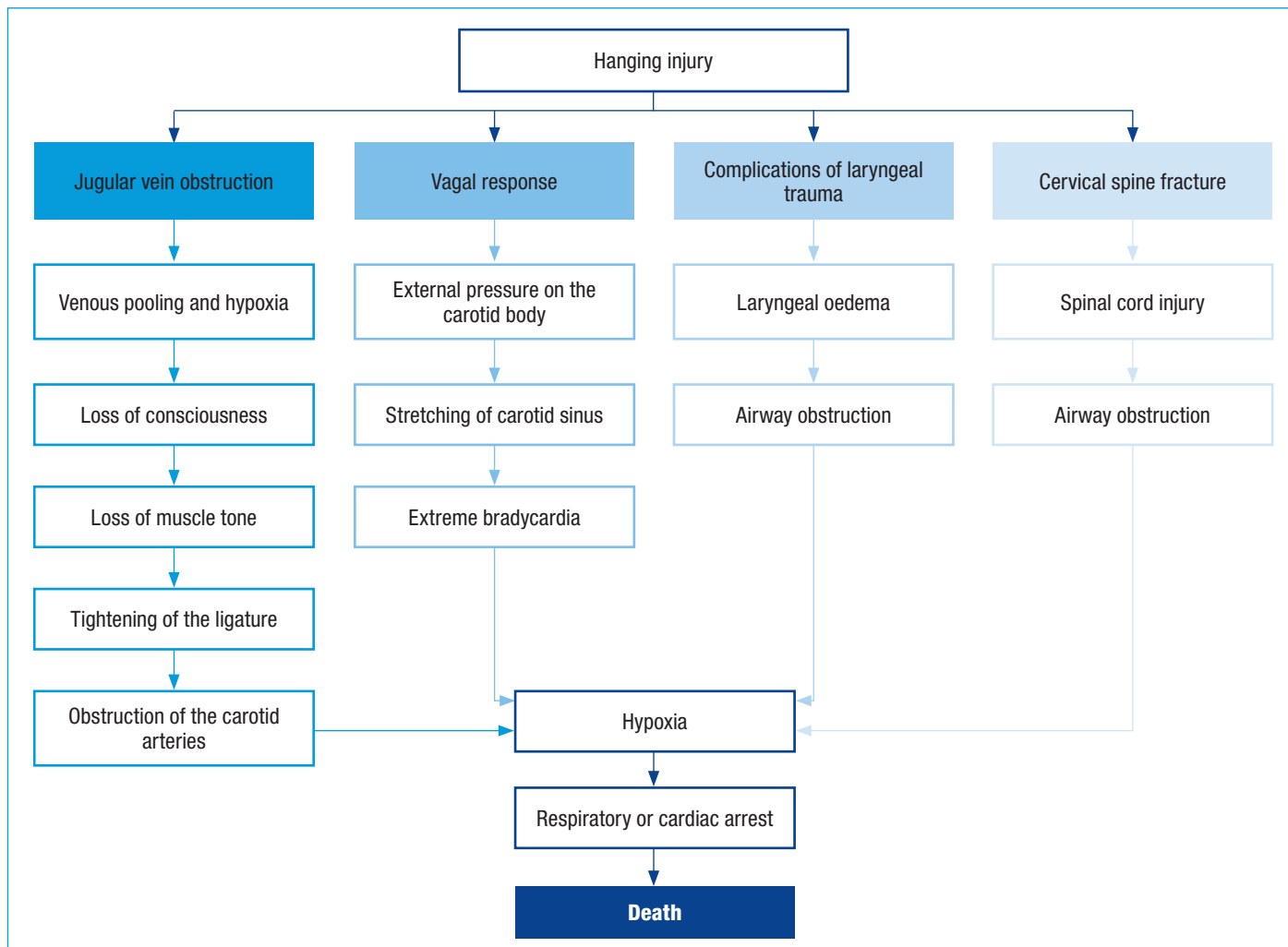
Children are at lower risk of laryngeal or vertebral fractures than adults because of the lack of ossification of those structures, and the relative elasticity of the hyoid bone, laryngeal cartilage and trachea making them less prone to fracture (Kumar et al, 2011; Hackett and Kitsko, 2013). A retrospective study from India spanning 12 years reported findings from inquest papers, post-mortem reports and other departmental records of 28 children with fatal strangulation. This found fractures of bone and cartilaginous structures in the neck in up to 25% of cases (Verma, 2007).

Children are more prone to suffer from complications of laryngeal oedema than adults because the narrower airway is easier to obstruct. Laryngeal trauma and airway obstruction secondary to oedema are known complications of hanging injuries, and should be recognized and managed in a time-critical manner (Kumar et al, 2011; Hackett and Kitsko, 2013). *Figure 1* shows the various pathophysiological mechanisms occurring following accidental hanging in children (Salim et al, 2006; Gandhi et al, 2011).

Clinical presentation

Management depends largely on the clinical presentation – best outcomes occur when children present to the hospital conscious, maintaining their own airway and

Figure 1. The pathophysiological mechanisms of hanging injuries.



haemodynamically stable. While some children may be brought in dead, others may present with the following:

- Undergoing active resuscitation – needs urgent assessment of hypoxia, brain injury and multi-organ failure
- Cardiac arrest – in a study of 53 paediatric hanging injuries presenting with cardiac arrest, 94% presented in asystole and 6% had pulseless electrical activity (Deasy et al, 2011)
- Seizures – generalized tonic-clonic convulsions (Kumar et al, 2011)
- Unconscious (reduced Glasgow Coma Scale; <8/15)
- Ligature mark
- Laryngeal oedema
- Stridor
- Non-reactive pupils
- Rapid, weak pulse, cyanosed
- Tachypnoeic
- Hypotensive, hypoxic, with signs of neurological deficits
- Hyoid bone fractures; injury to laryngeal cartilage and laryngeal oedema.

Management

This is mainly supportive to address pathophysiological issues that may have developed. Early intervention and

appropriate management are likely to improve the outcome; aggressive resuscitation is needed for patients who arrive in the emergency department showing any signs of life (Salim et al, 2006). Resuscitation takes precedence although a collateral history can aid the decision-making process.

History

Important aspects of the history include duration of hanging or strangulation, height from which the child was suspended, convulsions, provision of cardiopulmonary resuscitation before transfer, and any pre-existing illnesses.

The possibility of non-accidental injury or neglect demands involvement of social services and police. A full skeletal survey and complete set of investigations should be considered for children aged <2 years or those brought in dead as the child may have been killed and subsequently hanged.

Physical examination

This should be undertaken when the patient is stable, otherwise resuscitation takes precedence (Deasy et al, 2011). Children in respiratory or cardiac arrest need to be stabilized first. In addition to a systemic examination, the following should be looked for:

- Ligature marks on the neck
- Hyoid bone injuries
- Laryngotracheal injury
- Cervical spine fracture
- Pneumothorax or other lung trauma
- Stridor.

Treatment

This will depend on the condition of the child on admission and ranges from simple monitoring through to full resuscitation with admission to an intensive care unit. Children needing resuscitation should be managed by an ABCDE approach (Gandhi et al, 2011). After monitoring as an inpatient for 12–24 hours, patients who have remained well may be discharged (Paul and Bhadoria, 2010). Paediatric intensive care unit support will be needed for children with serious sequelae.

Airway

Airway management can be challenging in children with laryngeal oedema, hyoid bone fractures and cervical spine fractures. Airway support is needed where airway compromise is suspected, and skilled anaesthetists should be involved for early intubation and airway protection. Laryngeal trauma and cervical spine injuries may go unrecognized and should be assessed during the primary or secondary survey. Computed tomography imaging of the cervical spine can show features of laryngeal oedema and hyoid bone fractures, and guide specialist management (Salim et al, 2006; Hackett et al, 2013).

Breathing

Hypoxia worsens cerebral ischaemic injury and supplemental oxygen should be given even when oxygen saturations on pulse oximetry are normal. Care is needed during respiratory support as both hyperoxia and hypoxia can be harmful; hyperoxia causes vasodilation which may increase blood flow to the damaged cerebral areas with poor vascular integrity as a result of ischaemia, leading to cerebral haemorrhages (Agarwal et al, 2008; Kumar et al, 2011). Blood gas monitoring and obtaining arterial access are helpful.

Circulation

Cerebral perfusion is maintained through cerebral autoregulation of blood flow (Agarwal et al, 2008). Following strangulation, autoregulation is lost, cerebral perfusion becomes erratic and ineffective, and relies solely on the patient's blood pressure. Blood pressure needs to be adequately maintained to prevent further cerebral insult; use of normal saline, atropine and inotropes should be considered (Gandhi et al, 2011). Exaggerated sympathetic stimulation from reversible acute left ventricular dysfunction after accidental strangulation can mimic myocardial infarction (transient global ST elevation with rise of cardiac enzymes and global left ventricular hypokinesia) which can resolve with improvement in haemodynamic status (Sivanandan et al, 2009).

Fluid management is important to prevent lactic acidosis. If the computed tomography scan shows cerebral oedema, fluids are largely restricted, and diuretics with or without mannitol or hypertonic saline may be indicated. If hypertension is present, short-acting sympatholytics or centrally acting agents may be preferred over vasodilating agents to avoid an increase in the intracranial pressure (Gandhi et al, 2011). The child should be catheterized early; if urine output remains consistently low (<1 ml/kg/hr), outcome is likely to be poor (Agarwal et al, 2008).

Disability

Children with hanging injuries are at high risk of developing cerebral oedema; diffuse cerebral oedema from anoxia can precipitate hypernatraemia and hypocalcaemia. Hypocalcaemia can affect cardiac functioning and myocardial contractility (Agarwal et al, 2008). Electrolytes and blood glucose should be reviewed regularly; any biochemical disturbances need to be managed appropriately in a timely fashion.

Seizures

Nearly one-third of cases develop seizures (Garros et al, 2003; Kumar et al, 2011). Hypocalcaemia is particularly known to occur following asphyxiation, and a combination of hypocalcaemia and cerebral oedema may lead to seizures (Kumar et al, 2011). Before commencing anticonvulsants, it is important to identify and address any other correctable causes including electrolyte imbalance or hypoglycaemia. Although there are limited data, amplitude-integrated electroencephalography monitoring is likely to be beneficial and may help in early detection of non-convulsive seizure activities leading to early initiation of anticonvulsants (Davies et al, 2011).

Acute management of seizures should follow established resuscitation guidelines. Phenobarbitone is helpful, and phenytoin should be added if seizures persist; for uncontrolled seizures clonazepam, midazolam and sodium valproate may be tried (Agarwal et al, 2008). Close monitoring is important as anticonvulsants can precipitate hypotension and respiratory depression.

Antibiotics

If clinical suspicion of aspiration pneumonia is high, use of broad-spectrum antibiotics is suggested (Gandhi et al, 2011). Sputum or tracheal secretions obtained from suctioning the endotracheal tube should be sent for culture and sensitivity; patients are at increased risk of developing nosocomial infections and early suspicion and management should minimize these complications (Kumar et al, 2011).

Therapeutic hypothermia

The beneficial neuroprotective effects of therapeutic hypothermia in adults with asphyxial cardiac arrest have been described extensively (Wee et al, 2015; Kim et al, 2016; Piastra et al, 2016). Piastra et al (2016) reported two children aged 12 and 15 years with near hanging,

both received cardiopulmonary resuscitation on the site of incident with return of spontaneous circulation at 18 minutes and 20 minutes respectively. They subsequently received therapeutic hypothermia for 24 hours followed by 3 days of active fever control along with maintenance of continuous normothermia (36–37.5°C) with good outcome.

Prognosis

Prevention is preferable as mortality and severe neurological disability rates are high (Salim et al, 2006; Deasy et al, 2011). Long-term prognosis depends on the extent of neurological involvement, length of unconsciousness, and extent of metabolic derangements at admission (Kumar et al, 2011). Overall survival rates in those who show signs of life on admission following near hanging can vary from 70–100% (Gandhi et al, 2011).

Good prognostic factors

Early, effective resuscitation

An Australian study with 680 children with out-of-hospital cardiac arrest recorded 53 cases resulting from hanging injuries. Of these 53 patients, bystander cardiopulmonary resuscitation was performed in 16 cases; seven had a return of spontaneous circulation and three of these survived (Deasy et al, 2011). In a 10-year Canadian study with 41 children, 19 (46%) were found pulseless at the first emergency medical service assessment and received cardiopulmonary resuscitation, 16 died and the three survivors were severely disabled with two out of the three being in a 'persistent vegetative state'; of the 22 out of 41 children (54%) who had a detectable pulse at initial assessment, 18 made a full recovery (Davies et al, 2011).

Duration spent hanging

Several small studies have shown that duration of hanging of <5 minutes had a better outcome (Salim et al, 2006). A Japanese study of 47 children with 11 survivors noted a significant difference between the mean hanging times, with those for survivors being much shorter (11.8±8.37 minutes) than those for non-survivors (50.81±61.9 minutes) (Matsuyama et al, 2004).

Absence of cerebral anoxia

Presence of cerebral anoxia is an independent indicator of poor prognosis. In a study of 63 patients who presented following hanging injuries, 12 children needed definitive airway management with intubation. Of these, eight had evidence of cerebral anoxia on neuroimaging and six died (Salim et al, 2006).

Other predictors of good prognosis are drop height lower than body height, absence of cervical spine injury, admission to hospital within 4 hours of the incident, and lack of cerebral oedema on computed tomography scan of the head at initial presentation (Gandhi et al, 2011).

When the victim is detected to be pulseless at the first medical contact and after initiation of cardiopulmonary

resuscitation, and when there was delayed return of spontaneous circulation the outcome is likely to be extremely poor; if the child survives, severe disability or a persistent vegetative state is expected. In such cases it may be appropriate to discuss issues of brain death and withdrawing active life support with the family; consideration for organ or tissue donation may be initiated in a sensitive manner. There is no relevant literature regarding to paediatric hanging injuries leading to death and subsequent organ donation, but evidence from literature in adults supports the use of grafts for organs including liver and kidneys from adult donors who died from suicidal hanging (Yaprak et al, 2013; Hoti et al, 2014).

Prevention

Most cases discussed in the literature were accidents that could have been avoided. The risk could be reduced by a combination of educational, environmental and legislative interventions including:

- Not leaving small children unsupervised, particularly those who are mobile
- Ensuring that any cord-like objects posing an accidental hanging risk are kept out of reach of children
- Use of cordless (as in USA) or external (as in continental Europe) window blinds, with stronger legislation in the UK making them available and enforcing their use
- Supervision of children when they are wearing necklaces, scarves or loose clothing
- Bicycle helmets should not be worn in the playground
- Maximum length of toy strings be restricted to <7 cm by parents as well as manufacturers
- Ensure intravenous infusion or oxygen tubing and monitoring equipment used in hospital (or at home) does not become a hanging hazard for children.

Conclusions

Accidental strangulation in children is rare but often has a poor outcome. Management remains time critical; early initiation of cardiopulmonary resuscitation at the site of accident is associated with a better outcome. Safety information should be provided by manufacturers and promoted by health professionals regarding potential hanging risks. Stronger legislation is needed to encourage an environment safe for children. **BJHM**

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KEY POINTS

- Accidental hanging in children is rare, has a poor prognosis and can be fatal.
- Failure to comply with manufacturer's safety instructions (e.g. for window cord blinds or bicycle helmets) and lack of adult supervision often leads to these accidents.
- Time-critical airway management and initiation of cardiopulmonary resuscitation at the site of the incident may improve outcome.
- Intact neurological survival is unlikely in children who had a prolonged duration of hanging, are asystolic at presentation and who needed a prolonged period of cardiopulmonary resuscitation before the return of spontaneous circulation.
- Child safeguarding concerns need to be raised in children who present with hanging injuries.

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