*Lesson of the week***Gastric rupture associated with use of the laryngeal mask airway during cardiopulmonary resuscitation**

Nathaniel Haslam, G Claire Campbell, John E Duggan

The laryngeal mask airway has revolutionised airway management in anaesthesia and seems set to do so for resuscitation. Its appeal is based largely on less need for skill and training than with either facemask or an endotracheal tube.¹ All paramedic crews and emergency departments have the laryngeal mask as standard equipment, and its popularity in hospital resuscitation is growing. Gas leak and gastric inflation are well recognised complications of positive pressure ventilation with the laryngeal mask.^{2 3} We present a case in which the use of a laryngeal mask during an out of hospital cardiac arrest led to massive gastric dilation, gastric rupture, and a tension pneumoperitoneum.

Case history

A 71 year old man with a history of angina and hypertension developed chest pain and collapsed in a shopping centre. A bystander performed cardiopulmonary resuscitation for about seven minutes until a paramedic unit arrived. A paramedic inserted a laryngeal mask airway and started hand ventilation at a rate of 12 breaths/min with a 1600 ml self inflating resuscitation bag with reservoir and oxygen supply set to 12 litres per minute. Normal chest movement and auscultation of the chest confirmed correct placement of the mask. The paramedic then resumed chest compression at a rate of 100 per minute synchronous with ventilation. Three lead electrocardiography showed ventricular fibrillation. A single DC shock of 200 J restored sinus rhythm, with a good cardiac output after about five minutes of the paramedic starting cardiopulmonary resuscitation. The patient was then transferred to our emergency department; although some respiratory effort was noted, this was considered inadequate by the paramedic, who ventilated the patient by hand throughout the 25 minute journey to hospital. The paramedic saw no episodes of retching, coughing, or vomiting.

On the patient's arrival in the emergency department, doctors noted the following in the A, B, C, D (airway, breathing, circulation, disability) checklist: a laryngeal mask airway was in place; breathing was spontaneous and laboured, with a respiratory rate of 45 breaths/min and oxygen saturation concentration of 99%; the heart rate was 150 beats/min and blood pressure was 168/90 mm Hg; and the Glasgow coma score (range 3 to 15) was 3 (completely unresponsive).

Doctors noted that the abdomen was distended, tense, and tympanic. Arterial blood gases, taken shortly after arrival, showed pH 7.28; arterial oxygen tension 42.9 kPa; arterial carbon dioxide tension 4.4 kPa; carbon dioxide 15.7 mmol/l; and base excess -9.2 mmol/l. Twelve lead electrocardiography showed changes diagnostic of an acute inferior myocardial infarct. Chest radiography showed a massive pneumoperitoneum (figure).

We transferred the patient to the intensive care unit for respiratory and inotropic support. After sedation, neuromuscular paralysis, and endotracheal intubation, we drained the pneumoperitoneum. We used a Bonanno catheter and drained about six litres of gas, which was under tension. Over the next 12 hours the patient required continuous fluid resuscitation (250 ml colloid per hour) and six units of red cell concentrate to maintain haemoglobin concentration. We considered surgery but concluded that cardiac instability in the first 12 hours contraindicated this. After this period our patient's condition improved and we continued conservative management, which included antibiotics, omeprazole, high dose sucralfate, and intravenous feeding. Gastrointestinal haemorrhage was confirmed by the passage of melaena stool at 48 hours. The patient never exhibited any signs of peritonism or sepsis. A radiological contrast examination of the upper gastrointestinal tract on day 5 was normal, and nasogastric feeding was started. On day 13 the nasogastric aspirate contained altered blood. Endoscopy showed fresh clot adherent to a 5 cm longitudinal tear in the anterior wall of the stomach, but no active bleeding.

The patient's lungs were ventilated for 16 days. He made a slow but progressive neurological recovery. He was discharged to a medical ward on day 22 still with some minor cognitive deficit.

Discussion

This is the first report of rupture of the stomach caused by massive gastric dilation associated with the use of the laryngeal mask airway. Gastric rupture has previously been reported with facemask ventilation⁴ and a misplaced endotracheal tube.⁵

A large volume of gas may enter the stomach with only a small tidal leak during positive pressure ventilation with a laryngeal mask airway. Our patient's lungs were hand ventilated for 25 minutes, and we estimated that the volume of the pneumoperitoneum was more than six litres. This volume is consistent with a tidal

Gastric inflation is a dangerous complication of using laryngeal mask airways in advanced life support

Wansbeck General Hospital, Ashington NE63 9JJ

Nathaniel Haslam
clinical research fellow in anaesthesia

John E Duggan
consultant anaesthetist

James Cook University Hospital, Middlesbrough TS4 3BW

G Claire Campbell
specialist registrar in anaesthesia

Correspondence to: nhaslam@doctors.org.uk

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Chest x ray film showing massive pneumoperitoneum

oesophageal leak of just 20 ml per breath over this time. A volume of six litres is much greater than that known to cause gastric rupture. In a cadaver study ($n = 11$) gastric rupture occurred at a mean gastric volume of 2670 (SD 410) ml and mean pressure of 73 (SD 13) mm Hg.⁶ We found it easy to exceed these pressures with an adult resuscitation bag. The maximum pressure we could generate with a 1600 ml self inflating bag for one and two handed use against a closed aperture was 160 mm Hg and 300 mm Hg respectively (personal experiment).

Successful use of the laryngeal mask for positive pressure ventilation in anaesthesia is based on the avoidance of gas leak. Gas leak becomes more likely at greater airway pressure.^{2-7,8} Gastric inflation during cardiopulmonary resuscitation is associated with the use of large tidal volume, short inspiratory time, and reduced respiratory compliance.⁹⁻¹¹ External force applied is a potent way to reduce respiratory compliance, as is gastric dilation itself. The European Resuscitation Council's guidelines recommend an inspiratory time of 1-2 seconds.¹² Brimacombe and colleagues recommend limiting airway pressure to less than 20 cm H₂O during lung inflation and the use of small tidal volumes (8-10 ml/kg).¹³ Brain also recommends that if a gas leak is detected it must be immediately corrected because of the risk of gastric inflation and must be actively excluded by listening over the neck and abdomen with a stethoscope. Although gastric inflation led to gastric rupture in our patient, a more likely complication is regurgitation of gastric contents and pulmonary aspiration.

The Resuscitation Council (UK)'s guidelines for the laryngeal mask airway give advice contrary to Brain.¹⁴ The guidelines state, "If a laryngeal mask airway has been inserted, attempts can be made to perform continuous chest compressions, uninterrupted during ventilation" and recommend that chest compressions need to be interrupted for ventilation only if "excessive gas leakage results in inadequate ventilation of the lungs." Furthermore, the guidelines assert that "any gas leaking from between the laryngeal mask and the larynx will tend to pass up through the mouth rather than being forced into the patient's stomach." We believe that these statements are wrong. Chest compression synchronous with lung inflation will result in dangerously high airway pressure and should be used with caution with a laryngeal mask airway. We also consider that a pharyngeal gas leak is highly indicative of an oesophageal leak, and even a small leak can result in dangerous gastric dilation very quickly—for example, 2700 ml, the mean volume at which gastric rupture occurred in cadavers,⁶ can be attained during intermittent positive pressure ventilation with a tidal gas leak of 30 ml in just seven minutes.

Detection of an oesophageal gas leak by auscultation of the abdomen (as recommended by Brain) or of the chest can be difficult during cardiopulmonary resuscitation. A pharyngeal leak can be easily detected, however, by auscultation of the neck, even in noisy environments. We believe that this procedure should be included in all protocols for non-anaesthetists that relate to the use of the laryngeal mask airway and positive pressure ventilation.

A pressure relief valve may have prevented gastric rupture in this case. All paediatric resuscitation bags include a 40 cm H₂O pressure relief valve. Inflation pressures for adults in excess of this are rarely

beneficial, and the risk of barotrauma and gastric inflation are similar in adults and children. The inclusion of a pressure relief valve at 40-60 cm H₂O as standard for adult bags is worth considering.

A tidal volume of 400-600 ml of oxygen is recommended for adults during cardiopulmonary resuscitation.¹⁴ The volume of the standard adult self inflating resuscitation bags (Intersurgical 2000 ml, Ambu 1500 ml, Laerdal 1600 ml) may make this difficult to achieve. These bags are awkward to use, and the inexperienced practitioner has a tendency to deliver very large tidal volumes. Studies have compared self inflating "bag mask valve" ventilation using an adult bag, with ventilation obtained using a 500 ml paediatric bag. These studies showed that healthcare workers obtained similar levels of pulmonary ventilation but produced less gastric inflation with the smaller bag.^{15,16} The optimum volume for an adult resuscitation bag, particularly for use with the laryngeal mask airway, is worth re-evaluating. In adults, use of a 750-1000 ml self inflating bag with a 40 cm H₂O pressure relief valve would seem to be ideal for short to medium term ventilation with a laryngeal mask.

We believe that the common risk of gastric inflation with the facemask and laryngeal mask, and the associated risks of pulmonary aspiration of gastric contents and gastric rupture, requires appropriate emphasis in cardiopulmonary resuscitation guidelines.

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