PARALYSIS OF DEGLUTITION – SURGICAL CORRECTION

HOWARD C. NAFFZIGER, M.D., COOPER DAVIS, M.D.,
and H. GLENN BELL, M.D.

SAN FRANCISCO, CALIF.

FROM THE DIVISION OF NEUROLOGICAL SURGERY AND THE DIVISION OF SURGERY,
UNIVERSITY OF CALIFORNIA MEDICAL SCHOOL, SAN FRANCISCO

THIS PRESENTATION HAS TO do with reconstructive work necessary to restore the power of swallowing in a patient who has sustained extensive cranial nerve injuries. In 1864, Hughlings Jackson [1] called attention to the homolateral paralytic association of larynx, soft palate, tongue and muscles of the neck, particularly the sternomastoid and trapezius. In 1891, Avellis [2] wrote on palate laryngeal hemiplegia, a syndrome which sometimes bears his name. Since then additional articles by Schmidt,[3] Tapia,[4] Broeckaert,[5] have stressed certain features resulting from involvement of the last cranial nerves.

Particularly Vernet [6] and Collet [7] in 1915 have written on the syndrome of the jugular foramen characterized by involvement of the last three or four cranial nerves. In 1917 Villaret [8] used his term, "the syndrome of the retroparotid space," and included lesions of the sympathetic together with the last four cranial nerves. From World War I similar injuries have been reported.

CASE HISTORY

The patient, a white male 43 years of age, presented himself with the complaint of an inability to swallow dating from the time of a gunshot wound three years before. The wound of entrance of a 38 calibre bullet was alongside of the left ala of the nose and from there the bullet had passed directly back to a position just beneath the scalp, 1 cm. to the left of the external occipital protuberance (Fig. 1). In its course the mandible on the left had been fractured. Tremendous hemorrhage was presumably due to division of the internal jugular vein, and he required several transfusions. A long period of infection about the jaw ensued and union was considerably delayed; some months were required before healing was complete. The bullet had injured and caused a paralysis of several nerves (Fig. 2). The anterior two-thirds of the tongue on the left was anesthetic from injury of the lingual branch of the trigeminal. Farther posteriorly, near the jugular foramen, it had encountered and paralyzed the ninth, tenth, eleventh and twelfth cranial nerves. As a result of the paralysis of the twelfth nerve, the left half of the tongue, in addition to being anesthetic, was atrophic. By reason of paralysis of the tenth nerve, the palatal movement on the left was absent and the left vocal cord was paralyzed so that his voice was hoarse, and the upper, middle, and inferior pharyngeal constrictors were paralyzed. With paralysis of the eleventh nerve, the supply to the left sternomastoid and trapezius was affected. The damage to the ninth nerve was responsible for anesthesia of the soft palate, nasopharynx and pharynx on the left. The stylopharyngeus muscle, which is the only muscle supplied by that nerve, was paralyzed.

Since the time of the injury the patient had been unable to swallow. He had learned to adjust himself and had become fairly well adapted to this, maintaining a

* Read before the American Surgical Association, May 29, 1948, Quebec, Canada.

fair state of nutrition with a liquid diet and regular use of a stomach tube. His most serious complaint was of strangling from excessive salivation. Since he was unable to swallow the saliva, it passed frequently into his larynx. This caused terrific explosions of coughing and vomiting, with regurgitation of the material into the nasopharynx and through his nose. Even with continued use of such drugs as atropine to lessen the amount of secretion, travel in public conveyances was almost prohibited because of the frequency and severity of these attacks. The patient was on the point of suicide.

It was apparent at once that numerous factors contributed to his disability. In the act of swallowing, the tongue rises and presses upward and backward; the soft palate closes off the nasopharynx, the larynx rises and its opening is covered by the epiglottis as the material passes into the upper portion of the esophagus. During and after World War I, occasional reports

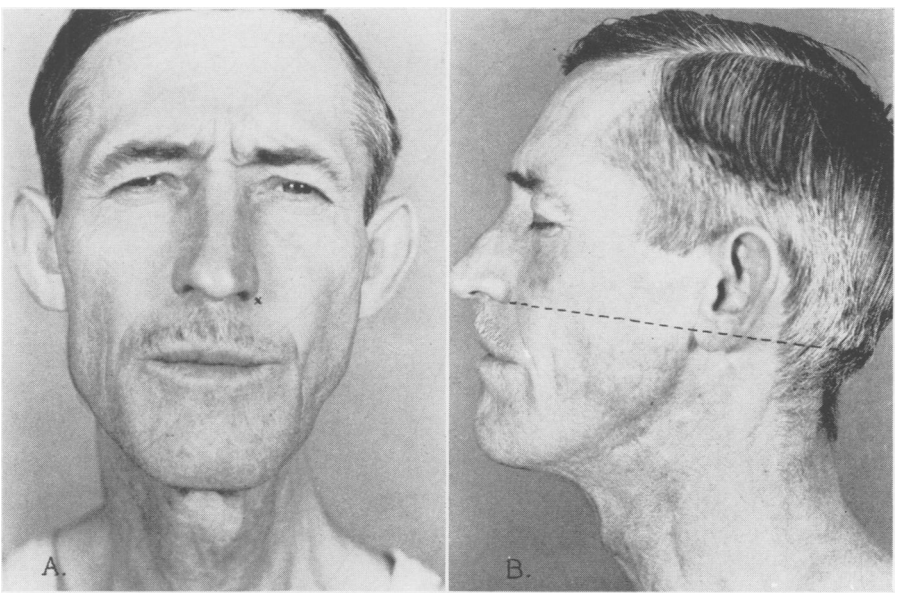

FIG. 1.—Showing course of bullet.

describing extracranial paralysis of the last four cranial nerves from bullet wounds appeared in the literature. We have been unable to find evidence of any surgical treatment which corrected such an inability to swallow.

Beginning with Majendi's work in 1813,[9] various theories of deglutition have been advocated. Majendi believed that ingested materials were forced from the mouth into the stomach by means of peristaltic-like muscular contractions of each area through which the bolus passed and that in effect the muscles of the mouth, pharynx and esophagus were active agents in propelling the food onward. He considered there were three stages: (a) a voluntary stage during which the mylohyoid and longitudinal lingual muscles contracted and enabled the tongue to propel the bolus past the fruces; (b) an involuntary, almost convulsive contraction of the pharyngeal constrictors

during laryngeal elevation which forced the material into the upper end of the esophagus and finally, (c) a slower, involuntary stage during which the bolus was driven along into the stomach by the esophageal circular fibers. In 1880 Kronecker and Falk [10] suggested that fluids and semifluids were projected by contraction of the muscles of the mouth (the mylohyoids) before the contraction of the pharyngeal and esophageal musculature occurred, and that this occurred later after the bulk of the bolus had passed and served to sweep along the remaining particles. Kronecker reported that

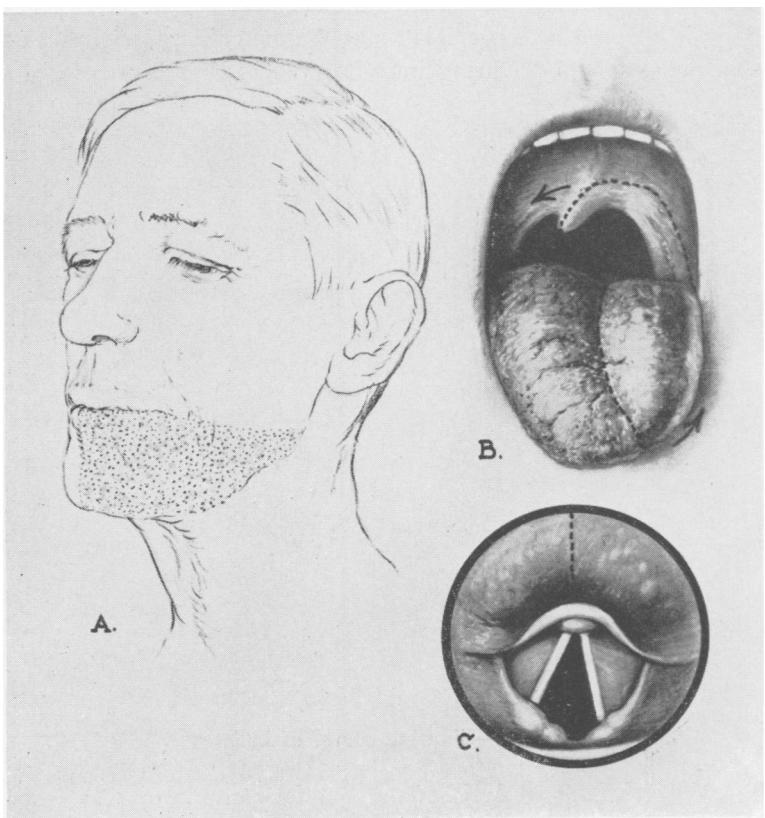

FIG. 2.—A. Dotted area of altered sensation from injury to inferior dental nerve and cervical branches. B. Atrophy of left half of tongue (twelfth nerve injury); deviation of uvula (tenth nerve); outline of anesthesia (ninth nerve). C. Adducted position of vocal cord (tenth nerve).

at the beginning of deglutition there was a rapid rise of manometric pressure, to 20 cm. of water, in the posterior mouth, pharynx and upper esophagus. By means of balloons in the pharynx and esophagus, they recorded the passage of the peristaltic wave some time after the descent of the ingested liquids.

Cannon,[11] in 1898 and 1900, showed that the act of swallowing varied

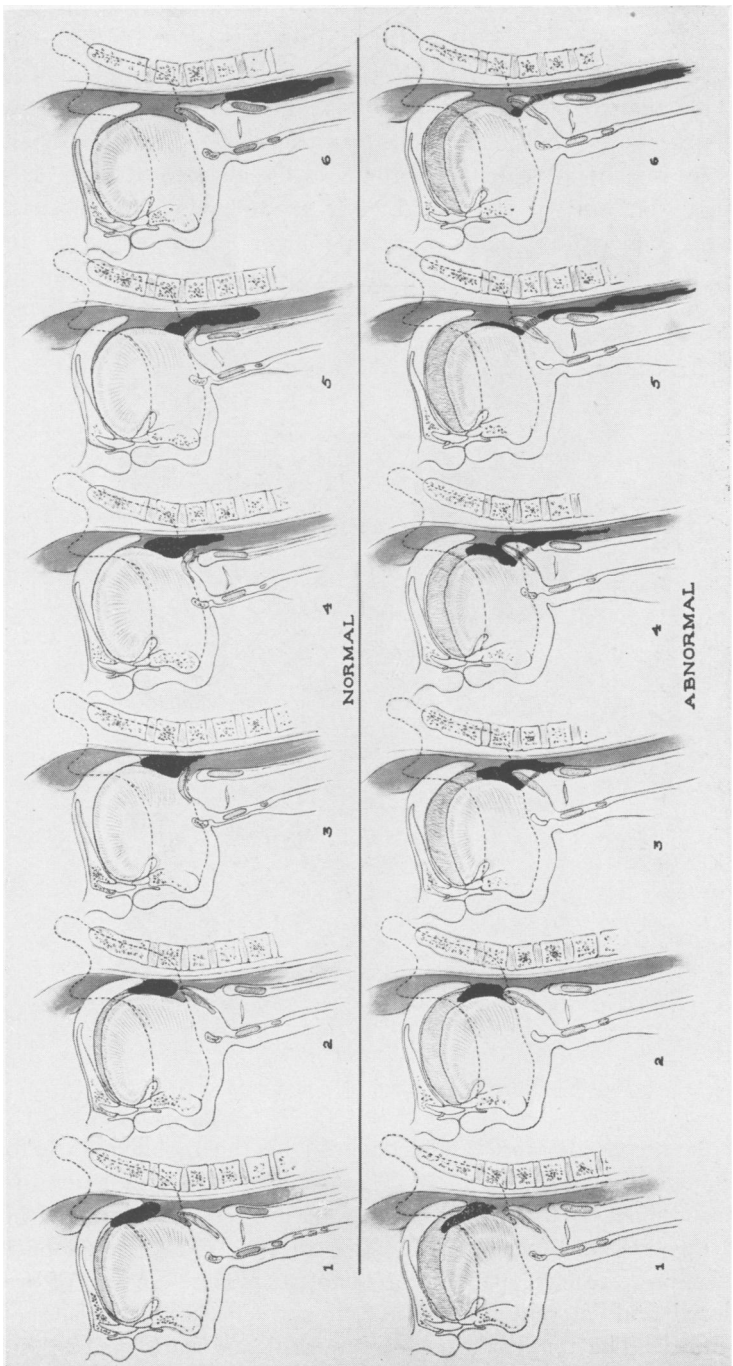

FIG. 3. NORMAL.—1 and 2. Bolus pressed against the soft palate occluding nasopharynx. 3 and 4. Tongue pressing up and back; larynx ascends; epiglottis occludes laryngeal opening as bolus passes; 4 and 5. Bolus passing into esophagus. 6. Larynx descended, epiglottis upright, bolus in esophagus. ABNORMAL.—1 and 2. One half of tongue atrophied; nasopharynx not closed off by palate. 3 and 4. Oral cavity and nasopharynx not closed by tongue; larynx has ascended only partially; epiglottis remains upright. Bolus has passed into valeculae and pyriform sinus. 5 and 6. Bolus gradually trickles into esophagus.

with different vertebrates and with different consistencies of the ingested material. By means of roentgen-ray studies, he came to the conclusion in agreement with Kronecker and Meltzer, that in the human fluids were shot directly down to the cardia, mainly by the action of the mylohyoids and not by peristalsis, but that the swallowing of solids and semisolids was a slower peristaltic-like process. Deglutition in fowls was relatively slow and peristaltic and there was no mylohyoid squirting action. In the absence of such action a greater reliance on gravity was noted. For example, in dogs when the mylohyoids were denervated, fluids were no longer rapidly squirted into the esophagus, but it was necessary for the animal to raise its head and swallow, after the manner of a bird. In the horse and in man, it has also

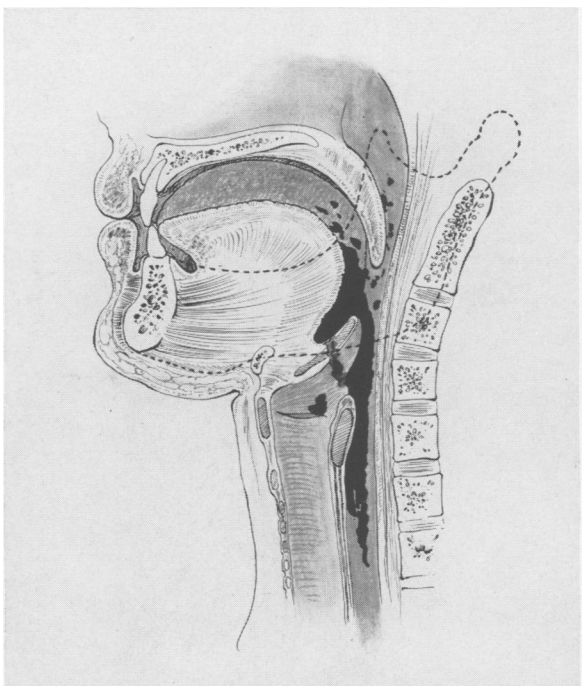

FIG. 4.—Barium scattered by coughing.

been noted that only fluids were squirted ahead by the mylohyoids before the peristaltic action occurs. Cannon described human swallowing of a solid bolus thus: When the food is sufficiently masticated, it is gathered in a depression on the dorsum of the tongue. The tip and lateral aspects of the tongue press against the hard palate and teeth, to prevent escape of food particles forward and laterally to the mouth and cheeks. Respiration is reflexly suspended. The tongue is pressed upward and backward by contraction of the mylohyoid and hyoglossus respectively (Fig. 3 Normal). The tongue, thus acting as a piston, drives the bolus first against the downward

sloping soft palate, next against the posterior pharyngeal wall, then on between this pharyngeal wall and the posterior surface of the upright epiglottis, the tip of which lies in contact with the base of the tongue. During this phase the action of the palato-pharyngeus muscles has thrown the pharynx into a narrow cleft and against this opening the soft palate is pulled by contraction of the levator palati, thus blocking entrance of the bolus into the nasal chambers. Thus far the esophageal opening has remained closed mainly by pressure of the larynx against it. With the rise of the hyoid and larynx, the esophagus opens. The epiglottis is pressed back until it shuts the laryngeal aperture. Then presumably the tip of the epiglottis

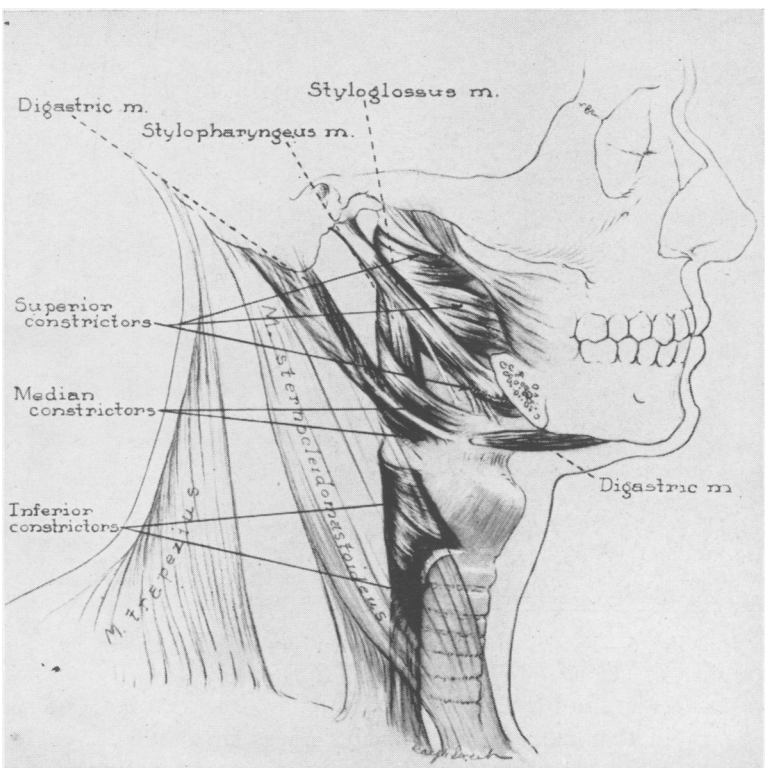

FIG. 5.—Final attachment of the posterior belly of the digastric in the human.

slips downward along the posterior pharyngeal wall, "pushing the bolus probably with a final quick impulse into the gullet." Whether or not the action of the epiglottis is a factor in pushing the bolus is a point that was disputed as far back as 1892 by Stuart.[12] Mosher,[13] in 1927, published studies from which he concluded that the epiglottis acts as a cover for the larynx during swallowing.

Fluoroscopic studies of our patient by Dr. Earl Miller demonstrated that the paralyzed pharyngeal constrictors bulged outward during the swallowing

effort and that barium accumulated and remained in the valleculae of each side of the base of the epiglottis. It was also apparent that the epiglottis remained upright and did not pass into a horizontal position to occlude the laryngeal opening. The barium trickled down from the valleculae on each side into the pyriform sinuses and occasionally small flecks passed into the larynx. Explosive efforts at coughing followed and observation after this showed flecks of the material scattered throughout the pharynx and in the

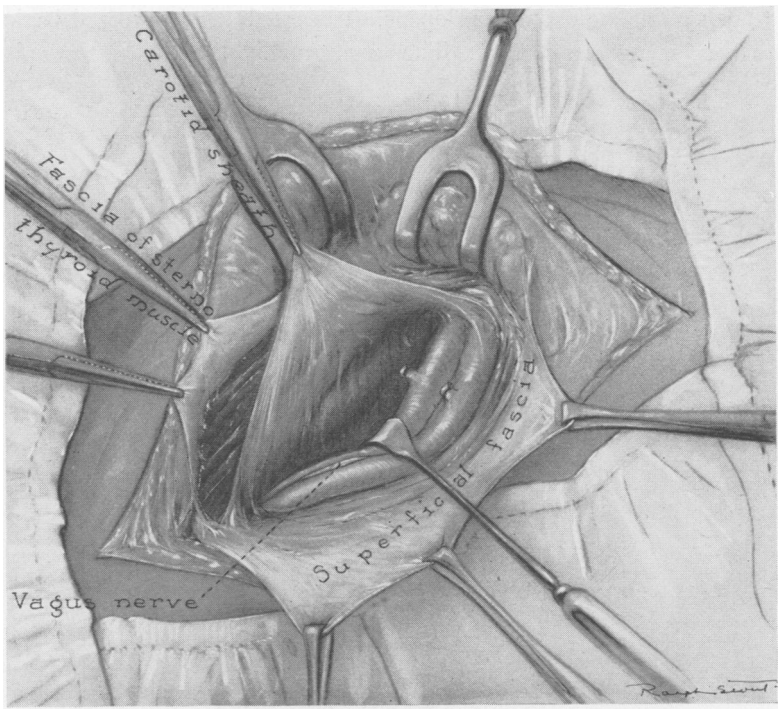

FIG. 6.—Fascial support of the lateral wall of the pharynx.

avrious pockets and in the nasopharynx (Fig. 4). The entire act of swallowing is so rapid that more detailed analysis was impossible. We found it necessary to secure more data on the normal act of swallowing before a satisfactory analysis could be made of the difficulties of our particular patient.

We were able to obtain the use of a fluoroscope synchronized with moving picture apparatus so that with this cine fluoroscope radiograms of deglutition could be taken at the rate of 60 to the second. Such studies were obtained of a normal individual and then upon our patient. It was possible then to study the motions of swallowing at intervals of one-sixtieth of a second and to compare the abnormal function with the normal (Fig. 3 Abnormal). It became evident that at least one important factor was that which prevented the epiglottis from assuming a horizontal position and closing the larynx during the act of swallowing. Although the larynx would rise during the

act of swallowing, its upward excursion was less than normal. The stylopharyngeus muscle, which is the only one supplied by the ninth nerve, passes down from the styloid process and inserts in the region of the larynx between the superior and middle pharyngeal constrictors. Its action in drawing the larynx upward had been lost through its paralysis. Other contributing factors were the bulging of the paralyzed pharyngeal constrictors on that

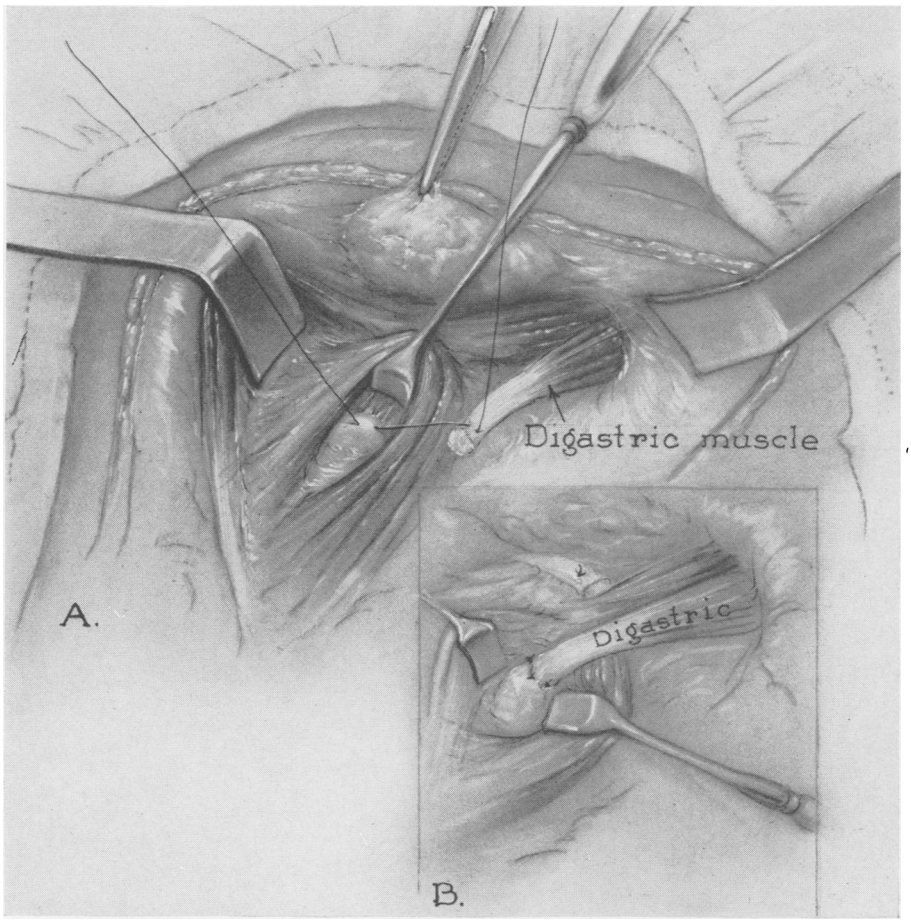

FIG. 7.—Digastric divided at the sling. Posterior belly sutured to laryngeal cartilage.

side and atrophy of the tongue. The pressure of the tongue on the epiglottis, which carries it down to a horizontal position, was impaired.

It seemed desirable, then, to reproduce the neurologic lesion in experimental animals and endeavor to find a solution for the difficulty. The anatomic arrangement in the dog was not suitable, but the macaque was found to be an appropriate animal. A similar lesion was produced by paralysis of the ninth, tenth, eleventh and twelfth nerves. Following this, the animal retained food in its mouth for 12 hours and was unable to

swallow. To prevent the lateral bulging of the pharynx, a fascial sling was devised which was attached to the prevertebral fascia posteriorly, then brought around the lateral pharyngeal wall and attached to the midline of the laryngeal and neighboring cartilages. In order to aid the upward movement of the larynx during swallowing, the posterior belly of the diagastric, which is innervated by the seventh nerve, was attached to the larynx to substitute for the paralyzed stylopharyngeus (Fig. 5). This was done in the animal and was followed by restoration of the ability to swallow. The

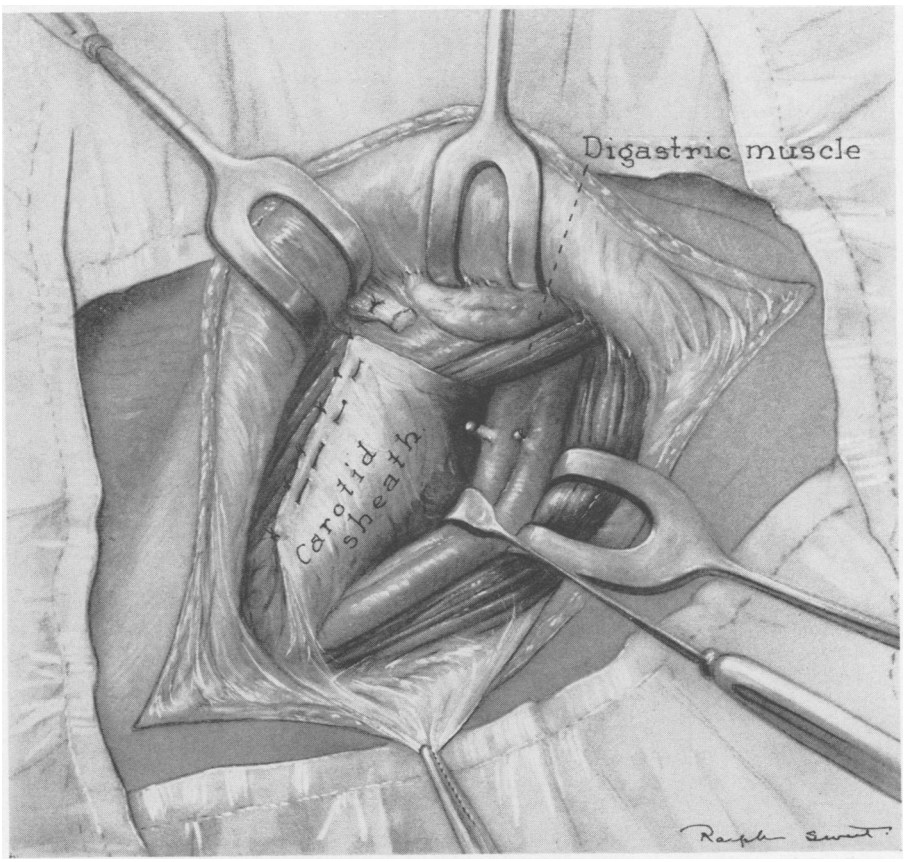

FIG. 8.—Carotid sheath reflected and sutured to midline to support the pharyngeal wall.

procedure was then planned for the human patient. (The seventh nerve was unimpaired.)

It was found that the use of a free fascial sling to wrap around the pharynx was not required, for by splitting the fascia of the neurovascular bundle from in front (Fig. 6) and dissecting away the mesial portion of it to its firm attachment to the prevertebral fascia, a free leaf was obtained which was then brought forward around the pharynx and fastened to the

midline of the larynx and cricoid. This gave firm support to that side of the pharynx. The posterior belly of the digastric was then cut loose from its junction with the anterior belly and firmly attached to the thyroid cartilage (Fig. 7) so that its contraction would cause ascent of the larynx. During the postoperative period the patient was taught to so grimace with the lower face that the digastric contracted at the instant of swallowing. By this maneuver, the larynx was elevated and the patient was trained to swallow. It has now been over two years since the operation and there has been no occasion to have recourse to the stomach tube. Swallowing is sufficiently satisfactory that the patient has been able to work in construction camps and partake of the more or less rough food which is available.

Advice, suggestions and help on the anatomic details and studies have been given freely by Professor Saunders of the Department of Anatomy. Research by the roentgen-ray studies has been carried out by Dr. Earl Miller.

REFERENCES

[1] Jackson, Hughlings: Loss of Speech, London Hospital Reports, 1:388-471, 1864.
[2] Avellis, G.: Klinische Beiträge zür halbseitigen Kehlkopflähmung, Berl. klinik **40**: 1-26, 1891.
[3] Schmidt, Moritz: Die Krankheiten der oberen Luftwege, *in* Praxis fur die Praxis, ed. 2, Berlin, J. Springer, 1897.
[4] Tapia, A. G.: Communication at the Congress of Lisbon, Arch, Internat. de Laryngol., 780, 1906.
[5] Broeckaert, J.: Étude de l'innervation vaso-motrice du larynx, Presse oto-laryngol. belge, **6**: 145-161, 1907.
[6] Vernet, M.: Sur le syndrome des quatres dernières paires crâniennes, d'après une observation personnelle chez un blessé de guerre, Bull. et mém. Soc. méd. d. hôp. de Paris **40**: 210-223, 1916.
[7] Collet, M.: Un nouveau type d'hémiplégie laryngée associée, Lyon Méd. **124**: 121-129, 1915.
[8] Villaret, M.: Le Syndrome de l'espace rétro-parotidien postérieur, Paris Méd. **23**: 430-431, 1917.
[9] Magendie, F.: Précis élémentaire de physiologie, Paris, Méquignon-Marvis, **2**: 58-67, 1816-1817.
[10] Kronecker, H. and F. Falk: Ueber den Mechanismus der Schluckbewegung, Arch. f. Physiol. (Leipz) 296-299, 1880.
[11] Cannon, W. B.: The Mechanical Factors of Digestion, London, E. Arnold, 11-31, 1911.
[12] Stuart, T. P. A.: On the mechanism of the closure of the larynx, Proc. Roy. Soc. Lond. **50**: 323-339, 1891-1892.
[13] Mosher, H. P.: X-ray study of movements of tongue, epiglottis and hyoid bone in swallowing, followed by discussion of difficulty in swallowing caused by retropharyngeal diverticulum, postcricoid webs and exostoses of cervical vertebrae, Laryngoscope **37**: 235-262, 1927.

DISCUSSION.—DR. MAX PEET, Ann Arbor: I was much intrigued with this paper when Dr. Naffziger kindly allowed me to read it in advance, because I could see applications for this procedure in cases other than the very rare gunshot wounds. Occasionally we have tumors in the posterior fossa which produce almost identical symptoms because of paralysis of the vagus and, in some cases, of the hypoglossal in addition.