Foreign body airway obstruction causing a ball valve effect

Johnny Kenth • Che Ng

Chase Farm Hospital, Enfield, Middlesex EN2 8JL, UK

Correspondence to: Johnny Kenth. Email: johnnykenth@doctors.org.uk

DECLARATIONS

Competing interests

None declared

Funding

None declared

Ethical approval

Written informed consent to publish the article was obtained from the patient

Guarantor

CN

Contributorship

JK and CN conceived the idea for the case report and wrote the paper

Acknowledgements

We would like to acknowledge the support of the Department of Anaesthetics and Otolaryngology at Chase Farm Hospital

Provenance

This article was submitted by the authors and peer

Foreign body airway obstruction (FBAO) in adults is a rare but potentially fatal anaesthetic airway emergency.[1]

Case description

The authors present the case of a 29-year-old fit and well ASA I patient. Whilst consuming his morning coffee, he suddenly began to cough violently. He then became dysphonic and severely dyspnoeic, with the symptoms quickly resolving after a few minutes. The patient thought that he had choked on his coffee. He initially complained of a sore throat, an intermittent rasping voice and the presence of a foreign object sensation. As the symptoms did not subside after 2 h, he dialled the emergency services.

He was taken to the resuscitation bay at the emergency department (ED) by ambulance for difficulty in breathing. He was immediately assessed by a junior trainee and was noted to appear comfortable and able to talk in full sentences. His observations were normal with no signs of respiratory compromise (respiratory rate of 12 bpm and SaO_2 99% on room air). There was no stridor or other signs of upper airway obstruction. A chest radiograph (Figure 1) was adjudged unremarkable with no obvious foreign body present, with perhaps few signs of hyperinflation.

After discussion with a senior doctor at the ED, the patient was declared medically fit for discharge. However, prior to discharge the patient deteriorated and started to develop signs of a soft stridor with rasping on deep inspiration. He was referred to ENT surgery for suspected FBAO of the upper airway. As his condition was stable, flexible bronchoscopy was considered the most appropriate investigation under the care of the respiratory physicians. On examination in endoscopy, he was found to have an inverted plastic milk bottle cap beneath the level of the vocal cords (Figure 2). He was then transferred to the ENT theatres and consented for an urgent rigid bronchoscopy and subglottic foreign body removal under general anaesthesia. A succinct preoperative assessment espied him to be ASA I, with no past medical history, not a smoker, not taking any regular medications and being fasted for over 6 h.

On arrival to theatre, two large bore IV cannulae were inserted. The patient was preoxygenated (with 100% oxygen), followed by a premedicaton with midazolam IV 2 mg and fentanyl in two 50 μg aliquots (due to his anxiety and musculature stature). A sevoflurane induction was then commenced to maintain spontaneous respiration. Judicious use of fentanyl was rationalized as it helped to obtund the laryngeal responses to instrumentation. Sevoflurane concentration was carefully increased to deepen anaesthesia with accentuation to maintain spontaneous respiration throughout. An i-gel® was inserted to assist with preoxygenation prior to rigid bronchoscopy. Anaesthesia was maintained by target controlled infusions of propofol (Cpt [target plasma concentration] 2–7 μg/ml) and remifentanil (Cpt 1–5 ng/ml). When anaesthesia was deepened to an adequate depth, the i-gel® was removed, and the rigid bronchoscope inserted by the ENT surgeon. Oxygenation was maintained by apnoeic insufflation of 100% oxygen through the side arm of the bronchoscope. High-frequency jet ventilation (HFJV) and surgical tracheostomy were immediately amenable should the need have arisen.

The larynx was visualized easily, and the milk cap was promptly removed through the vocal cords using forceps. This precipitated minor laryngospasm which was resolved with the

reviewed by Alex Cumberworth and Jonathan Collins

Figure 1. Chest radiograph taken, following admission of patient to the ED. The film fails to show the presence of the plastic ring cap in the upper airway. The upper airway is not entirely visualized and there are subtle signs of chest hyperinflation.

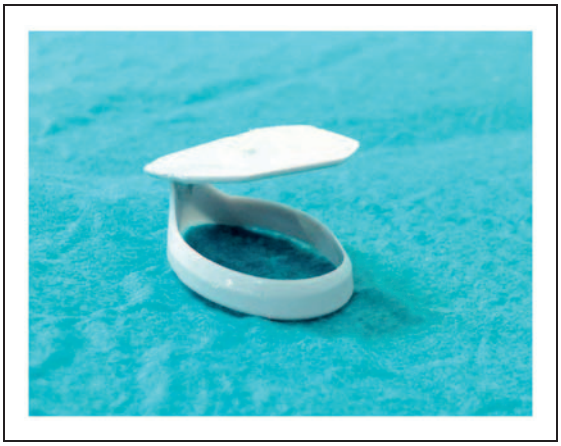

Figure 2. The milk ring cap that was aspirated causing a subglottic upper airway obstruction.

institution of positive, peak expiratory pressure (PEEP), jaw thrust and propofol boluses. The patient was then monitored in theatre and recovered from anaesthesia without any further complications.

Discussion

The incidence of mortality due to FBAO is low, at 0.66 per 100,000 population[2] with cases of partial

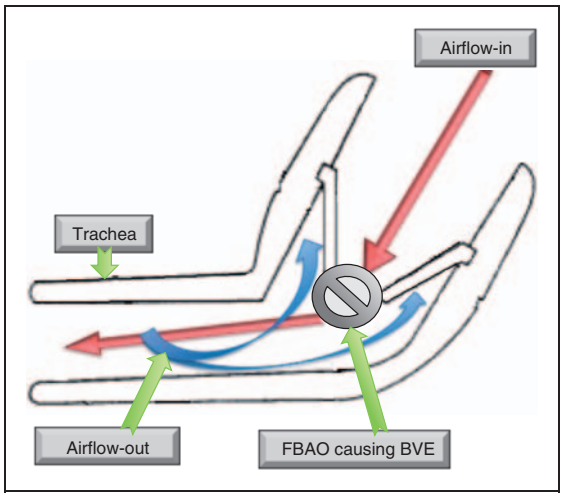

Figure 3. Illustration showing the mechanism involved in an FBAO with BVE. The FB allows inspiration of air (red arrows), however, opposes the egression of exhaled air (blue arrows). This results in air trapping and build up of pressure downstream from the obstruction.

FBAO creating a ball valve effect (BVE) seldom being reported in the literature. In fluid logics, a BVE can be described as a partial obstruction that countenances the ingression of forward flow of gas into the lung by convective bulk flow, whilst counterpoising the egression of gas out of the lungs.[3,4] This will then result in air trapping distal to the level of the obstruction, with a concomitant build up of pressure (Figure 3). The cardinal potential complication of a FB-induced BVE is the development of pneumothoraces, which untreated could lead to cardiorespiratory compromise and collapse.[5–9]

The milk cap consisted of an open end and a closed end. The patient had inhaled the cap with the open end below the level of the vocal cords, in the infraglottic space. This was creating a 'ball valve' mechanism that would have explained the rasping noises heard on deep respiration. It also explicated why the patient was found to have a normal physical examination and work-up. The partial BVE allowed the patient to continue to inspire air, whilst limiting expiration resulting in gas trapping. Crucially, had the milk cap been inhaled in the opposite direction (with the closed end of the cap against the vocal cords) complete airway obstruction would have ensued with fatal consequences.

The anaesthetic management for the removal of FBAO will vary depending on the clinical situation. If the patient is in extremis or cardiorespiratory arrest, then the ALS/APLS guidelines should be followed. For intubation, positioning the patient supine may cause the tongue and soft palate to fall back through gravity, producing narrowing of the retropalatal and retrolingual airways, compromising ventilation further.[10] In addition, once intubated, caution should be exhibited on mechanical ventilation with positive pressure, as this may push the foreign body to more distal parts of the airway.[11] If the FB can be visualized after intubation, care should be taken not to traumatize the larynx, as this would make further instrumentation even more difficult.[12]

For the management of FBAO (in non-emergencies) in both adults and children, a gas induction is the preferred method of induction, as this preserves spontaneous respiration.[8,13] The patient should be first preoxygenated with 100% oxygen, thereby de-nitrogenating the lungs. A rapid-onset and non-irritant agent is preferred such as sevoflurane or halothane. One should be mindful that with an agent with higher Oswald blood-gas coefficients, the time constants taken to reach equilibration between the alveoli, blood and effect sites are increased. Thus, deeper planes of anaesthesia will take longer to establish. Once the vocal cords are visualized, the cords can be sprayed with lidocaine prior to rigid bronchoscopy, thus reducing the risk of laryngospasm.[13]

During bronchoscopy, both volatile (VIMA – volatile induce/maintenance anaesthesia[14]) and total intravenous anaesthesia (TIVA) can be used for the induction and maintenance of an adequate depth of anaesthesia. However, no convincing evidence in the literature for either is available. The consensus being that the anaesthetic should be individually tailored to the clinical context and spontaneous respiration should be maintained whenever possible.[14,15]

Oxygenation can be temporarily maintained by insufflating high flow oxygen through the side-arm of the bronchoscope; however, CO_2 removal is somewhat limited.[14,15] If mechanical ventilation is required, choices include intermittent positive pressure ventilation (IPPV) (by attaching the side arm of the bronchoscope to an anaesthetic breathing circuit ventilator), low-frequency jet ventilation and HFJV. The latter incorporates the use of a relatively narrow cannula that can be used to jet air/oxygen mixtures down the airway.[15] The ventilator creates high velocity streams of gas of low tidal volumes, delivered at rapid frequencies (60–600 bpm).[14] The use of HFJV may improve the surgical view but does have some limitations.[13,14] These include the use of complex equipment and TIVA, difficulty in monitoring end-tidal CO_2, risk of barotrauma, having an unprotected airway and delivery of cool and dry gases to the distal airways.[13–15]

Key points

- Always listen to the patient. Carefully elicit key features in the history whilst employing a high index of suspicion when there has been a history of choking and possible aspiration of a foreign body into the upper airway.
- Understand the limitations of imaging techniques such as chest radiographs: plastic is radiolucent!
- FBAO is an anaesthetic emergency and senior help should be sought early. Techniques should be tailored to the clinical context but spontaneous respiration should be maintained wherever possible.

References

1. National Safety Council, Research and Statistics Department. *Injury Facts 2008 Edition*. Itasca, IL: National Safety Council, 2008;8:14–15
2. Mittleman RE, Wetli CV. The fatal cafe coronary. Foreign-body airway obstruction [abstract]. *JAMA* 1982;**247**:1285–8
3. Segen JC. Ball valve obstruction: Farlex medical dictionary, c2012. See http://medical-dictionary.thefreedictionary.com (last checked 29 July 2012)
4. Kruczek ME, Hoff BH, Keszler BR, Smith RB. Blood clot resulting in ball-valve obstruction in the airway. *Crit Care Med* 1982;**10**:122–3
5. Popovich J Jr, Babcock R. Intraluminal blood clot casts causing obstructive emphysema and recurrent pneumothorax. *Crit Care Med* 1982;**10**:482–3
6. Foucher P, Merati M, Baudouin N, Reybet-Degat O, Camus P, Jeannin L. Fatal ball-valve airway obstruction by an extensive blood clot during mechanical ventilation. *Eur Respir J* 1996;**9**:2181–2
7. Arney KL, Judson MA, Sahn SA. Airway obstruction arising from blood clot: three reports and a review of the literature. *Chest* 1999;**115**:293–300
8. Kain ZN, O'Connor TZ, Berde CB. Management of tracheobronchial and esophageal foreign bodies in children: a survey study. *J Clin Anesth* 1994;**6**:28–32

9. Hillman DR, Platt PR, Eastwood PR. The upper airway during anaesthesia. *Br J Anaesth* 2003;**91**:31–9
10. Robinson D, Airway management. In: Morton N ed. *Paediatric Intensive Care*. Oxford: Oxford University Press, 1997, pp.81–108
11. Liao R, Li JY, Liu GY. Comparison of sevoflurane volatile induction/maintenance anaesthesia and propofol-remifentanil total intravenous anaesthesia for rigid bronchoscopy under spontaneous breathing for tracheal/bronchial foreign body removal in children. *Eur J Anaesthesiol* 2010;**27**:930–4
12. Fidkowski CW, Zheng H, Firth PG. The anesthetic considerations of tracheobronchial foreign bodies in children: a literature review of 12,979 cases. *Anesth Analg* 2010;**111**:1016–25
13. Allman KG, McIndoe AK, Wilson IH. *Emergencies in Anaesthesia*. London: Oxford University Press, 2009
14. McRae K. Anesthesia for airway surgery. *Anesthesiol Clin North America* 2001;**19**:497–541, vi
15. English J, Norris A, Bedforth N. Anaesthesia for airway surgery. *BJA:CEACCP* 2006;**6**:28–31