ROENTGENOGRAPHIC STUDIES OF THE OROPHARYNGEAL AIRWAY

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Supralaryngeal obstruction arising during general anesthesia may persist in spite of the insertion of an artificial airway. Few studies of this clinical problem have been made recently (1, 2, 3). The standard artificial airway was designed by Dr. Ralph Waters, who made measurements on many cadavers but chiefly depended on trying various shapes in the throats of anesthetized patients. Unfortunately his work has not been published. Roentgenograms were used in the present investigation to study the action of the Waters airway and to test the effectiveness of a new design.

Methods

Roentgenograms of the mouth and neck were made in 3 men and 2 women prepared for general anesthesia. The patients lay supine on the operating table. Lateral views were obtained with a mobile unit, before and during induction of anesthesia with thiopental. The usual technique was: tube-film distance 36 inches centered over body of hyoid, 100 ma., 75 kv., ¼ second. A control film was made while the patient was still awake. Following induction, films were exposed before and after the insertion of various airways. Maximum support of the chin was maintained in all studies when comparing the effects of different airways.

Roentgenograms were taken postoperatively of 6 subjects who developed upper respiratory complications during anesthesia for evidence of anatomical abnormality.

Results

The normal relations in the oropharyngeal region are indicated in figure 1. When the mouth is closed the air space narrows anteroposteriorly behind the soft palate and at the entrance of the larynx.

Studies During Anesthesia.—Figure 2 presents the roentgenographic appearances in a recumbent man before and after the induction of sleep. With the onset of unconsciousness, this patient's respiration became completely obstructed. The roentgenogram showed the

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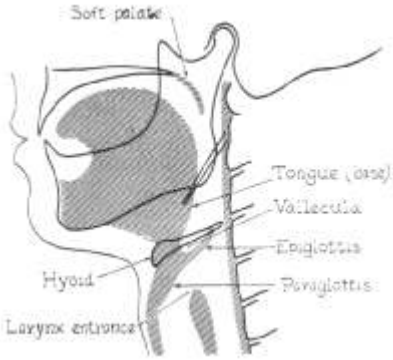

FIG. 1. The oropharyngeal passage in an erect, conscious adult, as seen on lateral films. Bony supports are in heavy outline; the soft tissues are shaded. During nasal respiration the tongue is well forwarded. The air passage is narrowest behind the soft palate and at the entrance of the larynx.

soft palate and tongue in contact with the posterior pharyngeal wall. The entire pharyngeal passage was obliterated.

The effects of standard artificial airways on this type of obstruction in a woman patient are shown in figure 3. A no. 3 Waters airway produced a clinically adequate result, but the roentgenogram shows that the base of the tongue was pushed down sufficiently to occlude the vallecula and cause a somewhat narrowed airway in this region. A no. 4 Waters airway was also judged fairly adequate

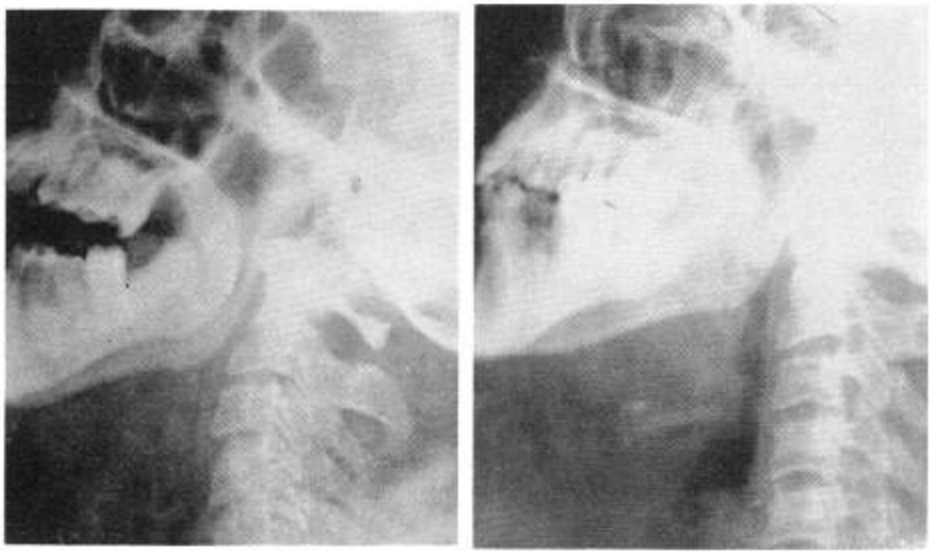

FIG. 2. The upper air passages in a recumbent male, after thiopental. Left: without chin support. Displacement of the tongue has caused complete occlusion of the lower pharynx and laryngeal entrance. Right: chin supported. The tongue has moved forward with the chin; the pharyngeal passage is restored; the laryngeal entrance is still somewhat narrowed.

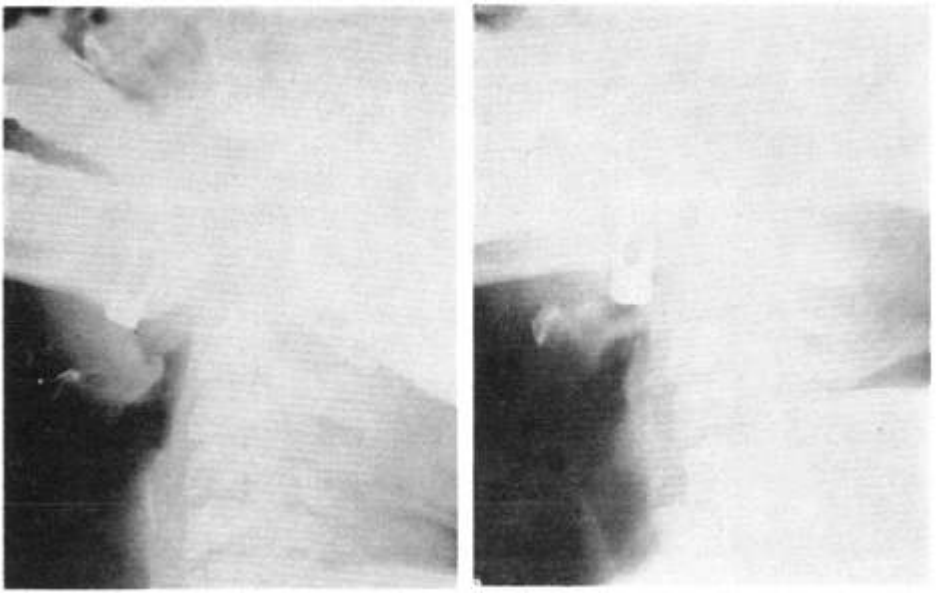

FIG. 3. Effect of artificial airways on pharyngeal obstruction. Left: Waters no. 3; the base of the tongue is unsupported and some lower pharyngeal obstruction persists. Right: Waters no. 4; the epiglottis is depressed, causing partial obstruction of the laryngeal entrance. Clinically the airway seemed adequate on both occasions.

clinically, but it can be seen that this larger instrument pressed the epiglottis against the posterior pharyngeal wall, partially obstructing the entrance of the larynx.

Similar findings in other patients suggested the need for an airway which would support the base of the tongue without depressing the epiglottis. The action required seemed similar to that of the Macintosh laryngoscope. This laryngoscope enters the vallecula and indirectly raises the epiglottis when the tongue and hyoid bone are pressed forward (5). It appeared that the same mechanism could be evoked with an artificial airway by adding an extension projecting into the vallecula (fig. 4).

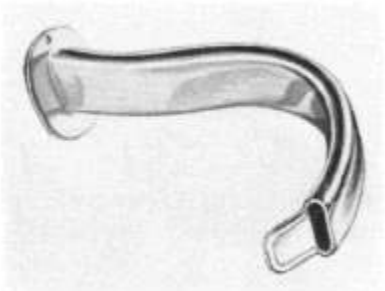

FIG. 4. Modified Waters airway no. 4, with extension designed to rest in the vallecula. Manufactured by the Foregger Company, New York, New York.

The vallecular extension is 13 mm. wide, with rounded edges. The optimum length was determined by roentgenogram and measures 11, 14 and 17 mm. in the nos. 3, 4, and 5 airways, respectively, the latter numbers corresponding to the Waters scale. Size no. 5 is suitable for males of the heaviest build. Size no. 3 suffices in most female patients. Figure 5 illustrates the effect of the device. Improved support of the base of the tongue is evident; the anteroposterior diameter of the laryngeal entrance is also increased.

Postanesthetic Studies.—Films were obtained postoperatively in six patients who manifested unusual upper respiratory obstruction during general anesthesia. Three abnormal types of anatomical configuration were found.

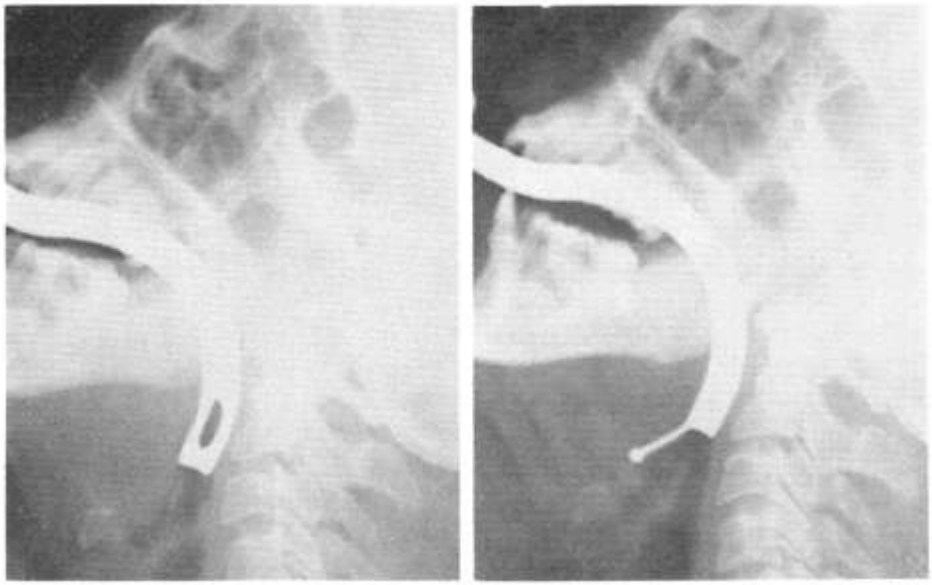

FIG. 5. Comparison of Waters and vallecular extension airways in a male. Left: Waters no. 4 airway; the tongue base is unsupported, the epiglottis droops backward over the laryngeal entrance. Right: vallecular extension, airway no. 4; the tongue base is well supported, the epiglottis is elevated, the laryngeal entrance is wide open.

Case 1.—A male physician of short and extremely stout "chinless" body build underwent three arm operations. On each occasion noisy respiration and impaired ventilation occurred as soon as sleep was induced. Waters airways nos. 4, 5, 6, and 7 were unavailing; a nasopharyngeal tube produced some improvement, but extreme traction on the chin was necessary. Endotracheal intubation was avoided by request but had to be performed during the third operation. A postoperative film (fig. 6) showed that this man's habitual posture involved forward inclination of the neck and extension of the head at the atlanto-occipital joint.

In this man the head was permanently in a "sniffing-the-air" position, an attitude recommended by laryngoscopists for good visualization (6)

FIG. 6. Case 1, conscious man, sitting upright. Note the strong lordotic curve of the cervical spine and the permanently extended posture of the head. Serious pharyngeal obstruction developed during anesthesia; efforts to improve the airway by manipulating the head and mandible were ineffective.

FIG. 7. Case 2, woman, awake, sitting. Localized hypertrophy of the base of the tongue caused marked narrowing of the pharyngeal passage.

and presumably adopted by him in order to help maintain the air passage while awake. The additional extension necessary for the proper functioning of a standard airway was not possible in this patient. This may explain the respiratory obstruction he developed when anesthetized. A vallecular airway has proved useful in this type of patient, but one was not available at the time.

Case 2.—A short obese woman developed obstruction during induction of anesthesia with nitrous oxide and ether preparatory to orotracheal intubation. Laryngoscopy was attempted but difficulty was experienced in seeing beyond the epiglottis. A postoperative roentgenogram showed hypertrophy of the tongue localized to the base. The laryngeal entrance was unusually narrow (fig. 7).

The base of the tongue varies greatly in size from person to person. In this case hypertrophy of the base was such that it depressed the

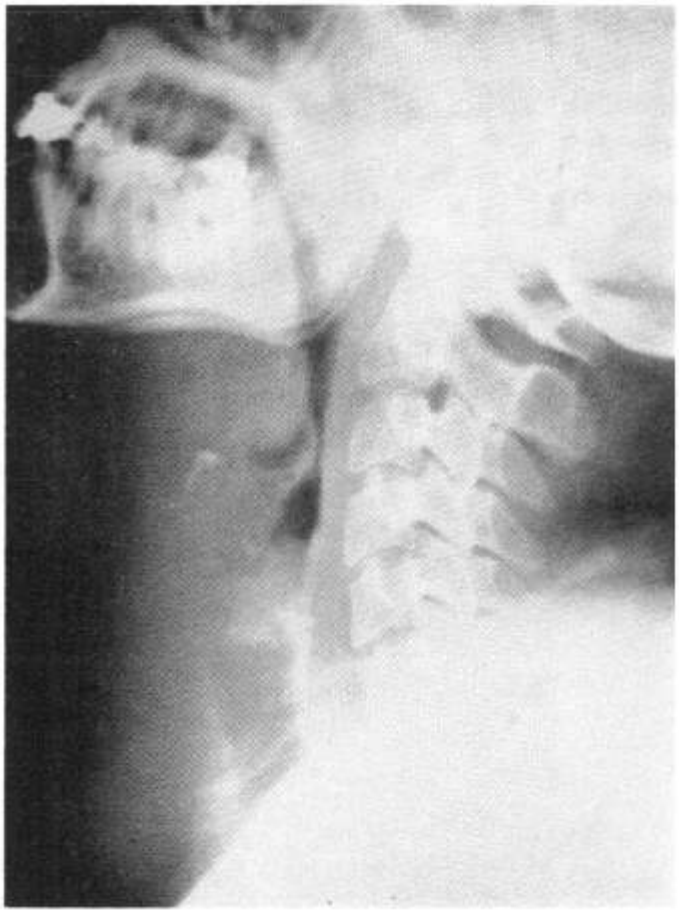

FIG. 8. Case 3, man subject awake and standing. A narrow pharynx, deep vallecula, long epiglottis and very small laryngeal entrance explain the difficulty experienced on attempting intubation.

paraglottis, rendering direct inspection of the larynx extremely difficult.

Case 3.—A husky plethoric man was to undergo endotracheal intubation preparatory to craniotomy. Efforts to introduce the tube with topical anesthesia were unsuccessful. The tube could not be advanced past the epiglottis, which hung across the pharynx and against the posterior pharyngeal wall (fig. 8). After induction with thiopental noisy breathing developed, unrelieved by the insertion of airways. Attempts at intubation remained unsuccessful.

The operation was ultimately performed with local anesthesia. Several factors probably contributed to the difficulties in this case. A very large tongue, a deep vallecula, and a very long yet stiff epiglottis probably account for the intractable obstruction during general anesthesia. The deep vallecula is particularly significant because a standard airway long enough to reach it would inevitably depress the epiglottis and cause further obstruction. The vallecular extension airway developed from this experience has been helpful in later cases of this type.

Discussion

The oropharyngeal passage has a rigid posterior wall formed by the cervical vertebrae and a collapsible anterior wall constituted by the tongue and epiglottis (fig. 1). The passage is kept open rather precariously by muscles attaching the tongue forward to the mandible and hyoid bone. When the tone of these muscles is lost at the onset of general anesthesia, the tongue tends to fall back, accompanied by the epiglottis. Since this cartilage also forms the anterior wall of the laryngeal entrance, collapse of the tongue involves a partial collapse of the laryngeal entrance as well. The vallecular extension counteracts this collapse by improving the support of the base of the tongue. A standard airway can usually produce a satisfactory ventilation in such patients. Nevertheless, use of the vallecular airway often results in further improvement, especially in the presence of an unusually large tongue or short neck.

The added length of the vallecular airway carries little risk of exciting reflex laryngeal spasm, provided the end is inserted into the vallecula (7). Stimulation of the vallecular mucosa may cause gagging, but this reflex is obtunded in a very light plane of anesthesia.

The airway is lubricated and inserted in the midline, care being taken to avoid the pillars of the fauces. If excessively long, the airway meets resistance at the bottom of the vallecula and may cause obstruction by depressing the epiglottis. This complication is avoided by allowing the airway to ride loosely on the tongue.

Summary

Roentgenographic studies of upper respiratory obstruction during general anesthesia have defined several limitations of standard oro-

pharyngeal airways. Improved results have been obtained with a vallecular extension that supports the base of the tongue and opens the entrance of the larynx by indirectly raising the epiglottis.

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REFERENCES

1. Hewitt, F. W.: Artificial Airway for use During Anaesthetisation, Lancet **2**: 490, 1908.
2. Lumbard, J. E.: Controller of Tongue and Palate During General Anesthesia, J. A. M. A. **64**: 1757, 1915.
3. Guedel, A. E.: Nontraumatic Pharyngeal Airway, J. A. M. A. **100**: 1862 (June 10) 1933.
4. Macintosh, R. R.: New Laryngoscope, Lancet **1**: 205 (Feb. 13) 1943.
5. Gillespie, N. A.: Endotracheal Anesthesia, ed. 2. Madison, Wisconsin, University of Wisconsin Press, 1948, p. 86.
6. Fink, B. R.: Mechanism of Closure of Human Larynx, Tr. Am. Acad. Ophth. **60**: 117 (Jan.–Feb.) 1956.