# INFLUENCE OF THE HEAD-JAW POSITION UPON UPPER AIRWAY PATENCY

Sadao Morikawa, M.D., Peter Safar, M.D., John DeCarlo, M.D.

PHARYNGEAL obstruction in the unconscious patient from a sagging tongue is well known to anesthesiologists.[1,2] The role such obstruction may play in field resuscitation has been demonstrated.[3,4,5] Maximal backward tilt of the head has been found to be the single most important maneuver in resuscitation of curarized [3,4,5] and noncurarized [6] subjects. Roentgenograms have indicated that the degree of stretch of the anterior neck structures between larynx and chin determines the degree of separation of the base of the tongue and epiglottis from the posterior pharyngeal wall.[6] Furthermore, gravity, i.e., supine versus prone position, has been shown to have little influence on pharyngeal obstruction caused by the tongue, when the positions of the head and mandible were comparable.[6,7]

The present roentgenographic study was undertaken to evaluate the following questions: (1) Which maneuver provides greater pharyngeal patency: (a) forward displacement of the mandible with the head in the mid-position, or (b) maximal backward tilt of the head without forward displacement of the mandible? While a combination of the two maneuvers has been shown to provide the highest incidence of airway patency [6] a comparison of the two techniques is lacking. (2) Which provides a better airway with maximal backward tilt of the head: (a) elevation of the occiput; or (b) lowering the occiput by elevating the shoulders? While the first has been recommended for laryngoscopy,[8] the latter has been recommended for field resuscitation since it facilitates maintenance of the head tilt.[9]

## METHODS

Lateral roentgenograms of the pharynx were obtained in 10 adults who were lying

supine on an operating table, in the following 7 positions (table 1 and fig. 1):

(1) *Control-Conscious.* Head in the *mid-position*, face upward, with mouth closed; the plane of the upper teeth was maintained perpendicular to the table.

(2) to (7) *Anesthetized and Curarized.*

(2) Head in the *mid-position* with *mouth closed* by manual chin support (same as position 1).

(3) Head *tilted* backward maximally; the *mouth opened* automatically since there was no chin support.

(4) Head *tilted* backward maximally with *mouth closed* by manual chin support.

(5) Head *tilted* backward maximally with *mouth closed* by manual chin support; *occiput lowered* by elevating shoulders with a 3 inch pad.

(6) Head *tilted* backward maximally with *mouth closed* by manual chin support; *occiput elevated* by a 3 inch pad.

(7) Head in the *mid-position* with *mandible displaced forward* by grasping chin, with a thumb inserted between the teeth, simulating the Esmarch-Heiberg maneuver. An attempt was made to open the mouth as little as possible. The original Esmarch-Heiberg maneuver,[1,2] holding the mandible at its angles, would have obscured the pharynx.

Age, weight, height and sex are listed in table 1. All patients were scheduled for minor surgery and were generally healthy. Each was given an intramuscular injection of atropine or scopolamine (0.5 mg.) plus pentobarbital (100 mg.) or meperidine (50–100 mg.). Forty-five to 90 minutes following premedication, with the patient conscious, the film of control position 1 was obtained. Then anesthesia was induced with thiopental and maintained with $N_2O$-$O_2$-halothane. Succinylcholine was injected as needed to maintain muscular relaxation. During apnea and relaxation and in the absence of surgical stimuli the films of positions 2 through 7 were obtained. The lungs were ventilated by bag and mask between exposures,

## TABLE 1

### (A) HYPOPHARYNX. SMALLEST CLEARANCE BETWEEN TONGUE AND POSTERIOR PHARYNGEAL WALL (MILLIMETERS)

| Position | | | | Conscious Control | | Anesthetized Curarized | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Head* | | | | (1) Midposition Level | (2) Midposition Level | (3) Tilt Level | (4) Tilt Level | (5) Tilt Occiput Lowered | (6) Tilt Occiput Elevated | (7) Midposition Level |
| Surface | | | | | | | | | | |
| Mouth | | | | Closed | Closed | Open | Closed | Closed | Closed | Open, Mandible Displaced Forward** |
| **Patient** | | | | | | | | | | |
| Race Sex | Age yrs. | Wt. lbs. | Ht. in. | | | | | | | |
| 1. CF | 35 | 116 | -- | 8.0 | 4.5 | 12.0 | 17.5 | ? | 15.5 | 10.0 |
| 2. WF | 53 | 150 | 64 | 4.5 | 0 | 2.0 | 5.0 | 8.0 | 5.5 | 0 |
| 3. CF | 25 | 119 | -- | 14.0 | 7.5 | 14.5 | 18.0 | 19.5 | 19.5 | 0 |
| 4. CF | 28 | 122 | 61 | 9.0 | 0 | 13.5 | 18.5 | 11.5 | 17.0 | 3.5 |
| 5. CF | 24 | 158 | 68 | 14.0 | (17.5)† | 20.5 | 25.0 | 22.5 | 23.0 | 20.0 |
| 6. CF | 24 | 132 | 67 | 8.5 | 8.0 | 14.0 | 20.0 | 17.5 | 20.0 | 19.0 |
| 7. CF | 28 | 240 | 67 | 14.0 | 9.0 | 11.0 | 17.0 | 18.0 | 15.0 | (18.0)† |
| 8. WM | 57 | 155 | 67 | 7.5 | 0 | 3.0 | 11.0 | 11.0 | 16.0 | 9.0 |
| 9. WM | 20 | 145 | 70 | 11.5 | 6.0 | 10.5 | 22.0 | 16.5 | 21.0 | 0 |
| 10. CM | 19 | 155 | 71 | 14.0 | 10.5 | 10.0 | 21.5 | 24.5 | ? | 18.0 |
| Average | | | | 10.5 | 5.0 | 11.1 | 17.5 | 16.5 | 16.9 | 8.8 |
| (Range) | | | | (4.5–14.0) | (0–10.5) | (2.0–20.5) | (5.0–25.0) | (8.0–24.5) | (5.5–23.0) | (0–20.0) |

### (B) HYPOPHARYNX. SMALLEST CLEARANCE BETWEEN EPIGLOTTIS AND POSTERIOR PHARYNGEAL WALL (MILLIMETERS)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. CF | 35 | 116 | -- | 6.0 | 0 | 16.0 | 23.0 | ? | 20.5 | 0 |
| 2. WF | 53 | 150 | 64 | 0 | 0 | 1.5 | 9.5 | 11.5 | 10.0 | 0 |
| 3. CF | 25 | 119 | -- | 9.0 | 5.0 | 10.5 | 18.0 | 18.0 | 19.5 | 0 |
| 4. CF | 28 | 122 | 61 | 5.0 | 0 | 14.0 | 23.0 | 10.5 | 21.0 | 0 |
| 5. CF | 24 | 158 | 68 | 10.0 | (11.0)† | 14.0 | 21.0 | 21.0 | 21.5 | 13.0 |
| 6. CF | 24 | 132 | 67 | 4.5 | 5.5 | 9.5 | 15.0 | 13.0 | 16.0 | 13.0 |
| 7. CF | 28 | 240 | 67 | 6.5 | 0 | 7.0 | 13.0 | 11.5 | 13.0 | (8)† |
| 8. WM | 57 | 155 | 67 | 5.0 | 0 | 5.5 | 16.0 | 16.0 | 24.0 | 15.5 |
| 9. WM | 20 | 145 | 70 | 3.0 | 2.0 | 3.5 | 16.5 | 13.5 | 13.0 | 0 |
| 10. CM | 19 | 155 | 71 | 5.5 | 5.0 | 7.5 | 13.5 | 16.0 | ? | 8.0 |
| Average | | | | 5.4 | 1.9 | 8.9 | 16.8 | 14.5 | 17.6 | 5.5 |
| (Range) | | | | (0–10.0) | (0–5.5) | (1.5–16.0) | (9.5–23.0) | (10.5–21.0) | (10.0–24.0) | (0–15.5) |

### (C) NASOPHARYNX. SMALLEST CLEARANCE BETWEEN SOFT PALATE AND POSTERIOR PHARYNGEAL WALL (MILLIMETERS)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. CF | 35 | 116 | -- | 0 | 0 | 5.0 | 5.0 | ? | 7.0 | 0 |
| 2. WF | 53 | 150 | 64 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3. CF | 25 | 119 | -- | 7.0 | 4.5 | 6.5 | 6.5 | 6.0 | 6.0 | 0 |
| 4. CF | 28 | 122 | 61 | 5.0 | 0 | 6.5 | 8.0 | 7.0 | 9.0 | 8.0 |
| 5. CF | 24 | 158 | 68 | 6.0 | (9.0)† | ? | 10.0 | 10.0 | ? | 8.0 |
| 6. CF | 24 | 132 | 67 | 9.5 | 9.0 | 7.0 | 9.0 | 9.0 | 10.0 | 11.0 |
| 7. CF | 28 | 240 | 67 | 9.0 | 0 | 3.0 | 6.0 | 6.5 | 7.0 | (11.5)† |
| 8. WM | 57 | 155 | 67 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9. WM | 20 | 145 | 70 | 5.0 | 3.0 | ? | 5.0 | 7.0 | 7.0 | 0 |
| 10. CM | 19 | 155 | 71 | 10.0 | 6.0 | 6.5 | 8.0 | 9.5 | ? | 9.5 |
| Average | | | | 5.1 | 2.5 | 4.3 | 5.7 | 6.1 | 5.7 | 4.2 |
| (Range) | | | | (0–10.0) | (0–9.0) | (0–7.0) | (0–10.0) | (0–10.0) | (0–10.0) | (0–11.0) |

\* Tilt: maximal backward tilt of head.
\*\* Simulated Esmarch-Heiberg maneuver.[1]
† Some backward tilt of head by mistake; not included in average.
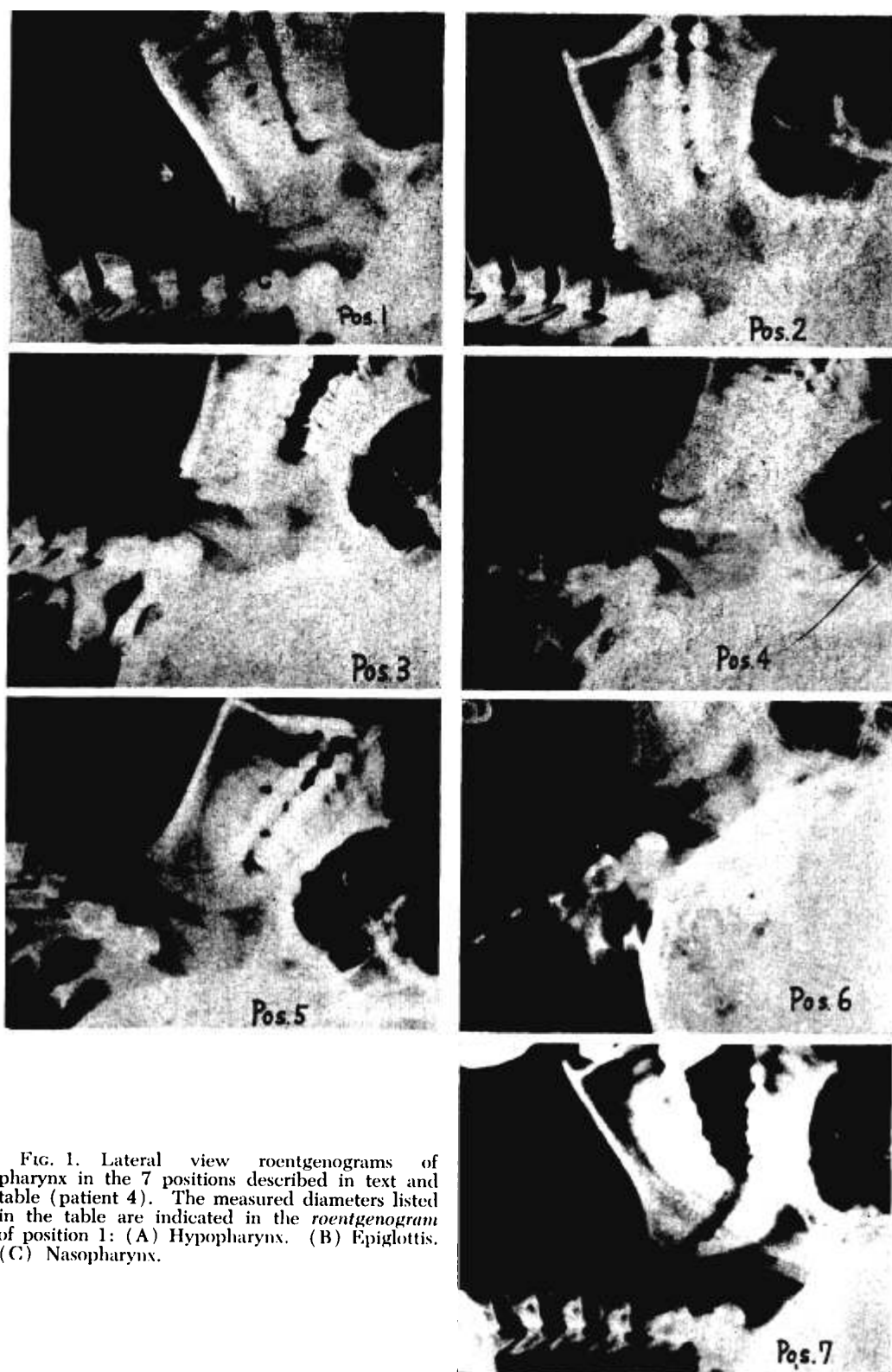? Roentgenogram unsatisfactory for measurement.

FIG. 1. Lateral view roentgenograms of pharynx in the 7 positions described in text and table (patient 4). The measured diameters listed in the table are indicated in the *roentgenogram* of position 1: (A) Hypopharynx. (B) Epiglottis. (C) Nasopharynx.

The divergent nature of a roentgen-ray beam results in some distortion due to magnification and thus actual measurements of anatomical structures are not possible with usual radiographic techniques. Roentgen tube-film distance and anatomical part-film distance vary the degrees of distortion. They were kept constant in this study by making all films of each patient under identical conditions. This was confirmed by measurements of the fourth cervical vertebral bodies, which did not vary from film to film. The measurements herein reported therefore reflect accurately relative airway changes in each patient, but do not represent actual anatomical measurements.

## RESULTS

A series of 7 representative films from one subject is shown in figure 1. Listed in table 1 are the smallest antero-posterior diameters at the level of the hypopharynx (fig. 1, A), at the level of the epiglottis (fig. 1, B), and at the level of the nasopharynx (fig. 1, C).

The *hypopharyngeal diameter at the base of the tongue* in control position 1 varied between 4.5 and 14.0 mm. (table 1A). Curarization without changing the head position reduced this diameter in all patients and produced complete obstruction in 3 patients.

Backward tilt of the head in all curarized patients increased the diameter over that of the mid-position (position 2). With the head-tilt and the mouth opened (position 3) in only 5 of 10 patients was the hypopharynx wider than in the control position. However, with the mouth closed (position 4) all patients had a wider hypopharynx than in the control position. With the head-tilt there was never complete obstruction, even when the chin was unsupported.

When in addition to the tilt the occiput was either elevated (position 5) or lowered (position 6), variations in the diameters were not statistically significant as compared to the level position 4. A comparison of elevation and lowering of the occiput likewise showed statistically insignificant changes.

The airway in position 2 was improved in only 5 of 8 patients by forward displacement of the mandible without head-tilt (position 7). The failure to relieve obstruction in 2 patients may have been due to excessive opening of the mouth. Head-tilt alone always provided a wider hypopharynx than forward displacement of the mandible without head-tilt.

The smallest *diameter between the epiglottis and the posterior pharyngeal wall* was zero in several patients when the head was in the mid-position, but never when the head was tilted backward (table 1B).

The *nasopharynx* appeared obstructed both with a patent and nonpatent hypopharynx, and with or without clinical evidences of airway obstruction (table 1C). The soft palate or uvula touched the posterior pharyngeal wall in 4 of 10 patients in the control position, in 5 of 10 curarized patients when the head was in the mid-position 2, and in 2 of 10 curarized patients when the head was tilted backward (position 3).

## DISCUSSION AND CONCLUSIONS

The roentgenologic diameter of the hypopharynx at the base of the tongue (fig. 1, A) reflects airway patency more than the other diameters measured, since there was always clincal airway obstruction when the base of the tongue touched the posterior pharyngeal wall. However, there was not always clinical airway obstruction when the other diameters (fig. 1, B and C) were zero. This might be explained by the possibility that air flows around the sides of the epiglottis when the tip of the epiglottis touches the pharyngeal wall, or that air can pass through the oropharynx when the soft palate touches the posterior pharyngeal wall. The roentgenographic sagittal diameter of the nasopharynx may indicate more truly the degree of airway patency than does the roentgenographic sagittal diameter of the oropharynx (between tongue and soft palate), since the convexity of the palate may obscure an open oropharyngeal air passage.

Flexion of the neck caused complete airway obstruction in all 80 patients previously studied.[6] Previous roentgenographic observations [6, 7, 10] and spirometry and clinical observations [3, 6, 11] pointed out the importance of the head-tilt, as it makes the tongue move forward by stretching the anterior structures

of the neck between larynx and chin. This stretch with head-tilt is further increased by closure of the mouth, as shown by Fink[12] and Ruben[10] and confirmed by this study. The stretch is even further increased by forward displacement of the mandible.[6]

The advantage gained by mouth closure may be offset by simultaneously approximating the lips in a patient with obstructed nasal passages. Attempts at inflating the lungs of apneic patients through the nasal air passage (mouth closed), even with maximal backward tilt of the head, met complete expiratory obstruction without inspiratory obstruction in 7 of 68 patients studied (S. Morikawa, unpublished data). The functional residual capacity increased until the lungs could no longer be ventilated unless the mouth was opened for exhalation. This has been attributed to a valve-like behavior of the soft palate.[13] Occasionally, we also observed valve-like expiratory obstruction when using the oral air passage. This seemed to be due to the sagging tongue, since it could be corrected by forward displacement of the mandible, increased head-tilt and insertion of an artificial oral airway.

Maximal head-tilt with the mouth closed did not prevent complete airway obstruction in 4 of 80 patients or partial obstruction in 37 of 80 patients.[6] This obstruction may have been due to sagging of the tongue in spite of the head-tilt or to approximation of the lips in the presence of nasal obstruction. Three of the 4 complete obstructions were relieved by adding forward displacement of the mandible to the head-tilt; the fourth required in addition insertion of a Guedel type airway.

In the present study the head-tilt always produced a better pharyngeal air passage than forward displacement of the mandible without head-tilt.

Laryngoscopy and tracheal intubation is facilitated by elevation of the occiput, since it brings the laryngoscope and trachea into one line (fig. 2). This was shown by Bannister and Macbeth in 1944.[14] Elevation of the occiput, however, did not improve pharyngeal patency over that of the level position 4, provided the head was tilted backward in both. Lowering of the occiput by elevation
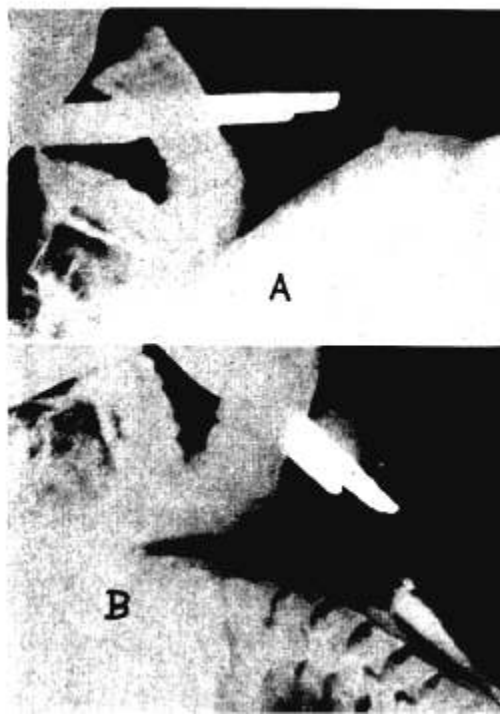


FIG. 2. Lateral view roentgenograms of pharynx during direct laryngoscopy. (A) Occiput lowered. Angle between laryngoscope blade and trachea. (B) Occiput elevated. Laryngoscope blade and trachea in line.

of the shoulders likewise did not increase or decrease significantly the pharyngeal air passage. This study indicates that head-tilt is more important than raising or lowering of the occiput. Since raising the occiput makes maintenance of the tilt more difficult than lowering of the occiput, the latter maneuver should be taught for field resuscitation of unconscious and nonintubated patients.

In view of the variety of airway obstruction problems in comatose patients, the teaching of concepts rather than a single maneuver should be stressed. No single maneuver can provide airway patency under all circumstances. Therefore, personnel often faced with the resuscitation of unconscious patients should be taught first and foremost to tilt the patient's head maximally backward. In addition, such personnel should learn to *diagnose* partial and complete airway obstruction, both in apneic and spontaneously breathing subjects and to add to the head-tilt—if necessary—one or more of the follow-

ing maneuvers: forward displacement of the mandible, separation of the lips, forcing the mouth open for clearing of the pharynx and insertion of an artificial oropharyngeal airway.

## SUMMARY

Roentgenograms of the pharyngeal air passages were obtained in 10 conscious and subsequently anesthetized and paralyzed adults to determine airway patency.

(1) The smallest antero-posterior diameter of the hypopharynx measured in the conscious person with the head in the mid-position ranged between 4.5 and 14 mm.

(2) Anesthesia and curarization led to a decrease in the hypopharyngeal diameter of all patients when the head remained in the mid-position.

(3) Maximal backward tilt of the head increased the diameter in all instances, more so when the mouth was closed by chin support.

(4) Maximal backward tilt of the head increased the hypopharyngeal diameter more than forward displacement of the mandible without head-tilt.

(5) With head-tilt neither elevation nor lowering of the occiput changed the hypopharyngeal diameter significantly.

(6) The diameter of the hypopharynx at the epiglottis and the nasopharyngeal diameter were also measured but found to be of less importance.

(7) Prevention of upper airway soft tissue obstruction depends on the stretch of the anterior neck structures between larynx and chin. Stretch is produced by head-tilt or by forward displacement of the mandible or by closure of the mouth. The head-tilt produces the greatest stretch. All 3 maneuvers produce maximal stretch.

## REFERENCES

1. Esmarch, J. F.: The Surgeon's Handbook on the Treatment of Wounded in War, New York, Schmidt, 1878, p. 113.
2. Heiberg, J.: A New Expedient in Administering Chloroform, Medical Times and Gazette, (January 10) 1874, (Abstract from Zbl. Chir. **9**: 141, 1874).
3. Safar, P., Escarraga, L. A., and Elam, J. O.: Comparison of mouth-to-mouth and mouth-to-airway method of artificial respiration with chest-pressure arm-lift methods, N. Engl. J. Med. **258**: 671, 1958.
4. Safar, P.: Ventilatory efficacy of mouth-to-mouth artificial respiration. Airway obstruction during manual and mouth-to-mouth artificial respiration, J. A. M. A. **166**: 335, 1958.
5. Safar, P.: Failure of manual respiration, J. Appl. Physiol. **14**: 84, 1959.
6. Safar, P., Escarraga, L. A., and Chang, F.: Upper airway obstruction in unconscious patient, J. Appl. Physiol. **14**: 760, 1959.
7. Asmussen, E., Hahn-Petersen, A., and Rosendal, T.: Air passage through the hypopharynx in unconscious patients in prone position, Acta Anesth. Scand. **3**: 123, 1959.
8. Jackson, C.: Bronchoscopy, Oesophagoscopy and Gastroscopy, ed. 3. Philadelphia, W. B. Saunders, 1934, pp. 85–91.
9. Safar, P., and McMahon, M.: Resuscitation of the Unconscious Victim. A Manual for Rescue Breathing. Springfield, Illinois, Charles C Thomas, Publisher, 1959.
10. Ruben, H.: Air passage through pharynx of anesthetized patient as influenced by head and jaw position, Second World Congress of Anesthesiologists, Toronto, September, 1960.
11. Elam, J. O., and others: Head-tilt method of oral resuscitation, J. A. M. A. **172**: 812, 1960.
12. Fink, B. R.: Roentgenographic studies of oropharyngeal airway, ANESTHESIOLOGY **18**: 711, 1957.
13. Safar, P., and Redding, J.: "Tight jaw" in resuscitation, ANESTHESIOLOGY **20**: 701, 1959.
14. Bannister, F. B.:, and Macbeth, R. G.: Direct laryngoscopy and tracheal intubation, Lancet **2**: 247, 1944.