Manual Resuscitators (Ambu Bags) Can Ventilate The Lungs Adequately Despite Big Subatmospheric Pressure In The Breathing Circuit

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Abstract

Manual resuscitator (Ambu bag) is one of the most common devices used to ventilate and oxygenate patients in medical practice. Even though most health providers has a general idea about the way these devices function, few of them knows the exact mechanisms of it. This case report aimed to explain the mechanisms of one type of the manual resuscitators used in our hospital, and show why is this device was superior to the breathing bag and the anesthesia machine ventilator in the situation of subatomspheric pressure and big leak in the circuit. On the other side, to make anesthesia providers aware of the serious complications of endotracheal nasogastric tube placement.

CASE REPORT

A 32 year-old man, weight 90 kg, height 176 cm, was brought to our operating room emergently for exploratory laparotomy for an abdominal gunshot wound in the early hours of the morning. A brief history and physical examination showed that patient has no significant past medical or surgical history. On arrival to our operating room, the patient was awake and alert and vitals signs were stable. He had two large-bore intravenous lines. Induction of anesthesia was smooth and uneventful. Rapid sequence technique with cricoid pressure was used (preoxygenation/lidocaine/etomidate/succinylcholine). The trachea was intubated with a cuffed endotracheal tube (Portex Tracheal Tube) size #8. An esophageal temperature probe and nasogastic tube (Argule, Salem Sump Tube with Anti-Reflux Valve) size# 18 French were inserted.

The abdomen was opened and blood was suctioned from the surgical field. The patient continued to be stable while the anesthesia team was giving crystalloid and colloid fluids and transfusing packed red blood cells until the abdominal aorta was cross-clamped. Thirty minutes into the case, the surgeon requested Trendelenburg position to improve the surgical exposure. Immediately after positioning, the ventilator (Ohmeda, 7800, Modulus SE) began alarming “apnea alarm”. We did the following:

- The ventilator was checked and it could be seen that the ascending bellows collapsed
- “Oxygen flush” helped to inflate the bellow for a few seconds
- The pressure gauge monitor showed 20 H2O cm pressure and remained there
- The breathing circuit was switched to the reservoir breathing bag, which collapsed in few seconds

The “oxygen flush” inflated the bellow for few seconds before it collapsed again. Obviously, there was a significant negative pressure in this closed circuit. W used a back-up adult manual resuscitator bag (Silicone, 1600 cc) with 10-12 l/mint O2 flow used while we were searching for the source of this problem. The anesthesia technique was switched to total intravenous anesthesia (TIVA) with low dose infusion of propofol, ketamine, midazolam, fentanyl, and rocuronium. The ventilation with the manual resuscitator was adequate, breath sounds were normal and bilateral, SaO_2 always stayed at 98-99%.

The patient had full muscle relaxation during the whole crisis. Detailed check of the ventilator, the breathing circuit, and the scavenging system showed no failure. Therefore, the breathing circuit was reconnected to the endotracheal tube, but the problem remained. The ventilation was switched back to the manual resuscitator. To rule out all possible

causes of this problem, one anesthesiologist removed the gastric tube and reconnected then the breathing circuit to the endotracheal tube. Ventilation went back to normal. The whole incidence took 8 to 10 minutes. The rest of anesthetic management was uneventful. A chest x-ray was done in the surgical intensive care unit and showed no apparent lung injury. The patient recovered and was discharged from hospital several days later with no pulmonary problems.

DISCUSSION

Inadvertent insertion of a gastric tube into the trachea in anesthetized intubated patients is not an uncommon complication. Various complications (some are serious such as hemothorax and pneumothorax) have been reported in the medical literature ([1], [2], [3]). Big leak and ventilation volume loss is one of these complications. This problem is usually easy to recognize when the leak in the breathing circuit happens immediately while/or after inserting the gastric tube using the simple principle in anesthesia "When something goes wrong immediately after making a change, first consider the change as the source of the problem". It is unusual for misplaced endotracheal gastric tubes to manifest as a significant ventilation volume loss and total failure of mechanical ventilation.

This kind of complication was published in a few case reports in the medical literature ([4], [5], [6], [7], [8]). However, in all those cases, the gastric tube was connected to the suction tubing just before the ventilation volume loss happened, which did not happen in this case. This case explores two interesting points that have not been published before:

1. No immediate temporal relationship between the insertion, connecting the gastric tube, and the ventilation loss of volume, which made it difficult to diagnose this serious problem quickly.

2. The ability of manual resuscitators to neutralize the huge subatmospheric pressure created by the suction tubing, and enabling to ventilate the lungs adequately, while the anesthesia machine ventilator and the reservoir bag with the breathing circuit completely failed.

Manual resuscitator use is extremely common in the medical practice. Ambu bags are principally used for transport and at the site of emergencies, especially by paramedics, emergency room staff, critical care staff, and the operating room personnel. However, few practitioners know the exact mechanism of these simple, very important tools. Figure (1) shows the basic components of the manual resuscitator involved with this case ([9]).

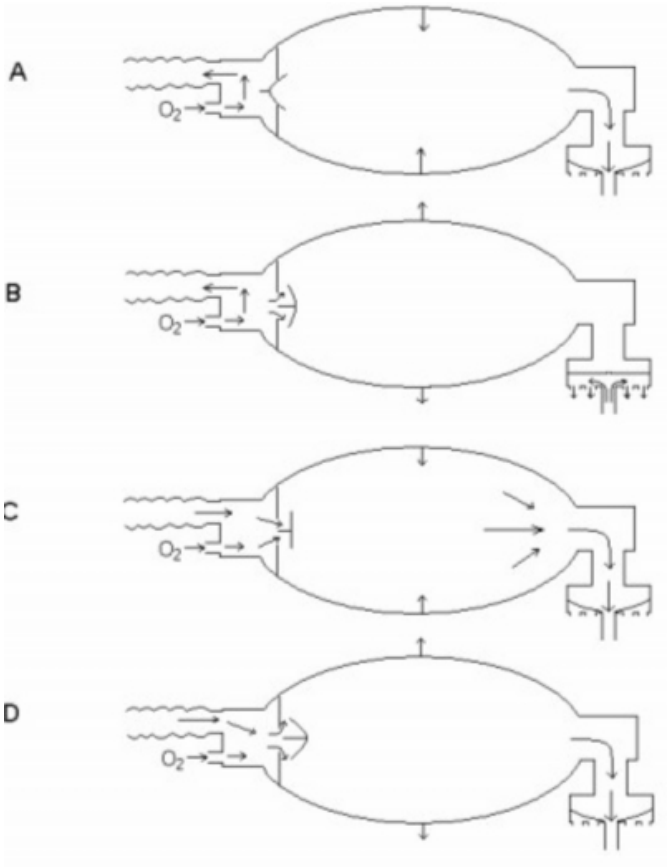
Figure 1

Figure 1: Basic Components of a Manual Resuscitator

Figure (2, A, B) demonstrates the mechanism of the manual resuscitator in the normal conditions. On the proximal side (close to the patient), during inspiration (A), when the bag is squeezed, the diaphragm seated against the exhalation ports and the fishmouth portion of the valve opens. During expiration (B), the fishmouth closes and the flap falls away from the exhalation channel. A second flap valve over the exhalation ports prevents air from being inspired during spontaneous respiration. On the distal side (away from patient), during inspiration (A), the bag is squeezed, the bag refill valve closes, and oxygen from the delivery tubing flows into the reservoir tubing. During expiration (B), the bag self-expands (made of Silicone), the bag refill valve opens and the bag fills when oxygen from the delivery tubing as well as reservoir tubing flows into the bag. Figure (2, C, D) shows how this device works in the presence of negative pressure in the breathing circuit.

Figure 2

Figure 2: Mechanisms of the manual resuscitators: A and B in the normal conditions, C and D in the presence of big negative pressure in the breathing circuit.



The big negative pressure created by the nasogastric tube in the trachea and the endotracheal tube will keep the fishmouth valve and the bag refill valve open most of the time. This process neutralizes most of the negative pressure, because of the open connection to the atmospheric pressure through the reservoir tubing. When the bag is squeezed during inspiration (C), some positive pressure created will be able to inflate the lungs. During expiration (D), the lungs deflate passively, and the nasogastric tube sucks air and oxygen into the trachea, then out to the vacuum. This way the lungs will be ventilated with mixture of air and oxygen. On the other side, in the closed circuit, where there is no connection to the atmospheric pressure to neutralize this large negative pressure, it impossible to create practical positive pressure in the circuit to ventilate the lungs, even with the use of the oxygen flush system with its very high oxygen flow.

It is crucial to have adult and pediatric manual resuscitators in the operating room. This case report intended the show the importance of the manual resuscitators in anesthesia and to shed light on the interesting mechanism, which saved our patient's life.

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