by the combined use of the response to nerve stimulation and clinical signs and symptoms of residual curarization.

In conclusion, manual evaluation of the response to TOF nerve stimulation is of value in the adjustment of individual dose regimens for neuromuscular blocking agents during anesthesia in order to avoid overdose and secure reversibility. However, postoperative absence of visual and manual fade in the TOF response does not exclude residual neuromuscular blockade.

REFERENCES

Cricoid Compression is Effective in Obliterating the Esophageal Lumen in the Presence of a Nasogastric Tube


Intravenous induction of anesthesia immediately followed by a full paralyzing dose of a muscle relaxant and tracheal intubation is a widely used technique for patients who are likely to vomit or regurgitate.1,3 With complete muscle paralysis, vomiting cannot occur but regurgitation is possible.1,3 To enhance the safety of the technique, Sellick,1 in 1961, introduced cricoid compression to pre-ven}

vent gastric contents from reaching the pharynx in case regurgitation occurs.1 The maneuver consists of temporary occlusion of the upper esophagus by backward pressure of the cricoid ring against the bodies of the cervical vertebrae.1,2 Despite the reliability of cricoid pressure, its efficacy in occluding the esophageal lumen in the presence of a nasogastric tube has been questioned.1 Perhaps by tripping the sphincters at the upper and lower ends of the esophagus, a tube inside the esophagus may increase the risk of regurgitation.1 Furthermore, this tube may interfere with obliteration of the upper esophageal lumen during cricoid compression.1

The present investigation was undertaken to determine the efficacy of cricoid compression in the presence of a nasogastric or an orogastric tube in adult cadavers.

METHODS

The study was approved by our committee on human investigations. Six fresh adult cadavers subjected to autopsies were studied. Authorization for postmortem examination and consent for the investigation were obtained from the next of kin. The stomach was exposed by an abdominotomy incision. A mushroom gastrostomy or Foley catheter was inserted into the distal esophagus via the stomach. Tape was placed firmly around the esophagus to secure the catheter and prevent leakage distally. The catheter was connected to a three-way stopcock sys-
tem to allow colored saline to run freely into the esophagus from a height of 100 cm. An 18-French Salem Sump nasogastric tube was introduced from the nose in five cadavers and from the mouth in one cadaver to the mid-esophagus and a clamp was applied proximally to it (fig. 1).

Cricoid compression (as described by Sellick) was applied. The esophagus then was filled with saline containing methylene blue from a height of 100 cm with the use of an iv infusion set with a three-way stopcock system (fig. 1). The intraesophageal pressure was assumed to equal 100 cm H₂O when complete cessation of the flow of saline was observed. The pharynx was visualized continuously while the nasogastric tube was clamped and following the release of the clamp. Thereafter, the clamp was reapplied and the esophagus was refilled to a pressure of 100 cm H₂O while cricoid pressure was maintained. The pharynx was visualized after releasing cricoid pressure and 20–30 s after the removal of the clamp. In three cadavers, the experiment was repeated with the use of contrast material and lateral roentgenograms of the head, neck, and upper chest were taken.

RESULTS

In the presence of a clamped nasogastric tube, the colored saline solution failed to reach the pharynx while cricoid compression was maintained. After release of the clamp, saline passed freely through the nasogastric tube.
to the outside, but no fluid was seen in the pharynx during cricoid compression. Upon removal of cricoid pressure, fluid immediately appeared in the pharynx, oropharynx, nasopharynx, and mouth. When the clamp was removed after release of cricoid pressure, the colored saline was seen coming out of the proximal end of the nasogastric tube as well. The results were consistent in all cadavers. Similar findings were obtained in the three cadavers studied with the use of contrast material (figs. 2–4).

DISCUSSION

The present investigation confirms that firmly applied cricoid pressure is effective in sealing the esophagus around an esophageal tube against an intraesophageal pressure up to 100 cmH₂O. The present study is in agreement with previous findings on infant cadavers that cricoid compression is effective in obliterating the esophageal lumen in the presence of a nasogastric tube. In one previous

FIG. 3. A roentgenographic film of an adult cadaver after the clamp was removed while an intraesophageal pressure of 100 cmH₂O was maintained. Contrast material appeared inside the open orogastric tube, but no material appeared in the pharynx as long as cricoid pressure was maintained. The arrows point to the contrast material inside the esophageal lumen.

FIG. 4. A roentgenographic film of an adult cadaver taken 10 s after the release of cricoid pressure. Contrast material was seen in the pharynx, oropharynx, and nasopharynx. The arrows indicate the contrast material inside the esophageal lumen.
study on five human cadavers, Fanning found that the mean pressure from within the esophagus necessary to overcome cricoid compression without a nasogastric tube was 74 cmH₂O. The difference between his findings and ours may be attributed to the inclusion of one case where leakage occurred at the point of entrance of the catheter rather than into the pharynx. Perhaps pressures higher than those observed were actually exerted temporarily, since he used a syringe for injection.

The findings that nasogastric tubes were unoccluded by cricoid pressure are not surprising. Plastic tubes that were used in the present study are too firm to be occluded by cricoid compression, even if considerable pressure is exerted. In Sellick's original studies, soft latex tubes were used that were occluded by slight pressure. The type of tube used apparently determines the efficacy of cricoid pressure in occluding the tube.

The presence of a nasogastric tube has been thought to act as a wick and thus enhances regurgitation by making the lower and upper esophageal sphincters less competent. Conversely, the incidence of regurgitation is less during general anesthesia in patients with nasogastric tubes. There are many conditions that make patients likely to vomit or regurgitate during induction of anesthesia. However, placement of a nasogastric tube before anesthetic induction seems to be indicated only in patients with overdistension of the stomach. A functioning nasogastric tube will help reduce the intragastric pressure until the time of induction of anesthesia. Although emptying the stomach by a wide-bore gastric tube before induction of general anesthesia has not been an accepted practice in obstetrics, Cohen, in an editorial review, pointed out that it is probably advisable when the patient has eaten after the onset of labor.

Based on our findings that cricoid pressure is effective in sealing the esophagus in the presence of a nasogastric tube, the following technique may be utilized for induction of anesthesia in patients who have a nasogastric tube in place. The nasogastric tube need not be withdrawn before anesthetic induction. After oxygenation, a rapid-sequence induction (unless contraindicated) may be performed. Adequate muscular relaxation will prevent vomiting, coughing, and straining and will facilitate intubation.

Cricoid pressure from the moment of loss of consciousness will obliterate the esophageal lumen around the tube. If a rise in the intragastric pressure occurs during induction of anesthesia, an unoccluded nasogastric tube will act as a "blow-off" valve, while cricoid pressure will prevent gastric contents from reaching the pharynx.

REFERENCES

5. Fanning GL: The efficacy of cricoid pressure in preventing regurgitation of gastric contents. ANESTHESIOLOGY 32:553-555, 1970