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THE ROLE OF THE THORACIC COMPRESSION REFLEX IN THE HEIMLICH MANEUVER

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Résumé

ROLE DU REFLEXE DE COMPRESSION THORACIQUE DANS LA MANŒUVRE DE HEIMLICH. — En employant le chien comme modèle expérimental, nous avons examiné les rapports entre le Réflexe de Compression Thoracique (RCT) et la « Manœuvre de Heimlich » (MH). Le RCT s'est montré aussi efficace que la compression pectorale latérale pour éliminer une occlusion expérimentale des voies aériennes supérieures. La suppression du RCT par vagotomie rendit inefficace le soulagement de l’étouffement par MH chez 5 chiens sur 8. En conclusion, le RCT peut être un facteur de la MH, mais la compression mécanique des poumons joue aussi un rôle dans l’efficacité de la MH.

Introduction

The Thoracic Compression Reflex (TCR) was described by Whitehead and Draper (1944, 1947). Later, Crawford and Bowen (1968) elucidated the neural pathways of the reflex. The afferent limb of the reflex was the vagus; the efferent limbs were the phrenic and intercostal nerves. Compression of the thorax by a wide belt drawn moderately tight regularly elicited the reflex. The TCR resulted in a sustained increase in respiratory rate sufficient to maintain ventilation and accelerate recovery in the deeply anesthetized dog (Crawford and Bowen, 1968). Many veterinarians found the TCR clinically useful, particularly in the barbiturate anesthesia era (Stein, 1966).

Heimlich (1974) occluded the airways of anesthetized dogs and relieved the simulated choke by forceful thoracic compression. The Heimlich Maneuver (HM) is now regularly used in human medicine to relieve choke (Visintine and Baick, 1975).

The HM is thought due to mechanical expulsion of residual air (Heimlich, 1975). Respiratory reflexes or other mechanisms have not been accorded importance in the HM. However, d-tubocurarine abolishes the capability of the HM to relieve choke in experimental animals (Heimlich et al., 1975). Curare-induced paralysis of the intercostal muscles and the diaphragm would disrupt the TCR (Crawford and Bowen, 1968).

The optimal position for elicitation of the TCR corresponds to that area (perpendicular
to the point where the 8th and 9th ribs insert on the sternum) which produces maximal thoracic compression with a constricting device, *i.e.*, a wide belt (Crawford and Bowen, 1968). Similarly the optimal positioning of the hands in the HM corresponds to that area (just caudal to the xiphoid on the median dorsal plane) where maximal thoracic compression can be produced with one hand forcefully pressing on top of the other hand (Heimlich et al., 1975).

The purpose of this study was to determine the role of the TCR in the HM. The probability that the TCR is regularly elicited in the application of the HM provided the rationale for the initiation of this project.

**Method**

Eight mongrel dogs of average weight, 1-6 years of age, and equally divided by sex were selected. Each dog was anesthetized with pentobarbital sodium (approximately 25 mg/kg). Respiratory rate was allowed to stabilize at less than 10/min over a period of 30 min.

Each dog was tested for the presence of TCR using the method previously described (Crawford and Bowen, 1968). A cuffed endotracheal tube was inserted and inflated with 4 ml of air. A rubber stopper (size 00) was inserted into a metal adapter on the external end of the tube thus occluding the airway (Coulter et al., 1975).

The TCR was elicited and the effect on airway occlusion was recorded. An indwelling section of tubing connected to a pressure transducer was used to record pressure in the endotracheal tube. The effect of the reflex on the occluding device was recorded.

The HM was done on each dog and the results recorded as above.

Each dog was bilaterally vagotomized. The effect of vagotomy on the TCR, the HM, and the capacity of the TCR and the HM to relieve the airway occlusion were recorded.

**Results and discussion**

The TCR was readily elicited in all dogs. The TCR relieved tracheal occlusion in all 8 dogs in the test (Tab. 1). The endotracheal tube was stoppered tightly enough to prevent the test animal from being able to inspire or expire. Moderate tightening of a wide belt around the thorax (at the point where the 8th and 9th ribs insert on the sternum) resulted in increased depth and rate (58.1% average increase) of respiration that resulted in expulsion of the occluding device in all cases tested.

Unlike the experience of Heimlich et al. (1975), forceful ventral abdominal pressure was not as effective in relieving the occlusion as was lateral chest compression. It is possible Heimlich used older dogs with less thoracic elasticity. We placed the dogs in lateral recumbency, and applied force to the rib cage with both hands. This procedure was effective, but frequently had to be applied a number of times before dislodgement occurred. Ventral abdominal thrusting was ineffectual.

Vagotomy abolished the TCR. Likewise, the capability of the constricting device to expel the endotracheal bolus was abolished (Tab. 1).

Forceful manual thoracic compression (HM) was effective in relieving artificial choke in 3 of 8 dogs following vagotomy. Both lateral and abdominal thrusting were employed in all trials. These results were

<table>
<thead>
<tr>
<th>Subject No.</th>
<th>Pre-Vagotomy TCR</th>
<th>Pre-Vagotomy CC</th>
<th>Post-Vagotomy TCR</th>
<th>Post-Vagotomy CC</th>
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</table>

TCR = Thoracic Compression Reflex  
CC = Lateral Chest Compression  
(+ ) = Relief of choke  
(−) = Method did not relieve choke
consistent with Heimlich's experience in curarized dogs (Heimlich et al., 1975).

Endotracheal pressures necessary to displace the occluding boluses were remarkably low. During TCR, expulsion pressures averaged 8.5 mm Hg with the TCR and 11.3 mm Hg with the HM. HM pressures in the human average 31 mm Hg. Heimlich, however, commented on lower pressures in children by speculating that increased resistance to air flow because of the smaller diameter of the trachea is perhaps responsible for the obviously adequate pressures. He also stated the likelihood the occluding bolus would be smaller in children. The explanation may also apply to small domestic animals.

These results (Tab. 1) tend to indicate the TCR is involved in the HM. The receptors of the TCR are compression receptors located in the finest air ducts and alveoli (Comroe, 1965). The afferent limb of the reflex is the vagus nerve, and the efferent outflow is accomplished via the phrenic nerves and the intercostal nerves (Crawford and Bowden, 1968). Vagotomy rendered the HM ineffectual in choke in 5 of 8 experimental animals (Tab. 1). Curare, which obviously paralyzed the muscles innervated by the phrenic and intercostal nerves (diaphragm and intercostal muscles), likewise rendered the HM ineffectual.

It is unlikely TCR is predominantly responsible for the bolus ejection when the HM is applied, but it does seem a factor. Heimlich has convincingly argued that compression of normal tidal volume plus expiratory reserve volume constitutes sufficient physical explanation for the effectiveness of the HM in relieving choke. Activation of the TCR could aid in the mechanics of expulsion by restoring breathing or increasing the depth and rate of breathing in the choked patient. The TCR also could be value in respiratory recovery subsequent to expulsion of the occlusion. Patients medicated with vagolytic agents or skeletal muscle relaxants may not respond well to the HM.

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Summary

Using the dog as an experimental model, the relationship of the Thoracic Compression Reflex (TCR) to the Heimlich Maneuver (HM) was examined. TCR was equally effective as lateral chest compression in relieving artificially induced choke. Destruction of the TCR by vagotomy rendered relief of choke by HM ineffectual in 5 of 8 dogs. It was concluded TCR may be a factor in HM, but that mechanical compression of the lungs is also involved.

References


