Brief Reports

Water flow between the upper esophagus and pharynx for the LMA and COPA in fresh cadavers

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Purpose: In this randomised, crossover cadaver study, we determine the esophageal pressure (EP) at which water flow occurs between the upper esophagus and pharynx for the laryngeal mask airway (LMA) and cuffed oropharyngeal airway (COPA).

Methods: Ten male and ten female cadavers were studied. The infusion set of a pressure controlled, continuous flow pump was inserted into the upper esophagus and ligated into place. The EP was increased in 2 cm H_2O increments. This was performed without an airway device (controls) and over a range of cuff volumes for the LMA (0-40 ml) and COPA (0-60 ml). Regurgitation pressure (RP) was the EP at which fluid was first seen with a fibreoptic scope in the hypopharynx (controls) and above or below the cuff (LMA and COPA).

Results: The RP was higher for the LMA than for the COPA and controls ($P < 0.0004$), and RP was similar for COPA and controls. There was an increase in RP with increasing cuff volume for the LMA from 0 to 10 ml ($P < 0.0001$). There were no increases in RP with increasing cuff volume for the COPA. The EP at which fluid leaked above and below the cuff was similar for the LMA at all cuff volumes. The EP at which fluid leaked above the cuff was higher than below the cuff for the COPA when the cuff volume was 40 ml ($P < 0.0001$).

Conclusion: In fresh cadavers, the LMA provides better airway protection from fluid in the upper esophagus than the COPA.

Objectif : Déterminer, par une étude croisée, randomisée, sur des cadavres, la pression œsophagienne (PO) à laquelle l'eau s'écoule entre la partie supérieure de l'œsophage et le pharynx lors de l'utilisation du masque laryngé (ML) et d'une sonde à ballonnet oropharyngienne (SBOP).

Méthode : Dix cadavres d'hommes et dix cadavres de femmes ont été étudiés. Le dispositif de perfusion, comprenant une pompe à pression contrôlée et à débit continu, a été insérée dans la partie supérieure de l'œsophage et ligaturé en place. La PO a été augmentée par paliers de 2 cm H_2O. Ce qui a été réalisé sans appareil d'intubation (pour le groupe témoin) et selon divers volumes de ballonnet pour le ML (0-40 ml) et la SBOP (0-60 ml). La pression de régurgitation (PR) était la PO à laquelle le liquide était vu pour la première fois à l'aide du fibroscope dans l'hypopharynx (témoins) et au-dessus ou au-dessous du ballonnet (ML et SBOP).

Résultats : La PR a été plus élevée avec le ML qu'avec la SBOP et les témoins ($P < 0,0004$), mais la PR a été semblable avec la SBOP et les témoins. La PR s'est accrue avec l'augmentation de volume du ballonnet de 0 à 10 ml, dans le cas du ML($P < 0,0001$). Il n'y a pas eu de hausse de la PR avec l'augmentation de volume du ballonnet dans le cas de la SBOP. La PO à laquelle le liquide fuyait au-dessus et au-dessous du ballonnet a été similaire pour le ML et tous les volumes de ballonnets. La PO à laquelle le liquide fuyait au-dessus du ballonnet a été plus élevée que sous le ballonnet pour la SBOP quand le volume était 40 ml ($P < 0,0001$).

Conclusion : Sur des cadavres frais, le ML fournit une meilleure protection des voies aériennes, que la SBOP, contre le liquide présent dans la partie supérieure de l'œsophage.

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THE laryngeal mask airway (LMA) prevents water flow between the upper esophagus and pharynx in cadavers, probably by acting as a mechanical plug in the hypopharynx.[1] The cuffed oropharyngeal airway (COPA) forms a mechanical plug in the proximal pharynx,[2] exerts substantial pressures against the pharyngeal mucosa[3] and displaces pharyngeal structures.[4] We postulated that the COPA would promote water flow by stretching pharyngeal muscles attached to the upper esophageal sphincter. In this randomised, controlled, crossover study, we determine the esophageal pressure (EP) at which water flows between the upper esophagus and pharynx for the LMA and COPA.

Methods

Ten male and ten female supine cadavers (6-24 hr postmortem) were studied. Ethical committee approval and appropriate consent was obtained. Cadavers with esophageal or laryngo-pharyngeal pathology were excluded. After removal of the anterior chest wall, the esophagus was incised 10 cm below the level of the cricoid cartilage. The infusion set of a calibrated, pressure controlled, continuous flow pump (AR-6450, Arthrex, Innsbruck, Austria); accurate to 2 cm H_2O was inserted through the esophageal stump and ligated into position, 5 cm below the cricoid cartilage. An esophageal pouch was created to prevent water flowing distally. A fibreoptic scope was positioned in the laryngopharynx to provide a view of the hypopharynx. The EP was increased from 0 cm H_2O in 2 cm H_2O increments every 15 sec and the EP noted when water first became visible (controls). An experienced LMA/COPA user then inserted/fixed the LMA or COPA into each patient in random order. A #10 COPA and #4 LMA were used for females; a #11 COPA and #5 LMA were used for males. Two fibreoptic scopes were inserted: one was positioned in the oropharynx to provide a view of the proximal cuff (supracuff); another was passed through the LMA/COPA tube and positioned to provide a view below the cuff (infracuff). The EP was increased as in the control group and the EP noted when water first appeared above and below the cuff. This was performed at zero cuff volume and repeated after each additional 10 ml up to 40 ml for the LMA and 60 ml for the COPA. Measurements for the LMA were made with the head/neck in the neutral position, and for the COPA and controls with chin lift applied. Between each measurement, the water was removed from the pharynx and lungs and the infusion set opened and all fluid drained from the upper esophagus. The accuracy of the fibreoptic detection of fluid was confirmed by noting fluid dripping from the bag of the infusion set. Regurgitation pressure (RP) was defined as the EP at which fluid was first seen in the hypopharynx for the controls and above or below the cuff for the COPA and LMA.

Statistical analysis was with paired t test, Friedman's two-way analysis of variance and Chi squared test. Significance was taken as $P < 0.05$.

Results

The mean (range) age, height and weight were 74 (59-83) yr, 167 (150-188) cm and 71 (57-87) kg respectively. The EP at which fluid was seen without any airway device was 9 (8-10) cm H_2O and the EP at which fluid was seen below the cuff over the inflation range was higher for the LMA than the COPA ($P < 0.0001$) (Table). The EP at which fluid was seen above the cuff over the inflation range was higher for the LMA than the COPA ($P < 0.0001$). The RP was higher for the LMA than for the COPA at all cuff volumes ($P < 0.0004$), but was similar for the COPA and the control measurements. There was an increase in RP with increasing cuff volume for the LMA from 0 to 10 ml ($P < 0.0001$), but no changes thereafter. There were no increases in RP with increasing cuff volume for the COPA. The EP at which fluid was seen above and below the cuff was similar for the LMA at all cuff volumes. The EP at which fluid was seen above the cuff was higher than below the cuff for the COPA when the cuff volume was 40 ml or higher ($P < 0.0001$).

Discussion

We found that the LMA was a more effective barrier to water flow between the esophagus and pharynx than the COPA. The mean EPs at which fluid entered the pharynx with the LMA and COPA were 40 and 9 cm H_2O respectively. During spontaneous gastro-

TABLE Esophageal pressures at which fluid first appeared above (supracuff) or below (infracuff) the cuff for the laryngeal mask airway (LMA) and cuffed oropharyngeal airway (COPA) with increasing cuff volume. Data are mean (95% CI). Pressures are in cm H_2O.

	LMA		*COPA*	
Cuff Vol (ml)	*Supracuff*	*Infracuff*	*Supracuff*	*Infracuff*
0	15 (12-17)	14 (12-17)	9 (8-11)	9 (8-11)
10	43 (35-50)	42 (33-50)	10 (8-11)	9 (7-12)
20	47 (39-54)	47 (39-54)	10 (9-12)	9 (8-11)
30	49 (42-56)	47 (39-55)	11 (9-12)	9 (8-10)
40	49 (41-56)	48 (40-56)	13 (11-16)	9 (8-10)
50			20 (19-22)	9 (8-11)
60			23 (21-25)	9 (8-11)
Overall	40 (37-44)	40 (36-44)	14 (13-15)	9 (9-10)

esophageal reflux or vomiting, intragastric pressure equals EP with the creation of a common cavity. Intragastric pressure in the starved human is 10-30 cm H_2O,[5] but exceeds 60 cm H_2O during vomiting.[6] This suggests that the LMA, but not the COPA, will protect the airway from gastro-esophageal reflux and that neither device will protect the airway from vomiting. For the LMA, this provides a possible explanation for the low incidence of clinically detected aspiration (2:10,000).[7] Large scale data about aspiration is lacking for the COPA, but one study reported that the incidence was 1:300.[2]

We found that the COPA did not promote water flow between the esophagus and pharynx compared with controls. This suggests that the upper esophageal sphincter is unaffected by the forces generated in the proximal pharynx when the COPA cuff is inflated. We also found that the EP at which fluid appeared above and below the cuff was similar for the LMA, but that fluid appeared above the cuff at higher EP for the COPA. This suggests that regurgitation will be detected earlier with the LMA than with the COPA.

Our study was conducted in cadavers and the applicability of our findings to the anesthetised patient is uncertain. However, cadavers have been used extensively in cricoid pressure research[8] and a recent study showed that pharyngeal compliance was similar in fresh cadavers and paralysed anesthetised patients.[9]

We conclude that in fresh cadavers, the LMA provides better airway protection from fluid in the upper esophagus than the COPA.

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