THE CORPUS PONTO-BULBARE—A HITHERTO UNDESCRIBED NUCLEAR MASS IN THE HUMAN HIND BRAIN.

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WITH 12 FIGURES.

In the following paper I have described a ganglionic mass which can be seen overlapping the restiform body just caudal to the dorsal cochlear nucleus and forming a direct lateral process or extension of the ganglion mass of the pons. This structure was undoubtedly seen long ago by Clarke,¹ but he considered it to be an aberrant strand from the striæ medullares, and probably it had been seen by Arnold, who also described it as belonging to the strial system. The caudal tip, which is often prominent, has attracted the attention of various authors, and was particularly described by Retzius² and Henle³ under the name "Ligula" and "Ponticulus"; none of these observers, however, followed the structure in cross sections, and its significance was consequently overlooked. As far as could be learned, the following paper gives the first description of its whole form and for the first time demonstrates its connection with the ganglion mass of the pons. I have found that it is constantly present to a greater or less degree in all human brains and possesses definite characteristics which seem to me to warrant a name such as is herewith proposed—the corpus ponto-bulbare or ponto-bulbar body.

An adult formalin specimen, in which the structure was especially prominently developed, was photographed (Fig. 1) and after mordanting in a double chrome salt solution was imbedded in celloidin and cut in serial sections. The alternate sections were stained by the Weigert-

¹ Mr. J. L. Clarke: *On the Intimate Structure of the Brain.* Phil. Trans. London, 1868.

² Gustaf Retzius: *Das Menschenhirn*, Vol. I, Stockholm, 1896.

³ J. Henle: *Handbuch der Systematischen Anatomie des Menschen*, Vol. III, Part II, Braunschweig, 1879.

Pal method; the intermediate ones, for purpose of cell study, were stained by various cell stains, thionin having proved most satisfactory. A wax-plate reconstruction after the method of Born was made from this series showing the ponto-bulbar body and its relations to the adjacent cranial nerves, the cochlear nuclei, the trapezoid body, and the restiform body. A composite drawing of this model showing its relations to the surrounding region is represented in Fig. 12.

Through the kindness of Prof. Franklin P. Mall and Dr. Florence R. Sabin, I had the opportunity of making a macroscopical examination of fifty brains fixed in formalin, a description of which is included in

FIG. 1. Photograph of a human medulla with a well-marked corpus ponto-bulbare (c), transverse sections of which are represented in Figs. 3-11. Fig. 12 represents the same medulla reconstructed into a model and drawn in ventro-lateral view. $\times 2$.

this paper. They also placed at my disposal several series of both adult and new-born medullas which were valuable as a control over my own series. For these and many other courtesies on their part I take pleasure in using this opportunity to express my thanks.

GROSS APPEARANCE.

The structure, which I have designated as the corpus ponto-bulbare, constitutes a horn-shaped process of the pons which extends caudally, wrapping around the lateral side of the restiform body so as to end on its dorsal surface; forming, in part, the lateral boundary of the fourth ventricle. If one takes a brain from which the pia mater has been

stripped off, the ponto-bulbar body can be seen making its appearance on the ventro-lateral surface of the pons near the emerging root bundles of the trigeminal nerve and extending backward passing between the roots of the acoustic and facial nerves. Continuing backward ventral to the restiform body the main mass passes dorsal to the emerging glossopharyngeal roots, finally, assuming the dorsal position shown in Figs. 1 and 2. So that the ponto-bulbar body is superficial throughout its extent and its development usually throws the surface into a more or less well-marked fold which can be traced from its beginning on the ventro-lateral surface of the pons to its ending at the lateral wall of the fourth ventricle. As soon as these caudally directed fibers leave the pons it becomes evident that they are accompanied by a cellular mass which is itself distinct from the neighboring structures. This nuclear mass fused with the pons between the facial and acoustic nerves gains the dorsal surface of the medulla by passing around the restiform body caudal to the dorsal cochlear nucleus.

Out of fifty brain specimens which were examined macroscopically, it was found that nearly all showed clearly the ponto-bulbar body throughout its entire extent. About half showed a prominent ridge from its beginning on the pons to its ending at the lateral wall of the fourth ventricle. In all the brains examined, the ponto-bulbar body was visible macroscopically in some part of its course. The reason it is not seen throughout its whole extent in all of the specimens is not due to its absence, but to its retraction beneath the surface of the hind-brain.

At the point of its emergence on the pons its position, size, and shape vary considerably in different brains. The ponto-bulbar body appears first as small bundles of fibers which turn away from the transverse pons fibers proper somewhere median to the trigeminal nerve. Gradually these bundles converge to form a more or less compact ridge which curves backward just behind the fifth nerve and runs caudally almost at right angles to the other pons fibers, to pass between the facial and acoustic nerves. The eminence thus formed is generally single as far front as the fifth nerve and measures from 3-6 mm. in width; the extent to which it is raised above the pons surface varies from a sheet-like layer of fibers to a corded ridge. The manner in which the ponto-bulbar body sweeps out of the pons resembles somewhat the converging roots of the cauda equina; one specimen showed a distinct claw-like arrangement of fiber bundles. At times the fibers go to form two separate ridges which unite just cephalad to the facial nerve. The region from which these fibers turn

out from the pons extends from a point about 5 mm. in front of the fifth nerve to 4 mm. in front of the seventh nerve. An interesting variation to this general arrangement is found where fiber bundles encircle the trigeminal nerve or appear to come up out of the pons immediately behind it, and then take the regular course between the facial and acoustic nerves. Few specimens did not show this part of the ponto-bulbar body very plainly.

Although no reference is made to it, an admirable picture of the pontine part is given by Retzius⁴ in his Atlas, Plate IV, Fig. 1. On the left half of the brain (right side of figure) the eighth and seventh nerve roots can be seen just median to the flocculus. In front of these nerves a definitely corded ridge is present passing forward, median to the trigeminal nerve to be lost in the pons. The choroid plexus from the lateral recess hides the corresponding right part of the brain in the neighborhood of the seventh and eighth nerves, but the way in which the ponto-bulbar body arises from the transversely directed pons fibers, median to the root bundles of the fifth nerve, and then assumes a caudal direction, is particularly well illustrated.

By far the most constant part of the ponto-bulbar body, appearing on mere gross examination of brain, is the welt-like ridge which it forms ventral to the restiform body after it has passed between the facial and acoustic nerves. This portion is difficult to display in the whole brains preserved in formalin, because it necessitates removing the pia mater from the depression between the flocculus and the olive and, unless great care is used, this procedure takes with it the root bundles of the glosso-pharyngeal nerves. The part of the ponto-bulbar body which is then brought into view, extends about 6 mm. caudally as a prominent elevation having a width of 3 mm. in all specimens which were measured. We find it nearly always extending so as to surround the most cephalic of the glosso-pharyngeal roots. In this event, the appearance is that of a hill-shaped eminence with the stumps of the glosso-pharyngeal nerve emerging from the summit. On the left side of the brain illustrated by Retzius,⁵ Fig. 11, Plate XXXVIII, there appears the best illustration of this portion of the ponto-bulbar body. Here the hypoglossal nerve roots may be recognized as they emerge mesial to the olive. Lateral to the olive is a well marked ridge with five root bundles of the glossopharyn-

⁴ Gustaf Retzius: *Biologische Untersuchungen*, Neue Folge XII, 1905.

⁵ Gustaf Retzius: *Das Menschenhirn*, Vol. II, Stockholm, 1896.

geal nerve emerging from the summit. This ridge can be traced anteriorly as it passes between the facial and acoustic nerves and a very little part of the pontine portion may be seen just anterior to the seventh nerve as is indicated by vertically directed lines in contrast to the horizontally placed lines representing the direction of the pons fibers proper. Other figures, 9, 12, and 13, of the same plate, furnish good illustrations of this region.

At the point where it emerges below the lateral recess, we see it turning around the restiform body just caudal to the dorsal cochlear nucleus from which it is separated by a shallow sulcus. In some specimens it might easily be mistaken for the dorsal cochlear nucleus; but if one will carefully follow the cochlear nerve, the real dorsal cochlear nucleus can be made out in front of the attachment of the tela choroidea inferior, i. e., the dorsal cochlear nucleus lies in the lateral recess and is covered with ependymal cells; while the ponto-bulbar body, which often approaches the dorsal cochlear nucleus in elevation and extent, is situated more caudal, and makes a curve of greater radius around the restiform body to gain the dorsal surface of the medulla.

On the dorsal surface of the medulla, the ponto-bulbar body undergoes its greatest variation in different brains and, in fact, on the two sides of the same brain. Instead of the welt-like ridge which it presents in the more cephalic part of its course, it here spreads out into a flattened leaf-like structure overlapping the restiform body and the lateral part of the floor of the fourth ventricle. In its exact form it shows considerable variation. Of the fifty brains which were examined five of them presented the prominent mitten-like form 4.5—6.0 mm. wide with a free tip, projecting, as it were, out into the tela choroidea, as is seen in the Fig. 1. These would be called markedly well developed. On the other hand, in about 40% of the specimens this part of the ponto-bulbar body forms such a thin lamella that it is not noticeable macroscopically on at least one side of the brain. Between these two extremes there are all gradations. It may take the form of a single ridge usually 2—3 mm. in width; or may be divided into two finger-like ridges. In well developed cases the caudal tip may help to form the roof of the fourth ventricle, forming a free end to the edge of which is attached the tela choroidea. In the specimen photographed, Fig. 1, there was a tip of this kind 1.5 mm. long. The fact that the tela choroidea is attached to it, makes it a thing easily damaged in removal of the pia. A drawing of an average human medulla is represented in Fig. 2 and this gives the usual position and size which the ponto-bulbar body presents in a dorsal

view of the fourth ventricle. It may be seen turning around the restiform body caudal to the line of attachment of the tela choroidea along the lateral recess and projecting as a lamella into the roof of the fourth ventricle.

There are many excellent photogravures of this region in Retzius,* in which the relations of the ponto-bulbar body to the restiform body and the fourth ventricle are brought out. In his Plate XXXV, Fig. 9 shows

FIG. 2. Drawing of an average human medulla giving the usual appearance of the corpus ponto-bulbare caudal to the dorsal cochlear nucleus. $\times 2$.

a doubled ridge, above described as "finger-like," on the right side extending antero-lateral from the base of the detached tænia (labeled "t"). A similar though not so well marked arrangement is shown in Plate XXXVI, Fig. 2. Figure 4 of Plate XXXVII gives the best illustration of the whole dorsal extent of the ponto-bulbar body because the pia has been completely removed from the specimen. It may be recognized as the first transversely placed ridge which encircles the restiform body in front of the clava. The way in which it turns around the restiform body

* Loc. cit.

and ends at the attachment of the tela choroidea is particularly well shown. It compares with the right half of my figure 1 except that the free edge is apparently lacking, possibly having been torn away with the pia. Plate XXXVIII, Figs. 5 and 6, also give admirable pictures of this region; attention might be called to the free edges of the ponto-bulbar body on both sides of the former figure.

HISTOLOGICAL APPEARANCE.

On microscopical examination it is found that the ponto-bulbar body consists of a mass of multipolar ganglion cells supported in a dense neuroglia network closely resembling the nuclear masses of the pons. The lateral or free surface of this ganglionic body is entirely covered by a layer of medullated nerve fibers which in general follow the direction of the long axis of this structure and continually give off collaterals which branch among the underlying ganglion cells. On its median surface throughout its greater extent there is no such layer of fibers present and consequently the ganglion mass lies directly adherent to the adjacent structures and fuses more or less completely with them. The ponto-bulbar body presents a uniformity of histological structure throughout, so that in passing from section to section the same characteristics can be made out everywhere. The cells lie very close to one another and in large areas are separated from each other by less than the width of a cell. The narrow space between the cells is found to be filled by a dense framework of neuroglia and an intricately interwoven network of very fine nerve fibers, which in their complexity and number resemble the hypoglossal nucleus. On the other hand this rich felt-work stands out in contrast to the ala cinerea, which in Weigert sections gives such a clear picture.

The cells are of the multipolar type and show several different forms; many are spindle-shaped with their long axes parallel to the fibers; while most have the characteristic multipolar form. The former are found in greater numbers in the part of the ponto-bulbar body which lies lateral to the restiform body, the latter in the rest of the body. The size is fairly uniform, so that, of cells which were measured in sections stained in thionin, the average was $23 \times 14.5 \mu$, some cells being as large as $29 \times 17 \mu$, others only $17 \times 10 \mu$. This corresponds exactly to measurements taken of the ganglion cells scattered through the pons. To afford a means of comparison, cells from the hypoglossal nucleus were measured in the same sections and were found to be $40 \times 23 \mu$. These measurements

were made on celloidin sections of tissue which had been fixed in formalin and mordanted in a double chrome salt.

A section in any part of the ponto-bulbar body shows the free border of the nucleus outlined by a layer of nerve fibers cut either transversely as in Figs. 3, 4, 5, 6, and 7, or longitudinally as in Figs. 8, 9, 10, and 11; in no case was there a stratum of cellular material on the surface. The diameter of these fibers, including their medullary sheath, ranges from $0.8 - 2 \mu$; those making up the larger strands $1 - 2 \mu$ thick, while those between the cells generally 0.8 in thickness. This small size makes the fibers easily distinguishable from the surrounding structures with which they come into close relation. The fibers and cells together form a structure whose shape varies in section but the relation of cells to fibers are always such that masses of nuclear material lie between the fiber bundles and the rest of the brain. Occasionally only do we find strata of cells between the fiber bundles as in Figs. 9 and 10.

For the sake of simplicity it might be well in describing its finer structure to arbitrarily divide the ponto-bulbar body into a pontine part which fuses with the ventro-lateral surface of the pons, a middle part which extends median to the ventral cochlear nucleus and is perforated by the glosso-pharyngeal roots, and lastly a broad caudal part which overlaps the restiform body. With this in mind each part will be treated separately as was done in the gross description.

In the region of the trigeminal nerve small strands of fine fibers separate from the transverse fibers of the pons and turn caudally, forming rather compact small bundles which lie on the ventro-lateral surface of the pons just behind the root bundles of the fifth cranial nerve. The addition of fibers from the lateral side or middle peduncle is comparatively small, while the strands from the pons proper continue to turn in almost as far caudal as the emerging facial nerve. The nerve fibers gradually unite to form more or less rounded bundles which are spread out on the ventro-lateral border of the pons. Although there is this gradual increase of fibers from both sides, the cross section does not increase proportionately as it runs caudally. The reason for this is found to be due to rather large bundles of fibers which separate from the other fibers and run into the middle peduncle of the cerebellum.

In the region of its most cephalic part, the ganglionic mass adjacent to the fibers is very small; but as it approaches the caudal border of the pons, it increases in amount, fusing so completely with the pontine nuclei that no sharp line of demarcation can be drawn. This is well illustrated in Figs. 3 and 4, where the fibers, cut transversely, can be seen on the

surface of the pons between the facial and acoustic nerves. The nuclear mass which lies adjacent to the fibers can be traced serially back into the caudal tip of the process, but it will be noticed in these two sections that the nuclear mass is directly continuous with that scattered throughout the pons. Fig. 4 shows the *nervus intermedius* passing through the ponto-bulbar body on its way to join the facial nerve in the same manner as the glosso-pharyngeal nerve does farther caudally.

We may say its middle division begins at the point where the ponto-bulbar body leaves the pons between the facial and acoustic nerves. It lies ventral to the restiform body and all the fibers in our sections, as in Fig. 5, are cut across transversely—that is they are running caudo-cephalically. Here again it will be noted that the fibers are arranged along the surface. Throughout the length of the ventral portion numerous small strands of obliquely cut fibers are found scattered in the nuclear mass. By carefully following the sections serially it becomes evident that these small bundles are passing between the restiform body and the ponto-bulbar body. These nerve fibers leave the restiform body and travel obliquely out across the nucleus in a caudal direction and finally take their position on the surface of the nucleus, thereby swelling the number of fibers. As we pass back and forth in serial sections, a variability in the number of fibers cut transversely, calls attention to the fact that there are not only fibers arising in the nucleus itself and running along the edge, but that there are also fibers which are passing into other structures. These obliquely cut fiber bundles can be seen in Figs. 5 and 6, between the superficial fringe of transversely cut fibers and the restiform body. The exchange of fibers between the ponto-bulbar body and the restiform body takes place even in the regions where the nucleus has fused with the pontine nuclei and although the obliquely cut fibers with the same directions persist, the cross fibers from the pons and the trapezoid body make it impossible to trace bundles from the ponto-bulbar body to their junction with the restiform body. The ponto-bulbar body is separated from the restiform body by the trapezoid body as soon as the level of the ventral cochlear nucleus is reached. The separation is partial in Figs. 5 and 6, and complete in Figs. 3 and 4, where the trapezoid body can be traced to the superior olive. Attention might be called to Fig. 7, where the coarse fibers of the most cephalic of the glosso-pharyngeal nerve roots may be followed from the fasciculus solitarius through the descending spinal root of the fifth nerve and the restiform body and out through the most ventral part of the ponto-bulbar body. Fig. 7 also shows the dorsal cochlear nucleus in its relation to the ponto-bulbar body which, a

few sections farther caudally (c.p. Fig. 8), occupies a similar position with regard to the restiform body. Sections like Fig. 8 might easily be misinterpreted as containing a dorsal cochlear nucleus.

The caudal part embraces that portion of the ponto-bulbar body which sweeps around the restiform body to gain the dorsal surface of the medulla. As its most cephalic border is reached, the fibers are cut a little more obliquely indicating that they are turning out of their caudo-cephalic course, see Fig. 8 and Fig. 9. A little farther backward the fibers run around the restiform body in a rather heavy layer (Fig. 10); the nuclear mass, on the other hand, does not follow them immediately, so that in sections where the front part appears, fibers alone are seen encircling the restiform body—c.p. Fig. 8. When the body reaches its greatest development, the fibers can be traced for some distance as they bend around the restiform body; always separated from it by a mass of nuclear material. It is here that the fiber bundles which skirt along the edge may be interspersed with thin strata of ganglion cells as in Figs. 9 and 10. From the part of the nucleus which adjoins the median vestibular nucleus a few small strands of fine fibers could be traced as they ran cephalically toward one of the striæ acusticæ, which had a caudal direction. On reaching this stria, the fibers made a sharp turn and joined it. Numerous other smaller groups of fibers had a similar direction and gave the impression of joining the striæ but only one such bundle could be followed from the ponto-bulbar body to the striæ acusticæ. It is probably this connection which led Clarke to interpret this structure, which he undoubtedly saw, as belonging to the group of striæ acusticæ.

The caudal tip extends out as a tongue-like structure which projects to a greater or less extent into the roof of the fourth ventricle in the edge of the tela choroidea inferior, see Figs. 9, 10, and 11. The ventral side of the free process is lined by a layer of ependyma which is continuous with the ependymal cells lining the rest of the ventricular cavity, while the dorsal side is covered by pia mater—in every respect then it appears to be an enlarged portion of the secondary “Rautenlippe” of His. An illustration not unlike my Fig. 9 is given by Spalteholz⁷ in his figure 727. Here it appears to be disregarded as an individual structure and has no label referring to it; the characteristic superficial fiber layer, the fusion of the cell mass with the restiform body, and even the

⁷Werner Spalteholz: *Hand Atlas of Human Anatomy*, Vol. III, Leipsig, 1906.

tongue-like process are well illustrated. His figure 728 has almost the same level as Fig. 5, and here he has called it "pons (Varoli)." This latter is very natural when we consider that a little farther front the ponto-bulbar body is actually fused with the pons.

In the tongue-like projection the cells occupy a central position, being surrounded on all sides by the fiber bundles which may then be regarded as forming a capsule; Figs. 9, 10, and 11 show this very well. Single fibers may be traced for some distance in a section showing that here in the dorsal portion the fibers take the same direction as the body that is toward the median line. These fiber strands run along the border of the nucleus and converge as they turn around to gain the lateral side of the restiform body forming a bundle which is gathered together in wisp-like fashion. The efferent fibers from the abducens, facial, and other nuclei have this same confluence into a root bundle. Toward the median end of this projection appears a rather large bundle cut transversely which gives off collaterals to the nuclear material in a very irregular manner.

The above description applies to adult material, but I have also had the opportunity of examining a series of the new-born babe, the one which was prepared by Dr. John Hewetson and belongs to the collection of this laboratory. In this series the ponto-bulbar body could be distinctly made out, and in its relations to the surrounding structures showed the same features as described in the adult. However none of its fibers are as yet myelinated, the non-myelinization made it particularly easy to identify it in the region of the cochlear nerve, ventral cochlear nucleus, and trapezoid body, all of which have at this age acquired their myeline sheaths. Further caudally where it lies against the side of the restiform body it comes into contact with the cerebello-olivary fibers. Although these unmyelinated fibers fuse with the ponto-bulbar body, the closely arranged ganglion cells of the latter are easily distinguished from the coarse nerve fibers. The pons with which this body fuses cephalically also contains no myelinated fibers. It may also be added that it is present in the early stages of both human and pig embryos. It can be seen in the reconstructions of this region in a 50 mm. human embryo which are about to be published by Dr. Streeter, and it was also noted by him in dissections of pig embryos.⁸

⁸G. L. Streeter: Development of the Membranous Labyrinth and the Acoustic and Facial Nerves in the Human Embryo. Amer. Jour. of Anat., Vol. VI, p. 163.

In conclusion, I wish to acknowledge my indebtedness to Dr. George L. Streeter, at whose suggestion and under whose supervision the study of this ganglion mass was carried on. I also desire to express my thanks to Prof. Max Brödel for his assistance in preparing Figs. 2 and 12.

ABBREVIATIONS USED IN FIGS. 3-12.

- Brach. pont.* = Brachium pontis.
Corp. Rest. = Corpus restiforme.
Corp. Trap. = Corpus trapezoideum.
Fibr. Cereb. Oliv. = Fibræ cerebello-olivares.
N. Coch. = Nervus cochlearis.
N. Vest. = Nervus vestibularis.
N. Glossoph. = Nervus glossopharyngeus.
Nu. Coch. Dors. = Nucleus cochlearis dorsalis.
Nu. Coch. Vent. = Nucleus cochlearis ventralis.

EXPLANATION OF FIGS. 3-11.

FIG. 3. Transverse section through the pons immediately in front of the emerging facial nerve. $\times 4.5$.

FIG. 4. Transverse section just caudad to the preceding, through the nervus intermedius, showing the fibers of the corpus ponto-bulbare in cross section. $\times 4.5$.

FIG. 5. Transverse section through the medulla at the border of the pons. $\times 4.5$.

FIG. 6. Transverse section through the cephalic end of the olive. $\times 4.5$.

FIG. 7. Transverse section through the caudal border of the dorsal cochlear nucleus. $\times 4.5$.

FIG. 8. Transverse section through the cephalic border of the corpus ponto-bulbare where it encircles the restiform body. $\times 4.5$.

FIG. 9. Transverse section immediately caudad to the preceding, showing the longitudinally cut fiber strands turning around the restiform body. $\times 4.5$.

FIG. 10. Transverse section through the thickest part of the projecting caudal tip of the corpus ponto-bulbare. $\times 4.5$.

FIG. 11. Transverse section through the middle of the olive, showing the caudal end of the corpus ponto-bulbare. $\times 4.5$.

FIG. 7.

FIG. 8.

FIG. 12 represents a somewhat schematic drawing of a model reconstructed from sections of the specimen shown in Fig. 1, in a ventro-lateral view of the medulla and pons. Part of the nucleus cochlearis dorsalis (nu. coch. dors.) has been removed to show the relations of the corpus restiforme (c. r.) Numerals V-X refer to the cranial nerves. I refers to the nervus intermedius. $\times 3.75$.