Occurrence of a Deep Breath
after a Period of Airway Occlusion*

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Summary. In anaesthetized rabbits after a period of airway occlusion tidal volume is larger and has a longer duration than the following volumes.
The magnitude of these effects is proportional to the intrapulmonary pressure developed during the last inspiratory effort before re-opening the airway.
The severance of the vagal nerves abolishes these phenomena.
These reflex effects are tentatively related to the stimulation of "irritant receptors" sensitive to changes in lung compliance and congestion of pulmonary circulation.

Key-Words: Vagal Reflexes — Airway Occlusion — Respiratory Reflexes — Sighing.

Schlüsselwörter: Vagusreflexe — Luftwegverschließung — Atmungsreflexe — Seufzen.

During apnea pulmonary compliance diminishes markedly (Griffio and Ross, 1962). The occurrence of a "sigh" which occasionally is seen during normal breathing has been related to the decrease of compliance normally occurring in spontaneous breathing (Bendixen, Smith and Mead, 1964); in the absence of these periodic deep breaths lung compliance decreases even more (Mead and Collier, 1959; Ferris and Pollard, 1960). Vagotomy abolishes the occurrence of sighing (Knowlton and Larrabee, 1946).

A decrease of lung compliance leads to an increase of the inspiratory activity (Reynolds, 1962; Sellick and Widdicombe, 1970) which appears to be of reflex nature and mediated through vagal afferent pathways. Lung receptors sensitive to changes in lung compliance have been described and termed "lung irritant receptors" (Mills, Sellick, and Widdicombe, 1970; Sellick and Widdicombe, 1970); they should be located in the walls of the intrapulmonary airways. There appears to be a striking similarity

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of the dependence on lung compliance between the irritant receptors discharge and the "gasp" reflex.

Possibly the airway occlusion which involves no appreciable volume change of the lungs during inspiratory efforts leads to a decrease of lung compliance too. In anaesthetized rabbits after a period of airway occlusion the first breath has a larger volume than the following breaths; this may be interpreted as an increased inspiratory activity of reflex origin and this hypothesis seems substantiated by the fact that this phenomenon is no longer present after vagotomy.

This study describes the quantitative aspect of the factors involved.

Methods

The experiments were performed in 11 rabbits, 9 of which were anaesthetized with a mixture of urethane and pentobarbitone (initial dose 2.5 ml/kg body weight, given i.v. in a solution containing 218 mg urethane and 7.5 mg pentobarbitone per ml), and 2 with urethane solution only (1.2--1.8 g/kg). The trachea was canulated 2 cm below the larynx and the vagi were isolated in the neck ready to be cut or blocked.

Nervous conduction in the vagi was blocked by a D.C. current applied through a couple of platinum electrodes on which the nerves were placed (Guz and Trenchard, 1969; Sellick, Sant'Ambrogio, and Camporesi, 1970).

Respiratory flow and volume were measured by a Fleisch pneumotachograph and a Godart integrator; the intratracheal pressure was determined by a Sanborn transducer. The diaphragmatic electromyogram was recorded with a couple of silver wires inserted into the sternal region through a midline incision of the abdominal wall. All signals were recorded on a Sanborn oscillograph. Action potentials from single diaphragmatic fibers were recorded in one experiment using a bipolar needle electrode inserted in the sternal portion of this muscle; the signal was amplified by a R.C. Tektronix amplifier, displayed on a Tektronix 551 oscilloscope, and photographed on 35 mm film.

The airway was occluded at the end of expiration (F.R.C.) and the animals performed a series of inspiratory efforts of increasing strength; after varying times the airway was re-opened at the end of an inspiratory effort and the animals resumed ventilation. Different trials were performed before and after vagotomy.

Results and Discussion

When the airway is opened after a period of occlusion the tidal volume of the first breath is larger and its duration longer than in the following breaths (Figs.1 and 2, and the Table); the end-expiratory level (F.R.C.) is also increased for the first few breaths after the occlusion of the airway, especially when the effects on the depth and duration of inspiration become very marked.

The magnitude of these changes is proportional to the intrapulmonary pressure reached during the last inspiratory effort of the period of airway occlusion; in some cases, as shown in Fig.3 for the volume changes, this relationship is nearly linear ($r = 0.77$) which seems not to be the case in