Review Article

Indian Journal of Trauma and Emergency Pediatrics
Volume 12 Number 1 / January – March 2020
DOI: http://dx.doi.org/10.21088/ijtep.2348.9987.12120.4

Kerosene Poisoning in Children: A Review

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Received on 11.02.2020

Accepted on 28.02.2020

How to cite this article:
Chhaya A Divecha, Milind S Tullu. Kerosene Poisoning in Children: A Review. Indian J Trauma Emerg Pediatr. 2020;12(1): 29–36.

Abstract

Kerosene oil poisoning is a preventable health problem in children, common in developing countries. Kerosene oil has high volatility, low viscosity and low surface tension, increasing its risk of aspiration. The physical properties of kerosene oil also make it more likely to penetrate and spread deeper into lower airways increasing chances of severe lung injury. Risk factors which increase likelihood of accidental ingestion includ male gender, age below 3 years, summer season, storage in drinking water bottles and in areas of easy access (in and around the kitchen and stairs), and rural/ lower socioeconomic population.

Most common presentation after kerosene poisoning is with fever, cough, tachypnea and vomiting. While pneumonia is the commonest complication, central nervous system manifestations such as drowsiness, restlessness, stupor or convulsions may occur. Early diagnosis, avoidance of harmful first aid practices, observation for symptoms/ complications, supportive care and appropriate treatment of pneumonia are necessary to reduce the morbidity and mortality. Recommendations such as education of community and parents, use of child-resistant containers, appropriate safe storage areas and adequate parental supervision can reduce the incidence of kerosene poisoning in children.

Keywords: Aspiration; Children; Hydrocarbon; Kerosene; Morbidity; Poisoning; Pneumonia.

Introduction

The 'PubMed' database was used to conduct a literature search using word combinations of controlled vocabulary (MeSH terms): 'kerosene poisoning' and 'kerosene toxicity'. These controlled vocabulary terms were combined using 'OR' as the Boolean connector. The results were limited to studies available in English language. The age limit was set from birth to 18 years. With these search parameters 114 results were obtained, of which 63 were relevant. On limiting the search to the period from 2005 to 2020, there were 28 relevant articles. Other important and relevant articles from 'Google Scholar' as well as those hand searched from other sites and resources were also included for formulating this review. From these search results, and a couple of book chapters, 47 articles were finally shortlisted to include citations relevant to our review (we excluded the journal articles whose results were already incorporated in the subsequently published guidelines and other reviews), with an emphasis on review articles and landmark articles. A couple of book chapters were also included as references in the final review.

Hydrocarbons are heterogeneous organic compounds made up of hydrogen and carbon, and commonly available in thousands of products such

as gasoline, lubricating oil, motor oil, mineral spirits, lighter fluid/naphtha, lamp oil, and kerosene.[1] They are structurally categorized into aliphatic, aromatic, halogenated and terpene compounds. Kerosene and other petroleum distillates such as gasoline are aliphatic compounds.[2] Though kerosene oil use has decreased subsequent to the availability of improved electrical and gas supplies, it is still abundantly used in developing countries as a household energy source, i.e. for cooking, lighting and heating; due to which many cases of accidental kerosene oil poisoning in children are still relatively common. Though kerosene oil is not poisonous, its physical properties make it an aspiration hazard with potentially devastating consequences.

Epidemiology

In 2018, about 2 to 3% of non-pharmaceutical exposures were reported due to hydrocarbon ingestion to the United Nations poison control centers, of which 26.33% were in children less than 6 years of age.[3] Childhood poisoning is usually accidental, with low morbidity and mortality. In Western Europe and North America, household products and medications are commonly implicated in childhood poisoning; while in the developing countries, kerosene, traditional medicines, snakes bites and insect stings are more commonly involved.[4] Kerosene oil poisoning remains the commonest form of accidental childhood poisoning in most South Asian countries, including India, Pakistan, Nepal and Bangladesh; and African countries, including Nigeria and Kenya.[5–10]

Multiple Indian studies have identified kerosene oil ingestion to be the commonest cause of accidental poisoning in children. Sachdeva et al. observed kerosene to be the cause of accidental poisoning in 31% of children admitted to a tertiary hospital with accidental ingestion in Delhi in 2014; while Bhat et al. reported 18.8% children with kerosene oil poisoning in another North Indian Centre (Dehradun) in the year 2011.[11,12] Vasavada et al. from Ahmedabad, Western India reported 47.1% of the total cases with accidental poisoning attributable to kerosene.[13] Venkatesh et al. reported up to 60.4% of admissions due to poisoning subsequent to kerosene ingestion in a study from South India.[14] Thus, kerosene poisoning remains a predominant cause of childhood poisoning in the developing countries.

Pathophysiology

Hydrocarbons can be toxic due to their aspiration hazard or systemic toxicity after absorption from gastrointestinal or respiratory or dermal (skin) systems.[2] Kerosene has poor gastrointestinal absorption and thus produces minimal mucosal irritation.[15] Due to irritation of the larynx and trachea, it produces choking or gagging post-ingestion.[16] Aspiration is commonly encountered due to this choking/gagging or the vomiting induced after ingestion.[15] The aspiration risk of a substance depends on the following factors.[16]

- Directly proportionate to volatility (ability to vaporize),
- Indirectly related to viscosity (tendency to resist flow) and
- Indirectly associated with surface tension (adhesiveness of molecules along a surface).[16]

Kerosene has high volatility, low viscosity and low surface tension and thus spreads over a large surface area with ease, making even small quantities of around 1 ml to be potentially life-threatening.[15] It causes inactivation of Type 2 pneumocytes in the alveoli, leading to surfactant deficiency, alveolar collapse and reduced compliance and subsequent pneumonitis.[15,16] Kerosene is a solvent and hence dissolves cell walls and lipid lining layers, thus penetrating deep to the interstitial tissue, and producing severe foreign body reaction and inflammation. This lung parenchymal injury as well as interstitial inflammation/necrosis aggravate the ventilation-perfusion mismatch.[16] Being volatile, kerosene also displaces oxygen from the alveoli, producing hypoxia. Its volatility and lipid solubility enhances its absorption across the alveolar-capillary interface into the systemic circulation.[16]

The high lipid content of neurons also makes them vulnerable to kerosene and contributes to the central nervous system (CNS) manifestations. However, CNS symptoms can also be partially attributable to hypoxia due to severe respiratory involvement.[2] Commonest observed pulmonary finding on pathology is necrotizing bronchopneumonia due to bronchial, bronchiolar and alveolar tissue necrosis. Other pulmonary changes that have been observed include: atelectasis, interstitial inflammation, hemorrhagic pulmonary edema, vascular thrombosis and hyaline membrane formation.[17]

Risk Factors

Kerosene oil ingestion is predominantly accidental in children, due to their exploratory / curious nature, compounded by improper storage, easy access and inadequate parental supervision.[14,18] Following factors have been observed to be associated with an increased risk of kerosene poisoning:

- Male gender[8,19–22]
- Age less than 3 years[8,19–22]
- *Summer months:* Most cases of poisoning have been recorded in summer months, when kerosene has been mistaken for water and ingested due to extreme thirst.[8,19–22]
- *Sites of storage:* Most common sites associated with poisoning risk were under the stairs, and in, and around the kitchen area.[19,21]
- *Container of storage:* The risk of accidental ingestion was high when kerosene was stored in soft drink and plastic bottles and mistaken for water for drinking.[8,19,21,22] In one study, 82% of the ingestions were because of a family member administering kerosene to the child by mistake.[23]
- *Rural areas and lower socioeconomic strata:* This could be due to greater use of kerosene for household purposes due to lack of electricity and gas.[8,20–22]
- Parikh et al. also observed an increased incidence of kerosene poisoning during the *evening* period.[22]

Clinical Manifestations

Around one-third of children are found to be asymptomatic with only a history of exposure/ ingestion of kerosene oil.[23,24] Most of these children have a characteristic odor of kerosene.[2,22,23,25] The commonest findings recorded by most studies are cough, breathlessness, fever and vomiting, and are summarized in Table 1. Those who have significant respiratory symptoms, such as breathlessness, soon after ingestion, are more likely to progress to respiratory failure.[15] The common manifestations and systemic findings are given below.

Table 1: Clinical manifestations in kerosene oil poisoning

		Clinical manifestations (%)				
	No. in study (*N*)	Cough (%)	Dyspnea (%)	Fever (%)	Vomiting (%)	CNS findings (%)
Shotar et al.[19]	122	67.2	56.5	54.1	27.8	35.2
Thilakavathi et al.[20]	116	62.0	51.0	41.0	36.0	26.0
Venkatesh et al.[14]	48	80.0	100.0	20.0	45.0	35.0
Parikh et al.[22]	42	92.8	88.09	95.23	83.34	59.53
Priya et al.[29]	111	40.0	23.0	36.0	38.0	–
Nagi et al.[28]	103	83.5	51.5	73.8	60.2	29.1
Anwar et al.[8]	56	93.0	91.0	46.0	34.0	48
Gupta et al.[24]	70	31.4	55.7	47.0	–	25.7
Lucas et al.[25]	526	79.6	32.5	20.3	64.8	74.0
Benois et al.[23]	17	41.1	41.1	23.5	23.5	29.4

Respiratory: Immediate signs of the aspiration include choking, gagging, coughing and vomiting.[2] Though most respiratory symptoms due to aspiration generally present early after ingestion (within 30 minutes), the symptoms may be delayed for up to 12 to 24 hours.[26] Hence, clinical observation is recommended even in asymptomatic children. Common respiratory findings seen are tachypnea, dyspnea, cyanosis, grunting, bronchospasm, intercostal retractions, nasal flaring, head bobbing and use of accessory muscles.[2,16,27] On auscultation, decreased breath sounds, diminished resonance on percussion, bronchial breath sounds, crepitations or wheezing may be heard depending on the pathology and presentation.[2,27] Decreased oxygen saturation may be noted on pulse-oximetry.[2]

Central nervous system (CNS): Central nervous system involvement has been recorded in around 25 to 70% cases with kerosene poisoning.[8,14,19,20,22–25,28] Commonly observed CNS manifestations include drowsiness, which is often mild and transient.[15] Other signs of CNS impairment include restlessness, stupor, and convulsions, dizziness, euphoria, headache, visual disturbances, and impaired memory.[19,28]

Gastrointestinal system: These are common in the form of vomiting, abdominal pain, constipation, nausea, diarrhea and malena.[8,19] Excoriation around the anus has also been noted by Lucas et al. after excretion of the kerosene.[25]

Fever: Fever, often seen within 30 minutes, is generally triggered by inflammatory response due chemical irritation. Hence, it may not be a sign of bacterial infection.[27] However, if the fever persists beyond 48 hours, bacterial infection should be considered.[26]

Parikh et al. observed CNS manifestations, leukocytosis and vomiting to have significant correlation with pneumonia.[22] Shotar et al. also noted that CNS symptoms were associated with hypoxemia and fever.[19]

Investigations

Children who have ingested kerosene should have a chest radiograph within 4 to 6 hours of ingestion or sooner, if they show signs of pulmonary aspiration.[2] Radiological abnormalities have been noted in up to 60 to 70% of children admitted for kerosene poisoning in most studies.[19,22,24,25,30] X-ray abnormalities have also been observed in asymptomatic children or those with no auscultatory findings.[17] Thus, there appears to be a poor correlation between the clinical presentation, physical findings and the radiological features.[31]

Radiological findings: Radiological changes are generally evident in almost 88% within 2 hours and about 98% within 12 hours of the pulmonary aspiration.[32] Findings may range from multiple ill-defined punctate densities to enlarging/extensive infiltrates.[2] Radiological abnormalities generally peak between 2 and 8 hours post-aspiration and often precede the abnormal physical examination findings. Also, radiological improvement is slower and may extend or lag behind the clinical recovery.[2] Radiological findings observed subsequent to kerosene poisoning include varying degrees of peri-hilar and lung infiltration, lobar pneumonia, pulmonary cystic changes, pneumatoceles, pleural effusion, empyema, pneumothorax, pneumomediastinum, and surgical emphysema.[24,30,33,34] Pneumatoceles may be seen after 2 to 3 weeks after the incident when patient may be asymptomatic or have clinically recovered.[15]

Blood investigations: Leukocytosis is commonly observed in those with pneumonitis; however, it does not always signify bacterial superinfection.[15] Arterial blood gas after aspiration generally shows mild respiratory alkalosis with hypoxemia, which is due to V/Q (ventilation/perfusion) mismatch or diffusion block by the hydrocarbon vapors. If the hypoxemia is not corrected, it may develop into metabolic acidosis.[31]

Differential Diagnosis

Although typical history of kerosene oil ingestion is usually elucidated, following differentials should be considered if exposure is uncertain or findings are suggestive of other poisonings:

- *Bronchopneumonia*
- *Atelectasis*
- *Salicylate poisoning*
- *Other toxin ingestion.*[31]

Complications

The commonest complication post kerosene ingestion/inhalation is pneumonia, recorded in 30 to 70% children in various studies.[19,23,24] The other complications that have been described include: asphyxia, necrotizing chemical pneumonitis, lipoid pneumonia, secondary bacterial or viral infection, hemorrhagic pulmonary edema, pneumatoceles, pneumothorax, subcutaneous emphysema of the chest wall, pleural effusion and respiratory failure.[30,33,34] Other uncommon rare complications reported include myocarditis, auricular fibrillation and flutter, pancreatitis and skin bullae formation.[24,35–37] Around 10 to 20% of children admitted to centers in India have been reported to have required treatment in the Pediatric intensive care units.[14,22]

Management

Since the toxicity in kerosene oil poisoning is predominantly due to aspiration, there is no specific antidote. Most measures involve stabilization, supportive management, prevention and treatment of complications.

In case of an asymptomatic child having normal radiograph, aspiration may be unlikely, but it would be prudent to observe the child for at least 6 to 8 hours keeping the child NPO (nil per oral) for initial observation period.[2] If everything remains normal, the child can be discharged with follow-up

advice. In case of abnormal history, examination or radiological findings, an arterial blood gas should be asked for. If repeat examination and chest radiograph at 24 hours are normal, the child may be discharged, with reassurance and follow-up education.[31] Symptomatic patients should be admitted for further observation and management.

Initial stabilization: Initial measures in poisoning generally involve decontamination and removal from toxic environment. Due to risk of aspiration, induced emesis (syrup of ipecac) and gastric lavage are contraindicated.[15] Activated charcoal is not very useful as it does not bind to kerosene and may induce vomiting, which increases risk of aspiration.[15]

Supplemental oxygen should be administered in case of hypoxemia and adequate hydration with intravenous fluids should be maintained (with NPO in initial observation period).[31] A trial of bronchodilators (β2 agonists) may be given in cases of bronchospasm.[2] Though corticosteroids have often been administered, their role in limiting lung injury has not been established and hence, are not recommended.[15]

Though fever and leukocytosis are commonly observed, they are generally due to an inflammatory response and do not warrant antibiotic prophylaxis/use. However, antibiotic coverage may be necessary in case of fever recurrence after 48 hours of ingestion, leukocytosis after the first 48 hours, worsening chest radiology/symptoms or bacterial growth detected on sputum or tracheal aspirate.[2] Antibiotics may also be justified in those cases compromised due to malnutrition, debilitation, or pre-existing disease/condition.[31] Despite a consensus being of no role of prophylactic antibiotics, some practices have suggested use of metronidazole and other antibiotics due to likelihood of anaerobic organisms subsequent to aspiration. In a trial by Singh et al. (1992), the role of ampicillin, metronidazole and carbenicillin for prophylaxis after kerosene poisoning was studied and though no role was established, they observed reduced morbidity.[38]

In case of severe respiratory distress, unresponsiveness to oxygen or bronchodilators, or altered mental status, respiratory support in the form of endotracheal intubation and mechanical ventilation may be required.[2,15] In case of progression to ARDS (acute respiratory distress syndrome) and respiratory failure, standard mechanical ventilation, HFV (high frequency ventilation) and ECMO (extra corporeal membrane oxygenation) are options that have been successful.[15]

Prognosis

Although most children with kerosene poisoning survive without sequelae, some may progress to respiratory failure and death.[2] Though morality has been found to be low in most studies, few have reported mortality ranging from 0.7% to 7%.[18,22,24] Gupta et al. developed a prognostic score based on the findings such as fever, severe malnutrition, respiratory distress, cyanosis and neurological symptoms (maximum score of 10). A score of 4 or more was found to be associated with prolonged hospital stay and complications, and score equal to or more than 8 was associated with increased risk of death. The predictive value of the score was 85.7%. They suggested the use of this score to determine referrals to hospitals with advanced life support facilities from primary health care. A score of less than 8 was also associated with improved likelihood of survival.[39]

Factors that have been attributed to poor prognosis include lack of transport to hospital, financial restraints and administration of harmful first aid (forceful ingestion of coconut milk/milk/water/eggs, inducing emesis, etc.) by caregivers.[18,29] Severe malnourishment has also been observed with increased morbidity and mortality.[14,24] Prior lavage, hypoxemia at admission, need for ventilation, secondary sepsis and ventilator related complications were other factors associated with poor outcome.[40]

Small airways may be at risk of long-term injury after kerosene poisoning; however, there is no conclusive evidence. In a study of residual small airways lesions after kerosene pneumonitis in early childhood by Tal et al., subclinical and prolonged small airway abnormalities were seen in those with severe initial acute insult.[41]

Recommendations

Kerosene oil poisoning persists to be a major cause of childhood poisonings in India. Due to its preventable nature, there is a need to improve practices and introduce legislation to reduce accidents due to kerosene.

Since 1970, United States has introduced the Poison Preventable Packaging Act (PPFA), which mandates use of child resistant packaging for several household products.[42] In the European Union (EU), the Dangerous Substances Directive (67/548/EEC) also requires child resistant containers with clear and appropriate labeling for

storage of toxic substances, which should be placed outside reach of children and away from foodstuff.[43] Delhi introduced the "Kerosene-Free City Scheme 2012" with successful implementation as the first kerosene free city in India since June 2014. This has been welcomed as one measure to curb the availability of kerosene; thus eliminating morbidity and mortality due to its accidental poisoning.[44]

Media education regarding poisoning in general and kerosene in particular is required to reduce these events. There is a need to increase awareness regarding kerosene oil with respect to its harmful storage, accidental ingestion and harmful first aid practices (like inducing vomiting). Education of parents should be undertaken (talks/ leaflets/handouts) at every opportunity like well-baby visits and pediatric clinic consultations; to emphasize measures to keep toxic substances and medications out of reach of young children to prevent poisonings.

The introduction of Child resistant containers (CRC) in a South African district resulted in a 47% drop in the ingestion of kerosene during the 14-month intervention period.[45] The use of child resistant containers has been cost-effective compared with the expense involved in the management of the victims of kerosene poisoning.[46] Thus, there is a need for legislation to make it compulsory to sell kerosene in child resistant/close lock containers, to have clear labeling on kerosene bottles stating 'hazardous substance' and addition of less attractive coloring agents to kerosene.

Conclusion

Kerosene oil poisoning still remains a common cause of pediatric accidental poisoning in developing countries.[47] This is due exploratory behavior of children, augmented by improper storage, easy access and inadequate parental supervision.[47] Its physical properties makes it an aspiration risk, with even ingestion of quantities as less than 1 ml being potentially life-threatening. Since there is no antidote and clinical presentation is predominantly respiratory in nature, management is generally supportive. Those with severe respiratory distress may require endotracheal intubation and mechanical ventilation. Though mortality is not high, it is associated with significant morbidity. There is a need for education of consumers and high-risk groups about appropriate preservation and storage, use of appropriate labeling, use of child-proof containers and adequate parental supervision to eliminate such (preventable) accidents. Parents and caregivers should also be informed about recognition of symptoms of kerosene poisoning and avoiding harmful first aid practices after the ingestion.

Conflict of Interests: None.

Funding/ Financial Support: Nil.

Acknowledgment: The authors thank Dr. Hemant Deshmukh, Dean, Seth G.S. Medical College & KEM Hospital for granting permission to submit this manuscript for publication.

Dr. Chhaya A. Divecha and Dr. Milind S. Tullu have equally contributed for the manuscript and both are designated as "FIRST AUTHORS" of the manuscript.

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