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Medical Intelligence

The Curse of Adam:

Effort Closure Of The Larynx

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THE BIBLE says that earning a living by sweat-provoking hard work was Adam's punishment for eating the fruit of the tree of knowledge.[1] Legendarily, the fruit was supposed to have stuck in his throat and remained visible there as "Adam's apple." Physiologists have regarded the "apple" as linked to male pubertal lengthening of the vocal folds and deepening of the voice. This rationale is not entirely convincing, as it does not explain why the angle between the laminae of the cartilage should be more acute in the male, typically 70 degrees as compared with the female's 81 degrees.[2] Nor does it explain why the isthmus slopes forward more sharply, at an angle of 49 degrees to the linea obliqua in the male as against 43 degrees in the average woman.[3] Surprisingly, the biblical connection between man's birthright of heavy manual labor and the prominence in his neck provides a possible clue.

Consider first certain behavioral facts. Hard work takes effort. Violent effort such as hurling a stone with all one's might at an enemy demands not only a firm stance and a strong precision grip[4] but also the ability to hold one's breath by closing the larynx. The need for breathholding arises because a breathing chest is a relatively flail chest, whereas a chest closed at the larynx can be braced by the abdominal wall muscles for maximal exertion by the arm. Clearly this calls for a hermetic seal of the larynx against the escape of air and requires something more than simple closure at the glottis, since the latter merely leads to phonation. A barrier must be formed, proof against the highest expiratory pressures of which the animal is capable.

The still prevailing doctrine of laryngeal closure[5,6,7] postulates that the barrier is formed by the adducted vestibular folds' acting as an "outlet valve." For the folds to function in this manner, air must be trapped below each vestibular fold between the undersurface of the fold and the cartilaginous side wall of the larynx. Raised intrathoracic pressure will then tend to drive the adducted folds against each other. It is an old idea,[8] but modern research demonstrates that in man it is untenable. Air is not seen in this position in the closed larynx.[9,10,11] What the x-rays show is that the laryngeal passage is practically obliterated, as in a closed bellows whose folds

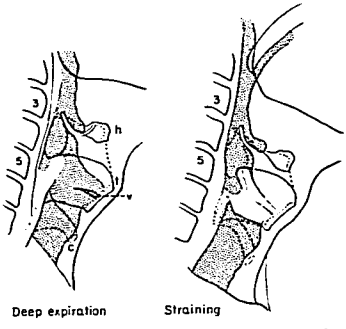

FIG. 1. Tracings of lateral x-ray views of an adult male human larynx. The stippled areas represent air. *Left*, open during expiration; *right*, closed during straining effort. v: ventricle; c: cr.coid cartilage. The unstippled area between the hyoid bone, h, and the thyroid cartilage, t, is the pre-epiglottic body. In the closed larynx the convex posterior bulge of the pre-epiglottic body impacts the concave superior margin of the adducted vestibular folds.

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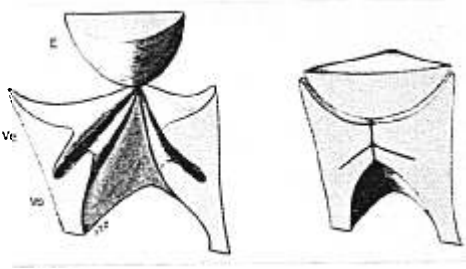

FIG. 2. Diagram illustrating "nutcracker" mechanism involved in effort closure of the human larynx. *Left*, open; *right*, closed. Vo, vocal fold; Ve, vestibular fold; E, tubercle of epiglottic cartilage. Note the elimination of the ventricular space between the vocal and vestibular folds in the diagram on the right.

meet in the midline. The plug is solid. Furthermore, it tapers from above down: the cartilaginous walls of the larynx diverge from below up, a shape hardly conductive to stable closure if pressure on the plug were all from below.

The three-piece plug is assembled in the act of closure. Adduction of the arytenoids and contraction of the thyroarytenoid muscle brings together the vocal and vestibular folds of the two sides. Part three, the pre-epiglottic body, meets the other two when the epiglottic tubercle impacts the top of the adducted vestibular folds (fig. 1) and packs them down against the vocal folds. The vocal folds themselves are supported by the raised intratracheal pressure. Before adduction, parts one and two are flattened against the tapering side wall—the thyroid cartilage—and appear tall and thin in cross section. To meet in the midline, they therefore have to be made short and thick, a transformation which the larynx effects by drawing closer to the hyoid bone. (The last-mentioned movement can be detected by placing a finger tip in the notch of the thyroid cartilage and then making a straining effort.) This not only aids adduction of the two vestibular folds but promotes backward bulging of the pre-epiglottic body from the notch, the whole resembling the coordinated closure of an imaginary three-pronged nutcracker (fig. 2).

The nutcracker is powered by the thyrohyoid muscles. By pulling the hyoid and thyroid toward each other, the muscles ensure leakproof mating of the components of the stopper and may further tighten the fit by squeezing the rim of the cavity from each side; thus the more strongly the muscles contract, the more strongly the three parts of the plug are driven together. Contraction of the inferior constrictor of the pharynx in swallowing also squeezes the V-shaped thyroid cartilage and pushes the vestibular cushions more firmly together.

The functional significance of the forward protrusion of the thyroid cartilage at Adam's apple can now be understood more completely. It increases the leverage of the auxiliary closing squeeze. On the other hand, when the larynx is open it reduces the obstruction to the airway by accommodating part of the pre-epiglottic body. The male larynx, by carrying this development somewhat further than the female larynx, not only subserves maleness of voice, but contributes to capacity for strenuous exercise, heavy weight lifting, and—unfortunately for anesthesiologists—tight laryngeal spasm.

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The Anesthesiologist's Bookshelf

Edited by MEREL H. HARMEL

Textbook of Veterinary Anesthesia. EDITED BY LAWRENCE R. SOMA. Baltimore, The Williams and Wilkins Company, 1971. Pp. 621, with illustrations, $22.50.

Advances in veterinary anesthesia, the increasing numbers and diversity of laboratory animals utilized in research, and new requirements for laboratory animal care, all make a new text in veterinary anesthesia most welcome.

The 41 chapters are written by 29 authors, many of whom are from faculties of human medicine and are internationally known in their fields. Chapters 5 through 11, concerning the pharmaco-dynamics of various anesthetic agents, are well written and relate predominately to man and the dog. Chapters dealing with the more fundamental aspects of anesthesia, such as the respiratory effects of general anesthesia, the depth of general anesthesia, and the systems and techniques for inhalation anesthesia, give greatest emphasis to the dog and cat, as do the chapters no intubation, intravenous techniques, intravenous anesthetic agents, anesthetic management, epidural analgesia, respiratory failure, and resuscitation. This emphasis upon man and dog is offset by the provision of specific chapters on equine anesthesia, general anesthesia of ruminants and swine, avian anesthesia, restraint and anesthesia of small laboratory animals, restraint and anesthesia of subhuman primates, anesthesia of the porpoise, capture and restraint of wild animals, and restraint and anesthesia of bears and undomesticated cats. In the last-mentioned chapter, the problems of dosage, environment, stress, and the need for rapid action during the intramuscular use of sedatives and narcotics are especially intriguing.

As in any multiple-author text, there is variation in the quality of the chapters, as well as occasional duplication. The toxicity of local anesthetic agents is treated superficially, and no references are given. The chapter concerning ruminant and swine anesthesia is likewise limited. On the other hand, there is repetition of the section on analgesia of the eye.

Despite such deficiencies, there are many excellent chapters, especially those dealing with shock and hypothermia, and in general the text is very worthwhile for those interested in the fundamentals of anesthesia, in anesthesia of the dog, cat, and exotic, zoo, and wild animals. The information concerning the larger domestic animals is more limited.

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Principles and Practice of Obstetric Anaesthesia. Third edition. EDITED BY J. SELWYN CRAWFORD. Oxford, England, Blackwell Scientific Publications, 1972. Pp. 305, $16.50.

J. Selwyn Crawford is consultant anaesthetist at Birmingham Maternity Hospital, England. Although the format of the third edition of his book remains the same as that of the second edition, published in 1965, the text has been extensively rewritten to incorporate the wealth of new information appearing within the past seven years. The book is divided into eight sections, dealing with the mother, the placenta, drugs, analgesia, cesarean section, vaginal delivery, the child, and equipment. Each section is well referenced; 962 references comprising the bibliography are cited by number in the text and may be easily identified in the listings at the end of each section. The book, however, does not treat obstetrical anesthesia in sufficient detail to become the new standard reference text. John Bonica's *Obstetric Analgesia and Anesthesia* will continue to fulfill this need for some time to come. *Principles and Practice of Obstetric Anaesthesia* is written in a clear, readable style, and presents fundamental information in a concise

(*Continued on page 336.*)

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