J Ped Surg Case Reports 1 (2013) 273–276

Contents lists available at ScienceDirect

Journal of Pediatric Surgery CASE REPORTS

journal homepage: www.jpscasereports.com

Sand aspiration in a child: Extracorporeal membrane oxygenation (ECMO) as a new management tool

Andre Isaac [a,*], Atsushi Kawaguchi [b], Daniel Garros [b], Gonzalo Garcia Guerra [b], Hamdy El-Hakim [c,d]

[a] Division of Otolaryngology-Head & Neck Surgery, Department of Surgery, University of Alberta, #603-10649 Saskatchewan Drive, Edmonton, AB T6E 6S8, Canada
[b] Division of Pediatric Intensive Care, Department of Pediatrics, The Stollery Children's Hospital, Edmonton, Alberta, Canada
[c] Pediatric Otolaryngology, Division of Otolaryngology – Head and Neck Surgery, Department of Surgery, The Stollery Children's Hospital, Edmonton, Alberta, Canada
[d] University of Alberta Hospital, Edmonton, Alberta, Canada

ARTICLE INFO

Article history:
Received 28 March 2013
Received in revised form
28 June 2013
Accepted 7 July 2013

Key words:
Child
Sand
Aspiration
ECMO
Bronchoscopy
Accident

ABSTRACT

Sand aspiration is rare in children. It is a potentially lethal injury, with outcomes ranging from full recovery to global cerebral asphyxia and death. The medical literature was searched for cases of sand aspiration in children, including mechanisms of injury and treatment methods. We found only ten reports of pediatric sand aspiration. The majority were treated with bronchoscopy and lavage. We present a unique case of sand aspiration in a ten-year-old boy caused by an accidental burial, which was successfully treated with bronchoscopy and extra-corporeal membrane oxygenation (ECMO) as a rescue therapy. This is the first ever case of the use of ECMO in the management of sand aspiration. We argue that ECMO is an effective and potentially life-saving measure in severe cases of sand aspiration requiring high ventilatory pressures allowing repeated bronchoscopies while resting the lungs.

Sand aspiration is an uncommon but potentially lethal injury. The clinical presentation can vary from moderate respiratory distress requiring supplemental oxygen, to complete airway obstruction resulting in severe hypoxemia leading to cerebral asphyxia [1,2]. Due to the rarity of occurrence in infants and children, clear diagnostic and treatment recommendations have not been established.

There have been only ten reports of pediatric sand aspiration in the medical literature since its first description in 1962 [3–10]. Mechanisms have included accidental burial, nonfatal drowning, and deliberate sand ingestion. Diagnostic and treatment modalities varied, but clinical outcomes were even more diverse from full recovery with no sequelae, to death.

We henceforth present a case of severe sand aspiration in a child caused by an accidental burial. This is the first case in the medical literature of the use of extracorporeal membrane oxygenation (ECMO) in the management of sand aspiration. The epidemiology and literature surrounding diagnostic and treatment modalities for this type of injury are also reviewed.

1. Case report

A previously healthy eleven-year-old boy (40 kg), was admitted with severe respiratory distress. He was digging a hole at the bottom of a sand dune with his younger brother when the dune collapsed, burying him completely except for the tip of his left hand. The child was immersed for approximately 5 min before his father was able to retrieve him. When he was extracted, he was unconscious and apneic, but did have a pulse. His father initiated rescue breaths for several minutes, after which the boy recovered consciousness and gasped for air, then vomited several times.

Emergency personnel arrived on the scene within 15 min, and immediately intubated the child with a 6.5 mm cuffed endotracheal

* Corresponding author. Tel.: +1 780 265 2556.
E-mail address: aisaac@ualberta.ca (A. Isaac).

2213-5766
http://dx.doi.org/10.1016/j.epsc.2013.07.016

tube. He was manually ventilated for 6 h during air transport to the nearest tertiary care center.

On arrival in hospital, the child was hemodynamically stable and manually ventilated via endotracheal tube. Examination of the chest revealed almost no air entry to the right lung, and bilateral wheezes with bronchial breath sounds and crackles to both lung bases. An arterial blood gas measurement taken demonstrated pH 6.9, pCO_2 120 torr [16.0 kPa], pO_2 63 torr [8.4 kPa], HCO_3 17 mmol/L, base excess −11, SaO_2 90%, and Hemoglobin 136 g/L.

The child was managed with nebulized albuterol and epinephrine, but displayed little improvement. He was also started on piperacillin/tazobactam for prophylactic antimicrobial coverage. He was commenced on mechanical ventilation, with initial settings as follows: peak inspiratory pressure (PIP) 20 cm H_2O, positive end-expiratory pressure (PEEP) 10 cm H_2O at F_IO_2 0.40. The *P*/*F* ratio (PaO_2/F_IO_2) was 158, and the oxygenation index (OI = [mean airway pressure × F_IO_2/PaO_2] × 100) was 57. The otolaryngology team was consulted and recommended that the child to undergo a bronchoscopy. However, the patient quickly deteriorated and had refractory hypercarbia and hypoxemia despite maximal support on mechanical ventilation. It was felt that the most appropriate course would be to place the child on ECMO to allow for adequate ventilation and oxygenation before proceeding with bronchoscopy. ECMO was chosen instead of cardiopulmonary bypass due to the fear of secondary lung injury from bronchoalveolar lavage (BAL), resulting in temporarily worsened oxygenation, in addition to the rapid clinical deterioration and level of distress hence the likelihood of requiring longer support.

A 23 French Avalon® Bi-Caval Dual Lumen Catheter (Avalon Laboratories, LLC., Rancho Dominguez, CA, USA 90220) was inserted from the right internal jugular vein, and venovenous (VV) ECMO was initiated at a flow of 50 mL/kg/min which maintained the patient's oxygen saturation above 85%. Higher flow was not achievable due to significant negative access pressure. A chest X-ray taken soon after ECMO cannulation revealed adequate cannula placement, with bilateral fluffy peri-hilar infiltrates, and near-complete opacification of the right lung. The X-ray also demonstrated a classic sand bronchogram (Fig. 1).

The child was then airlifted from the referring hospital to our facility by our Extra Corporeal Life Support (ECLS) transport team for definitive care with ECLS, since we are the regional center for this support modality. Given the limited flow obtained with the original catheter, a second drain (15Fr Bio-Medicus® cannula [Medtronic, Inc., Minneapolis, MA, USA 55432]) was inserted in the femoral vein to optimize flow and consequently minimize the required ventilator pressures.

Following successful initiation of ECMO, the patient underwent suspension laryngoscopy, and dexamethasone and epinephrine were topically applied to the airway. Rigid bronchoscopy was performed, revealing significant edema of the vocal cords and the trachea down to the level of both main-stem bronchi with significant mucosal inflammation and friability. Sand granules were seen almost completely obstructing both main stem bronchi. Repeated saline lavage was used to remove the remaining foreign material until both bronchi were cleared.

After the procedure, the oxygen saturation was easier to maintain with ECMO flow at 60 mL/kg/min. Initial echocardiogram showed decreased left ventricular function and mild mitral valve regurgitation, while the chest X-ray revealed white-out lungs bilaterally (Fig. 2). Therefore, low dose inotropes including epinephrine were used for three days, since the patient was kept on VV ECMO.

On day 2 the child required another bronchoscopy with BAL to clear the remaining sand debris in the airway. The patient was successfully weaned off ECMO by day 3 (Fig. 3). He continued to recover and was successfully extubated 6 days after the aspiration event. He was discharged from the pediatric intensive care unit the following day, and was discharged from hospital on day 12. He left the hospital without oxygen requirements and back to his baseline according to the parents' assessment.

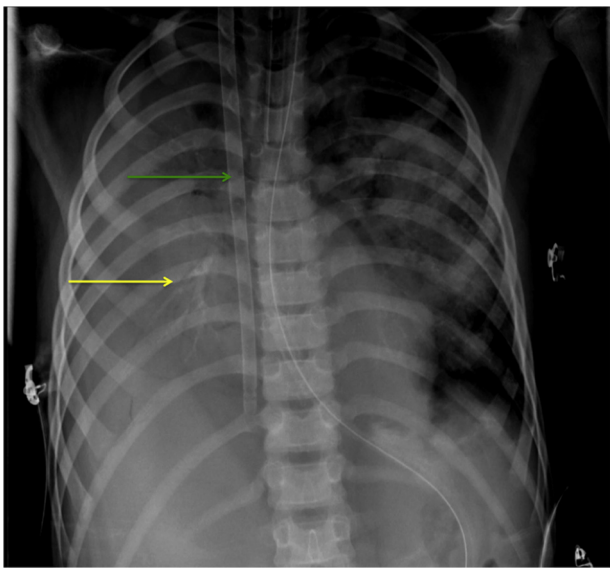

Fig. 1. Chest radiograph immediately following ECMO cannulation for sand aspiration, showing near complete opacification of the right lung indicative of early acute respiratory distress syndrome, and a right-sided sand bronchogram (yellow arrow). An ECMO cannula is seen entering at the right internal jugular vein (green arrow). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

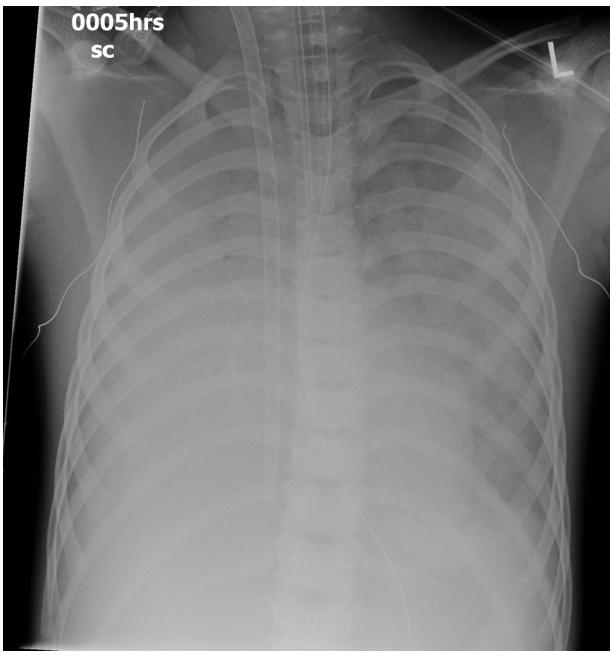

Fig. 2. Chest radiograph 1 h following bronchoscopy with bronchoalveolar lavage for sand aspiration showing complete white-out of both lung fields, consistent with severe acute respiratory distress syndrome. ECMO cannula is seen entering at the right internal jugular vein.

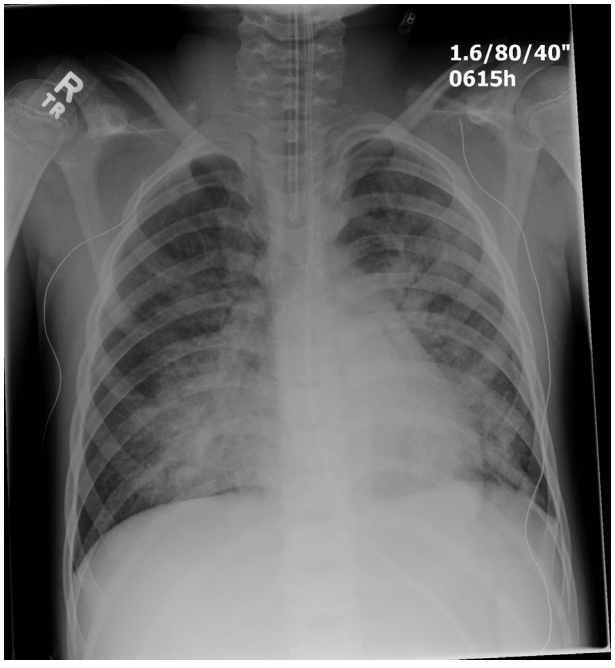

Fig. 3. Chest radiograph at discharge following treatment for sand aspiration and decannulation from ECMO, showing significantly improved aeration and near complete resolution of interstitial edema and atelectasis.

Follow-up was completed with the patient's family physician due to the large distance to the tertiary care center. Six months following the injury, the patient had normal neurological, pulmonary, and cardiovascular examinations, with normal pulmonary function and no sequelae from the injury.

2. Discussion

Foreign body aspiration is not an uncommon emergency in the pediatric population. Aspiration of particulate matter such as sand is rare, but can be particularly dangerous. In 1962 Hewer described the first case of sand aspiration in a nonfatal drowning incident. Van Dyke postulates that the morbidity may be due to one or combination of laryngospasm, mechanical obstruction, and chemical burn of the airways [8]. In more severe cases, respiratory failure and cerebral asphyxia can occur rapidly [10].

A MEDLINE search including EMBASE and Cochrane Library using the Medical Subject Heading (MeSH) terms "child" "infant," "sand," and "aspiration" revealed a total of ten cases of sand aspiration reported in children. In these reports (summarized in Table 1) the mechanisms varied, but the majority were due to accidental burial, such as the current case. Other situations included near-drowning episodes, and one case of deliberate sand ingestion in a two-year-old [2].

Signs of sand aspiration are non-specific. The diagnosis is often initially suspected based on the typical history. Physical examination can vary from mild coughing and increased work of breathing, decreased breath sounds, wheezes, and rales [5], to an acutely hypoxic child with severe respiratory distress or complete respiratory arrest [3]. Our patient experienced a severe clinical scenario, with a witnessed respiratory arrest requiring immediate intubation.

The classic diagnostic finding is the "sand bronchogram" on chest X-ray, first described by Bonilla-Santiago in 1978, which is caused by radiodense material filling the tracheobronchial tree forming a cast. Other chest X-ray findings have been described in the literature, including fluffy perihilar infiltrates and atelectasis with sparing of the lung bases and apices [5]. Other diagnostic modalities included computed tomography (CT) and lung scan, but their use is of limited diagnostic utility, and should only be considered when the diagnosis is in question [9]. Our case presented with the classic sand bronchogram on chest X-ray, and severe hypercapnia and hypoxemia refractory to conventional mechanical ventilation, strongly suggesting the diagnosis of significant sand aspiration. The diagnosis was confirmed on bronchoscopy.

Treatment of sand aspiration has varied, but the common denominator is aggressive pulmonary toilet, nebulized bronchodilators, and bronchoscopy with BAL for moderate or severe cases (Table 1). The decision depends largely on the clinical picture and hemodynamic stability of the patient. The majority of previous cases have required intubation, and only one required a tracheostomy [8]. Only once was cardiopulmonary bypass (CPB) required when a six-year-old boy experienced profound desaturations during a prolonged bronchoscopy to remove the sand from the airway [4].

Five of the cases required one or two bronchoscopic lavages with short hospital admissions and good outcomes. Three other cases did not require bronchoscopy, and two resulted in death. In our case, the severity of the respiratory failure (the degree of ventilation and oxygenation impairment) prompted the introduction of ECMO. This modality of support was used instead of temporal CPB for several reasons, including the extremely poor initial oxygenation status, and the fear of further lung injury with aggressive ventilatory support, as well as the anticipation of multiple bronchoscopies and lavage.

Table 1
Summary of previous cases of pediatric sand aspiration (age in years).

Author	Year	Age	Sex	Mechanism	Findings	Treatment	Outcome
Kapur [3]	2009	3	M	Near-drowning	Interstitial infiltrates, ground glass on CT	Intubation, bronchoscopy with lavage	Recovery with no sequelae
Mellema [4]	1995	6	M	Not reported	Sand bronchograms on CXR	Intubation, bronchoscopy with lavage, CPB	Recovery with no sequelae
Efron [5]	2003	10	M	Burial	Fluffy infiltrates on CXR	Bronchoscopy with manual removal	Recovery with no sequelae
Choy [6]	1996	3	M	Burial	Sand bronchograms on CXR	Intubation, bronchoscopy with lavage	Recovery with no sequelae
Kettner [2]	2008	2.5	M	Sand ingestion	Cardiopulmonary arrest	Intubation, CPR	Asphyxia, death
Glinjongol [7]	2004	5	M	Burial	Sand bronchograms on CXR	Intubation, bronchoscopy with lavage	Recovery with no sequelae
Bender [1]	1984	14	M	Burial	Decreased volumes on CXR	Pulmonary toilet	Recovery with no sequelae
Van Dyke [8]	1976	12	M	Burial	Severe upper airway obstruction	Tracheostomy, bronchoscopy with lavage	Recovery with no sequelae
Wales [9]	1983	14	M	Burial	Sand bronchograms, shifted mediastinum on CXR	Pulmonary toilet	Recovery with no sequelae
Bergeson [10]	1978	8	M	Burial	Cardiopulmonary arrest	CPR, intubation, bronchoscopy with lavage	Asphyxia, death

M, male; CXR, chest X-ray; CPR, cardiopulmonary resuscitation; CT, computed tomography; CPB, cardiopulmonary bypass.

Several other agents have been used for adjunctive therapy including surfactant for acute respiratory distress syndrome, systemic steroids, and empiric antibiotic therapy to prevent pneumonia [3–5]. However, there is no consensus for these indications and the evidence for them is lacking.

3. Conclusion

We have thus described the eleventh case of sand aspiration reported in children, and the first to be supported with ECMO. It is evident that sand aspiration is a potentially life-threatening injury and can have extremely varied clinical presentations. The diagnosis is based on recognition from history, as well as typical radiologic findings. Bronchoscopy with removal of the foreign material is a common denominator for successful management of severe cases. ECMO is an effective and potentially life-saving measure, particularly in patients requiring high ventilatory pressures and the need for support during repeated bronchoscopies.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Conflicts of interest

The authors have no conflicts of interest to disclose.

Sources of funding

No funding was used for this study.

References

[1] Bender EM, Moore EE, Kashuk JL, Hopeman AR. Conservative management of sand aspiration: case report. Mil Med 1984;149:98–9.
[2] Kettner M, Ramsthaler F, Horlebein B, Schmidt PH. Fatal outcome of a sand aspiration. Int J Legal Med 2008;122:499–502.
[3] Kapur N, Slater A, McEniery J, Greer ML, Masters IB, Chang AB. Therapeutic bronchoscopy in a child with sand aspiration and respiratory failure from near drowning – case report and literature review. Pediatr Pulmonol 2009;44:1043–7.
[4] Mellema JD, Bratton SL, Inglis Jr A, Morray JP. Use of cardiopulmonary bypass during bronchoscopy following sand aspiration. A case report. Chest 1995;108:1176–7.
[5] Efron PA, Beierle EA. Pediatric sand aspiration: case report and literature review. Pediatr Surg Int 2003;19:409–12.
[6] Choy IO, Idowu O. Sand aspiration: a case report. J Pediatr Surg 1996;31:1448–50.
[7] Glinjongol C, Kiatchaipipat S, Thepcharoenniran S. Severe sand aspiration: a case report with complete recovery. J Med Assoc Thai 2004;87:825–8.
[8] Van Dyke JJ, Lake KB. Survival after asphyxia secondary to gravel aspiration. Arch Intern Med 1976;136:471–3.
[9] Wales J, Jackimczyk K, Rosen P. Aspiration following a cave-in. Ann Emerg Med 1983;12:99–101.
[10] Bergeson PS, Hinchcliffe WA, Crawford RF. Asphyxia secondary to massive dirt aspiration. J Pediatr 1978;92:506–7.