UNILATERAL CONGENITAL LESION OF MEDULLA AND SPINAL CORD; DEATH FROM PONTINE HÆMORRHAGE.

BY PURVES STEWART, M.A., M.D., M.R.C.P.

Assistant Physician to the Westminster Hospital.

A HOT-POTATO hawker, aged 41, came to the out-patient department of the Westminster Hospital on account of chronic bronchitis, the urine being moderately albuminous and with a few granular casts. It was observed that he had marked asymmetry of the muscles of the neck. He was admitted as an in-patient, and on further investigation the following history was obtained :—

No information can be had about the patient's father. He himself is the fourth of six children. Before his birth his mother, during pregnancy, is stated to have had a severe fall in the street, but at what period of the pregnancy this occurred is not known. One sister, aged 40, is deaf and dumb, one brother is alive and well, three other sisters are dead, cause unknown. The patient as a child was slow in learning to talk, nor was he able to walk alone until 4 years of age. In the lower jaw on the right side he has never had any molar teeth, either of the first or second dentition. All the other teeth erupted normally. The right side of the neck has always been noticed to be peculiar in outline.

Many years ago he had gonorrhœa, and still possesses a urethral stricture. He has been subject to chronic bronchitis for many winters.

On examination he is found to be a man of only moderate intelligence. Speech and articulation are normal, but the voice is hoarse. Smell and taste are normal on both sides. Hearing is somewhat dull in both ears, especially on the right side. The right auditory meatus is narrower than the

left, and also higher up. There is no otorrhœa. The right pinna is much smaller than the left, its lobule being particularly diminutive. The right mastoid process is absent (see fig. 1).

The optic discs are healthy, vision is acute, the pupils are equal and normal in their reactions, and the external ocular muscles are normal. The masseter and temporal muscles are strong on both sides, but, on opening the jaw, it swings obliquely to the right, owing to deformity of the mandible, which is smaller on that side (see fig. 2). All the molar teeth of the right lower jaw are absent, the canines and incisors being present. The teeth of the left lower jaw and of both upper jaws are normal in number and in development.

The facial muscles, upper and lower, are normal on both sides, the platysmæ standing out strongly on bending the head forwards.

The right arch of the palate, at rest, stands nearer to the middle line than the left, and, on phonation, the left side moves alone, pulling the raphé upwards and to the left (see fig. 4).

The right sternomastoid is absent. So also is the *portio clavicularis* of the right trapezius. This latter muscle consists only of the middle portion, taking its origin from the seventh cervical to the fourth dorsal spine, inclusive, and being inserted into the acromion process and spine of the scapula. The lower third of the trapezius, below the fourth dorsal spine, is absent (see fig. 3).

The sensibility of the mouth, pharynx, and larynx is normal. The right vocal cord is immobile in the middle line; the left cord moves freely. The right omohyoid, stylohyoid, and posterior belly of digastric are absent. The right side of the tongue is smaller than the left (see fig. 2), and the tongue on protrusion points to the right side. (Part of this deviation is due to the obliquity of the floor of the mouth from deformity of the lower jaw.) The tongue can be moved freely in all directions. The right sternohyoid, sternothyroid and thyrohyoid muscles are absent. All of the above-mentioned muscles which are

Atlas

Lev. ang. scap.

Fig. 1.

Showing mal-development of right pinna. The bifurcation of the carotid is subcutaneous. The right mastoid process is absent. The bony projection behind the angle of the jaw is the transverse process of the atlas.

Lev. ang. scap.

Fig. 2.

Showing deformity of right pinna and right side of lower jaw; also moderate atrophy of right side of tongue. Note absence of right sternomastoid and upper fibres of right trapezius. The right levator anguli scapulae is subcutaneous.

Fig. 3.

Showing downward and outward displacement of right scapula. Note parallel congenital white lines on back of neck. Right levator anguli scapulae is subcutaneous. Right trapezius is absent above seventh cervical and below fourth dorsal spines.

Fig. 4.

Photograph of soft palate during phonation. Note also deformity of lower jaw and of right pinna.

clinically non-active, are also non-responsive to the strongest electric stimulation, faradic or galvanic. Both sides of the tongue react normally.

In connection with the absence of the right sternomastoid, it is observed that the mastoid process on that side is absent and the transverse process of the atlas is subcutaneous. There is thus a deep hollow behind the angle of the right mandible, where the carotid vessels are visible, the bifurcation into internal and external carotids being easily seen (see fig. 1).

The levator anguli scapulæ is subcutaneous on the right side (see fig. 3), so also is the scalenus medius (see fig. 1). The right scapula is displaced downwards and outwards, its inner border running obliquely from below upwards and outwards, thereby rendering the outward displacement of its acromial angle still more marked. There is a very slight backward projection of the lower angle at rest.

On the back of the neck, from the level of the scalp line to that of the lowest cervical spine, there are two parallel rows of white, flattened, papillomatous projections, congenital, one row on each side of the middle line (see fig. 3).

The rhomboid muscles, the latissimus dorsi and all the other muscles of the right upper limb, together with the diaphragm, the muscles of the trunk and of the remaining limbs, are normal. The gait is normal. There is no anæsthesia. The supinator-jerks, knee-jerks, and ankle-jerks are normal, and the plantar reflexes are flexor in type. The sphincters are perfect.

In spite of the absence of so many muscles on the right side of the neck, all movements of the head and neck are executed powerfully on both sides, and there is no deviation of the head at rest.

CLINICAL DIAGNOSIS.

The absence of the right sternomastoid and of part of the trapezius, together with the paralysis of the palate and vocal cord on the same side, pointed to a congenital lesion

of the spinal accessory and vagus nuclei on the right side. (This description of the spinal accessory nucleus is based on the modern nomenclature, maintaining that what was formerly termed the "bulbar part of the spinal accessory" is properly to be reckoned as part of the vagus nucleus.)

The absence of the mastoid process was probably the result of non-development of the sternomastoid muscle. The partial hemiatrophy of the tongue indicated an implication of the hypoglossal nucleus. The absence of the depressor muscles of the hyoid bone and of the posterior belly of the digastric indicated that the lesion extended down the anterior cornu of the spinal cord at least as far as the third cervical segment. This diagnosis of unilateral affection of the medulla and upper part of the cord was further supported by the maldevelopment of the right mandible and the absence of molar teeth in that bone, possibly attributable to an affection of the spinal root of the trigeminal nucleus. The other bulbar nuclei, from the facial upwards, were apparently unaffected.

The patient's unexpected death from pontine hæmorrhage, six weeks later, afforded an opportunity for pathological investigation of the case.

Subsequent history.—One morning the patient, who had not been complaining of headache or any other premonitory symptom, was sitting up in bed. Suddenly he fell back unconscious. When seen a few minutes later by the house physician, Mr. S. N. Crowther, he was found to be comatose, cyanosed, and breathing stertorously. The right arm and fingers were flaccid and motionless, whilst with the left he made semi-purposive clutching movements. The left lower limb was drawn up at the hip and knee. There was conjugate deviation of the eyes to the left. The knee-jerks were brisk and equal, there was ankle-clonus on both sides, and the plantar reflexes were extensor in type. The urine, drawn off by catheter, contained a large amount of albumen and a few granular casts. The temperature was 98° F. Two minims of croton oil were placed on the tongue.

When seen by me three hours later, the patient was still comatose and breathing stertorously, making occasional

movements with the left hand when stimulated by pinching the limb. Occasionally the right elbow made movements of extension. There was no movement of the other limbs, which were flaccid and extended at all joints. The eyes were still deviated to the left. The pupils were unequal, R. > L. semi-contracted and reacting to light. There was slight weakness of the right face, the nasolabial fold being shallower than on the left side, and the right ocular fissure wider than the left. The breathing was laboured, all the extraordinary muscles at the root of the neck being in action. The diaphragm was hardly felt to contract at all, respiration being chiefly costal in type. The knee-jerks were brisk and equal, there was ankle-clonus, R. > L., the supinator-jerks were not elicited. The plantars were now absent, also the abdominal and epigastric reflexes. The pulse was hard and bounding, 132 per minute. There was some œdema over the lumbo-sacral vertebræ, none of the ankles. The temperature was 98·4° F. Lumbar puncture withdrew clear fluid, which contained no excess of leucocytes on microscopic examination. With the sodium hypobromide test a small amount of urea was detected in the fluid.

The patient died, without regaining consciousness, twenty-four hours after the onset of coma.

AUTOPSY.

The heart was hypertrophied and the kidneys granular, the pelvis of the right kidney being dilated. There was some recent hypostatic pneumonia, and at the right apex some old pleuritic thickening.

All the muscles of the body were well developed, except on the right side of the neck, where there was total absence of the *sternomastoid*, *sternohyoid*, *sternothyroid*, *thyrohyoid*, *stylohyoid*, *digastric* (posterior belly), and *omohyoid*. The only muscle superficial to the carotid vessels was the platysma, which was well developed. The upper fibres of the *trapezius* were absent, the middle fibres, arising from the seventh cervical to the fourth dorsal spine inclusive, were

well developed, and below that level the muscle was absent. No signs of the spinal accessory nerve could be found. The rhomboids, levator anguli scapulæ, splenius and all other muscles of the neck were normal. The diaphragm was normal on both sides. The right *soft palate* was thinner than on the left side, and subsequent microscopic examination showed that on the paralysed side the *levator palati* was absent and the *azygos uvulæ* diminished in size. The right side of the tongue was smaller than the left. The epiglottis was bent over towards the right side and its right edge curved longitudinally.

The larynx was removed for more detailed examination. For most valuable aid in its dissection I desire to express my indebtedness to my colleague, Mr. James Black, lecturer on anatomy in the Westminster Hospital Medical School. The following are the chief points thus established:—

The thyroid cartilage, with its pomum Adami, was thrust across to the right side, giving the larynx a fictitious appearance of being more developed on the defective side. As a matter of fact the larynx was generally atrophic on the right side. This was noticeably the case with the right half of the cricoid cartilage. Subsequent dissection displayed the absence or most rudimentary condition of some of the muscles of the right side of the larynx.

Muscles.—The mylohyoid, geniohyoid and anterior belly of the digastric were about equally developed on the two sides. The posterior belly and the intermediate tendon of the last-named muscle were attenuated on the right side, and represented only by a faint strand of fibrous tissue. The right hypoglossus was well developed, but somewhat smaller than on the normal side. The right middle constrictor of the pharynx was very defective, and the styloid muscles could scarcely, if at all, be recognised. The intrinsic muscles of the tongue appeared generally fairly symmetrical on the two sides. *Muscles of the larynx.*—The right cricothyroid was totally absent. This, together with the absence of all the right infrahyoid muscles as already described, rendered the origin of the inferior constrictor of the pharynx strikingly apparent. The right

crico-arytenoideus posticus was absent, and the right crico-arytenoideus lateralis represented by a thin film of pale muscle fibres, too rudimentary to be capable of function. The small muscle described by Merkel as the kerato-cricoid, however, was present. Viewing the posterior surface of the cricoid cartilage, its asymmetry was very marked, the well-developed left crico-arytenoideus posticus presenting a noticeable contrast to the bare area of cartilage on the defective side. The arytenoideus transversus and obliquus were small but otherwise presented no feature for criticism. The right thyro-arytenoideus was but feebly developed, and this was well brought out on examining a coronal section of the larynx, when the meagre bulk of the prismatic sectional area of the right vocal cord contrasted strikingly with that of the opposite side.

Nerves.—A most careful search failed to discover any trace of the right hypoglossal nerve. The right lingual nerve was present, and a number of branches passed from it into the hypoglossus muscle (corresponding to those which usually form loops of communication with the hypoglossal nerve on this muscle). The right superior laryngeal (internal laryngeal branch), and the right recurrent laryngeal nerve, although smaller than on the left side, were recognised.

The foramen cæcum on the dorsum of the tongue was much deeper than usual. There was a well-marked lingual lobe to the thyroid gland, with a long pedicle leading upwards towards the root of the tongue, but no actual connection could be demonstrated between this pedicle and the lower end of the foramen cæcum.

The right external auditory meatus was shorter and narrower than the left, but the tympanum and auditory ossicles were normal.

The cerebrum showed no signs of disease on naked-eye examination, apart from an agonal thrombosis of the left middle cerebral artery, unassociated with any area of softening. The left cerebral hemisphere was larger than the right, weighing 18 ozs. as against 15 ozs. The left cerebellar hemisphere was also slightly wider from side to

side than the right, but not so deep from above downwards, the two halves of the cerebellum, after removal of the peduncles, weighing on the right side $2\frac{1}{3}$ ozs., and on the

FIG. 5.

(Showing hæmorrhages in pons).

FIG. 6.

(Showing hæmorrhages in pons).

left $2\frac{1}{2}$ ozs. This slight deformity of the cerebellum may have been the result of the asymmetry of the temporal and occipital bones.

The pons on naked-eye examination was symmetrical. On cutting into it, after hardening in Müller's fluid, several small hæmorrhages were found, of which the largest was about the size of a pea, in the upper third of the pons, dorsal to the transverse fibres, in the region of the fillet and posterior longitudinal fasciculus and in the intermediate area between these structures (see figs. 5 and 6). The remainder of the pons was normal and symmetrical on microscopic examination.

FIG. 7.

Pons.—Level of emergence of auditory nerve.

FIG. 8.

Medulla.—Upper.

FIG. 9.

Medulla.— Lower.

The medulla oblongata showed marked abnormality, as seen in figs. 8 and 9. The olivary bodies were normal and symmetrical. On the right side the hypoglossal nucleus and the adjacent lower part of the accessorio-vagus nucleus were absent, whilst the corresponding nuclei on the left side were well developed. A few cells were present in the position of the uppermost part of the right hypoglossal nucleus, but they were of a smaller type than those of the left hypoglossal nucleus, and apparently represented part of the vagus nucleus, displaced towards the middle line. The spinal root of the trigeminus, capping the substantia gelatinosa, was much smaller on the right side than on the left. This latter abnormality did not extend down into the cord. The other nuclei of the medulla were normal, likewise the various tracts, ascending and descending.

In the spinal cord the anterior median fissure was expanded into a deep cleft, extending from the lower part of the second cervical to the upper part of the seventh cervical segment. Along the right margin of this wide fissure ran the anterior spinal artery. The cleft was lined by a thin layer of pia mater. It penetrated deeply into the gray matter on the right side, near the junction of the anterior cornu with the gray commissure (see fig. 10). The gray matter of the cord was thus much distorted, and the asymmetry could be traced upwards above the level of the actual cleft to the first cervical segment and on into the medulla, as already described. Below the seventh cervical segment the cord showed no abnormality. The

nerve-roots, anterior and posterior, were given off from the gray matter on both sides, including the cervical region. A

FIG. 10.
Medulla and spinal cord.

small number of nerve-cells in the right anterior cornu were missing in the position of the cleft. The distortion of the remainder of the gray matter, however, rendered it impossible to identify precisely in each segment the particular groups of cells which were absent.

The points of interest in this case, clinically and pathologically, are numerous.

Firstly, as to the fatal hæmorrhage. This, a secondary result of chronic renal disease, was situated in the tegmental region of the upper part of the pons, located almost mesially, but more extensive on the right side of the middle line (see figs. 5 and 6). It was extra-pyramidal. Clinically, the signs were somewhat confusing. The lower limbs were flaccid, yet there was well-marked ankle-clonus on both sides, together with an extensor type of plantar reflex. There were semi-purposive irregular movements of the right upper limb, and slight facial weakness on the right side, together with conjugate deviation of the eyes to the left. These two latter signs would have been explainable by a lesion implicating the right sixth nucleus. But the autopsy showed the nucleus to be intact. The ocular deviation, therefore, is more probably attributable to an interruption of the fibres connecting the right sixth with the left third nucleus, as in a somewhat similar case recorded by Raymond and Cestan (7).

The condition of the reflexes, and especially the presence of the extensor type of plantar reflex, is of especial interest, for in this case there was no interruption to the pyramidal tracts in any part of their course, the hæmorrhage being situated posteriorly in the tegmentum. Kornilow (5) has recently maintained that the Babinski phenomenon can occur independently of a lesion of the pyramidal tracts, and this case supports such a view. The explanation of its occurrence, however, remains obscure. Another unusual feature was the absence of the high temperature which so frequently occurs in fatal pontine hæmorrhages. Nor were the pupils contracted.

Even more remarkable is the unilateral lesion in the

medulla oblongata and upper part of the spinal cord. The condition was congenital and non-progressive. It does not correspond to any variety of syringomyelia. I have been unable to find in the literature of nuclear lesions of the medulla or cord the record of anything precisely similar. The two parallel white lines visible in the skin of the back of the neck (see fig. 3), were probably associated developmentally with the lesion of the brain-stem. They may be regarded as analogous to the mole in the lumbar region, so commonly seen in cases of spina bifida occulta.

Only a small number of cases (chiefly of syringomyelia) have been published, *e.g.*, those of Schmidt (10), Kretz (6) and Weintraud (14), in which the diagnosis of nuclear paralysis of the accessorius was made, and in none of them was the case completed by subsequent pathological investigation.

In our case the lesion of the central nervous system was an extensive one, implicating the gray matter of the following motor nuclei :—vagus, accessorius, hypoglossal, and anterior cornu as low as the sixth cervical segment. Together with these, the spinal root of the trigeminus was also affected. The other cranial-nerve nuclei, from the facial upwards, were unaffected. On the affected side the spinal accessory and hypoglossal nerves were absent, whilst the anterior cornu, though distorted in shape and diminished in size, gave off its anterior nerve-roots throughout the affected region. The vagus trunk was present, though smaller on the affected side, its superior laryngeal and recurrent laryngeal branches being especially reduced in size.

This case is also of value in regard to the innervation of the trapezius and as to the parts played by the spinal accessory and by the cervical nerves respectively. In our patient the spinal accessory nerve was absent, the cervical nerves present. Associated with this there was total absence of the sternomastoid and of the upper and lower thirds of the trapezius, whereas the middle third of the trapezius was well developed. This indicates a separate innervation of the middle third of the trapezius by the cervical anterior

roots, the remainder of the muscle belonging to the territory of the spinal accessory. Such a view harmonises with the opinion of Remak (8). Gowers (4), in his latest edition, states that the whole of the trapezius is supplied by the spinal accessory, and that the twigs from the cervical plexus merely pierce the muscle without supplying it. Schulz (11), again, from a study of a large number of recorded cases, comes to the conclusion that the result of a pure lesion of the spinal accessory, without implication of the cervical plexus, is complete palsy of the lowest third and partial palsy of the upper two-thirds, the clavicular fibres being more severely paralysed than the acromial. The apparent divergence of these views is probably to be explained by variations in the proportional territory of the spinal accessory in different cases. Thus, for example, Schlodtmann (9) records an interesting case of unilateral paralysis of the palate, larynx, sternomastoid and trapezius, the result of a fracture of the base of the skull, without implication of the cervical roots, and in which there survived only a few strands of the acromial bundle, whose total breadth was about that of a pencil.

The characteristic deformity occurring in most cases of trapezius paralysis was clearly described by Duchenne (3), who applied to the displacement of the scapula the term "*mouvement de bascule*," and stated that the occasional absence of this deformity in certain cases was explainable by survival of the acromial bundle, quite a small strand of this bundle being sufficient to prevent the displacement. But in our case the acromial bundle was well developed, and yet the scapular displacement was perfectly evident.

As to the sternomastoid, it should be noted that in our case its absence produced neither deformity at rest nor impairment of the movements of the head and neck. This exemplifies the truth of Gowers' dictum (4) that there is no such thing as a "paralytic" torticollis, though Bernhardt (2) in his recent text-book states that unilateral paralysis of this muscle causes moderate deviation of the head towards the affected side, the chin being slightly raised. In our case no such deviation occurred.

Similarly, the absence of all the infrahyoid muscles produced no impairment of movement of the hyoid bone, though the larynx was distorted towards the affected side.

It is interesting to note that, in spite of the absence of the right hypoglossal nucleus and nerve, the corresponding hemiatrophy of the tongue was only moderate in degree. The intrinsic muscles of the tongue were certainly smaller on the right side than on the left, but the tongue itself was not curved longitudinally as in ordinary hypoglossal palsy, nor were its electrical reactions different on the two sides. Moreover the orbicularis oris was unaffected, contrary to what is usually found in bilateral lesions of the hypoglossal nuclei.

The explanation of these facts is somewhat difficult. Most likely the hypoglossal nucleus of the healthy side controlled both halves of the tongue. (The right and left nerves, according to Thane (13), are occasionally connected by a cross branch or loop in the substance of the genio-hyoid.) Another less probable view might be that, inasmuch as the lingual nerve supplied branches which entered the hyoglossus, the motor fibres of the trigeminus may have taken on a vicarious distribution.

Nor is the question appreciably enlightened by a consideration of the absence of the depressor muscles of the hyoid bone. Whichever nerve assumed the vicarious function of innervating the right half of the tongue, did not reach the infrahyoid muscles. These latter are commonly believed to be supplied, not by the hypoglossal itself, but by branches from the first and second nerves forming the loop of the *ansa hypoglossi*. Thus Beevor and Horsley (1), who stimulated the intracranial roots of the hypoglossal in the monkey, obtained no contraction in the infrahyoid muscles, which responded briskly, however, to stimulation of the first and second cervical nerves. Yet Stierling (12), on the other hand, records a case of annular fracture of the anterior part of the foramen magnum in man, implicating the hypoglossal nerve close to its origin, in which, together with paralysis of the vagus on that side, there was paralysis of the corresponding half of the tongue and of the depressors of the hyoid bone on the same side, the cervical roots being stated to be uninjured.

In our case there was a deep fissure in the anterior cornu, which was most probably causally connected with the absence of the infrahyoid muscles. And yet all the anterior roots were present in the cervical region, and, moreover, were efficient in supplying the other deep muscles of the neck, together with the middle third of the trapezius. Of course, it must be remembered that the nucleus of the spinal part of the trapezius lies lower in the cord than that of the infrahyoid muscles.

The atrophy of muscles in the larynx is undoubtedly to be associated with the lesion of the vagus, the lower part of whose nucleus was deficient, and whose trunk was much diminished in size, especially its superior laryngeal and recurrent laryngeal branches. Of the laryngeal muscles certain were absent (crico-thyroideus and crico-arytenoideus posticus); others were so rudimentary as to be incapable of function (crico-arytenoideus lateralis); others, again, were simply diminished in size (arytenoideus and thyro-arytenoideus). The position of the vocal cord corresponded to that usually seen in total recurrent laryngeal palsy, but there could be no question of contracture of abductor or adductor muscles, since the crico-arytenoideus posticus was absent and the crico-arytenoideus lateralis reduced to a rudimentary strand. The position of the cord was simply that of the edge of the thyro-arytenoideus muscle, which supported the cord immovably in a semi-abducted posture.

FIG. 11.

Soft Palate.—Showing absence of levator palati on right side.

FIG. 12.

Uvula.—Showing atrophy of azygos uvulae on right side.

In the soft palate the right levator palati was absent, and the right azygos uvulae was much smaller than the left (see figs. 11 and 12), whilst in the pharynx the right middle constrictor was greatly diminished in size. This corresponds with remarkable accuracy to a lesion of that part of the vagus formerly named the "bulbar part of the spinal accessory." Beever and Horsley (1) have shown experimentally in the monkey that the motor fibres for the levator palati and azygos uvulae, as well as part of the constrictor muscles of the pharynx, are thus supplied.

The deformity of the temporal bone and lower jaw is also deserving of notice. Absence of the sternomastoid is sufficient to account for the rudimentary condition of the mastoid process. The smallness of the lower jaw, however, cannot be explained as the result of muscular atrophy, since all the muscles attached to the mandible were present and well developed. Probably the condition of the lower jaw is to be associated with the congenital smallness of the spinal root of the trigeminus. Such a view is corroborated by the absence of the lower molar teeth and by the smallness of the external auditory meatus and pinna on the affected side. The external auditory meatus, pinna, middle ear and Eustachian tube are all developed from the first visceral cleft, whilst from the mandibular arch, between this cleft and the mouth, the lower jaw is developed. And all these structures lie within the territory of the trigeminal nerve.

To Dr. Ferrier I desire to express my indebtedness for

his permission to conduct the microscopical portion of the above research in the neuro-pathological laboratory of King's College.

REFERENCES.

- (1) BEEVOR and HORSLEY. *Proceedings of the Royal Society*, 1888.
- (2) BERNHARDT. *Die Erkrankungen der peripherischen Nerven*, 2te Aufl., 1902, p. 317.
- (3) DUCHENNE. *Physiologie des Mouvements*.
- (4) GOWERS. "Diseases of the Nervous System," vol. i., Gowers and Taylor, 1899, p. 34.
- (5) KORNILOW. *Deutsche Zeitsch. f. Nervenheilk.*, 1903, p. 217.
- (6) KRETZ. *Wiener Klinische Wochensch.*, 1890, No. 25, p. 479.
- (7) RAYMOND AND CESTAN. *Gazette des Hôpitaux*, July 18, 1903.
- (8) REMAK. *Deutsche Med. Wochensch.*, 1885, p. 468.
- (9) SCHLODTMANN. *Deutsche Zeitsch. für Nervenheilk.*, 1894, p. 471.
- (10) SCHMIDT, A. *Deutsche Medicinische Wochensch.*, 1892, No. 26, p. 606.
- (11) SCHULZ. *Deutsche Zeitschr. für Nervenheilk.*, 1903, p. 125.
- (12) STIERLING. *Archiv. für klinische Chirurgie*, Bd. 61, p. 130.
- (13) THANE. "Quain's Anatomy," 10th Ed., vol. iii., part 2, p. 274.
- (14) WEINTRAUD. *Deutsche Zeitschr. für Nervenheilk.*, 1894, p. 383.