Neurosurgical Classic—XXIX

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In 1895 Wilhelm Konrad von Röntgen revolutionized medical diagnosis by the introduction of roentgenography.\textsuperscript{13,14} Two years later the hope was expressed that brain tumors might cast shadows in roentgenograms of the skull,\textsuperscript{9} but it was soon found that no differentiation could be made between noncalcified tumors and the surrounding tissues.\textsuperscript{3} Furthermore, calcification could be demonstrated in only a small proportion of intracranial tumors.\textsuperscript{7} For these reasons, despite the occasional demonstration of bony erosion from intracranial neoplasms (such as Oppenheim’s observation of changes in the sella turcica\textsuperscript{19}), roentgenography had little use in the diagnosis of neurological diseases until the second decade of the twentieth century.

This lag was followed by the rapid introduction of ventriculography,\textsuperscript{21} pneumoencephalography,\textsuperscript{22} myelography,\textsuperscript{23} angiography,\textsuperscript{24} and a variety of special techniques for the demonstration of the cranial orifices.\textsuperscript{2-4,11} Also during this period it was predicted by Arthur Schüller,\textsuperscript{16} and verified by Howard Naffziger\textsuperscript{4} that the pineal gland frequently is displaced laterally by an expanding mass in the opposite cerebral hemisphere.\textsuperscript{1,3,4,11,12,15,17,20} Each of these two men was outstanding in his field, and working independently in different countries, they contributed an important sign for the diagnosis of intracranial disease.

"Without any shadow of doubt Arthur Schüller . . . was the father of neuroradiology. He was born in Brünn, the capital of Moravia in the old Austria, in 1874 . . . Schüller, qualifying in medicine in Vienna just after Röntgen’s discovery, graduated with the highest honours—\textit{sub summis auspiciis imperatoris Francesci Josephi}. This was a prize awarded by the Emperor Franz Joseph and was only given twice during his long reign of 68 years (1848–1916). Schüller immediately became interested in the radiology of the skull and in 1912 published a text-book on the subject: \textit{Röntgendiagnostik der Erkrankungen des Kopfes}. This work was translated into English in 1918 by an American, F. F. Stocking . . . One has only to glance at this text-book to see how far in advance of others was Schüller . . . He differentiated many types of normal and pathological intracranial calcifications, but perhaps his greatest contribution was his work on the pituitary fossa . . ."

"More than 300 publications—books, monographs and papers—came from his pen, mostly while he was in Vienna. They covered not only the radiology of the skull but various aspects of neurology, surgery and psychiatry. He described three diseases and devised three operations, though he was not a surgeon."\textsuperscript{73}

The ideas of Schüller about pineal displacement, which he thought should be evaluated routinely on anteroposterior roentgenograms of the skull, were expressed in the 1918 translation of his text-book as follows:

". . . One can also, for example, in case of a displacement of the shadow of a pineal gland to the right or left of the median line, in symmetrically formed skulls, conclude the cause of its displacement to be pressure on the part of a tumor or traction on the part of a brain scar, as the following case shows:

"R.F., male, thirty-six years old. Trauma to the skull two years previously. At the time of examination he was suffering from hemiplegia of the right side following an apoplectic stroke. Internal organs normal. Wassermann negative. Suspicion of cerebral tumor."

"The roentgenogram showed that the pineal gland, the shadow of which was plainly recognizable, was displaced several millimeters to the left from the middle line, from which fact one was able to draw the conclusion that no large tumor of the left hemisphere could be the cause of the hemiplegia, but, rather, that there was probably a contraction present, perhaps in consequence of an area of softening."\textsuperscript{16}

Howard C. Naffziger, an outstanding neurosurgeon, was born and educated in California. His surgical training was received under William S. Halsted and Harvey Cushing at the Johns Hopkins Hospital, and in 1929 he became Chairman of the Department of Surgery at the University of California. During the following quarter of a century he contributed many original concepts and useful techniques. Among other things, Naffziger emphasized the role of the anterior..."
The recognition of pineal displacement by Schiller and by Naffziger was followed by the more detailed studies of others on the charting of the normal position of the pineal gland. As an indication of the importance of this sign, pineal position has for many years been evaluated routinely in patients with suspected intracranial lesions.

References

A METHOD FOR THE LOCALIZATION OF BRAIN TUMORS—THE PINEAL SHIFT†

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The pineal shift as determined by X-ray examination will frequently localize a brain tumor. This method has been of great value in confirming opinions based on neurological examination, and it alone has frequently made the diagnosis possible.

It has also resulted in widening the range of diagnosis by X-ray examination. Formerly the minority of cases of intracranial pressure yielded X-ray evidence of the location of the lesion. Diagnostic information of a localizing character can now be obtained in the majority.

The percentage of brain tumors and of other gross intracranial lesions which cannot be localized by clinical methods of examination alone is considerable. It varies greatly if one considers the length of time the case is studied. It has been estimated at various figures. Dandy has made the statement that only 50 per cent of the tumors could be located with accuracy sufficient to guide the surgeon. This is probably a low figure for the clinical neurologist. Others have given much smaller percentages, but it seems reasonable to suppose that in a short period of observation there will remain something like 20 per cent which cannot be localized. In these, additional diagnos-

† Reprinted from Surgery, Gynecology and Obstetrics, 1925, 30: 481-484, with the kind permission of the Editor.
tic methods are required. We have found that, by simple and safe means, the number in this small and difficult group can be reduced.

It is a matter of common observation at autopsy that the portion of the brain in which a growth is situated increases greatly in volume. This is not only due to the presence of the lesion itself but to an increase in the fluid content of this hemisphere. To a less extent the brain as a whole becomes oedematous. In such conditions it is not uncommon to find the affected hemisphere even one-third larger than the opposite one (Fig. 1). The dislocation of the falk and of all mid-line structures to one side and the accompanying distortion are very striking.

Shueller [sic.] refers briefly to the displacement of the shadow of the pineal gland due to pressure from tumor or traction on the part of a brain scar. He quotes a case of right hemiplegia, presumably from circulatory causes, in which the pineal shadow was displaced to the left. He concludes that there was contraction of the left hemisphere perhaps from softening and that the pineal was drawn to that side from scar. No autopsy findings or confirmation of the diagnosis were mentioned.

Under the constantly improving methods of roentgenography and particularly with the use of the Bucky diaphragm, greater definition of structures is being obtained and more details are visible. Calcification in the pineal gland which occurs under normal conditions in a large percentage of individuals is often noted in lateral views of the skull. It occurred to us that the position of this structure might be of diagnostic value if variations in it occurred with gross lesions. The pineal shadow is seldom seen in the anteroposterior or postero-anterior view of the skull. This is chiefly owing to the position in which the film is taken. Ordinarily the pineal shadow is obscured by the accessory sinuses. When, however, the direction of the ray is parallel to a line drawn between the external canthus of the eye and the external auditory meatus, the pineal shadow is seen to be projected well above the sinuses. We have found it more advantageous to have the patient in a face up position with the occiput against the film, as the pineal gland is somewhat closer to the back of the head than to the front. If with the head in this position (Fig. 2) the tube is carefully centered so that the central rays pass along the mid-sagittal plane, one can readily determine the relation of the pineal shadow to this plane. Developmentally the pineal is a true mid-line structure. There is little to indicate that its calcification has any pathological significance. A study of a large number of normals has shown that the shadow lies exactly in the mid-line (Fig. 3).

In all conditions associated with intracranial pressure and in the presence of a calcified pineal, our cases have been studied from films taken as described. It has been shown in the presence of intracranial pressure that where the lesion is located in the right cerebral hemisphere the pineal shadow has been shifted from its position in the mid-line toward the opposite side. The degree of pineal shift, as we have termed it, varies considerably. A common shift is a distance of about 1 centimeter (Fig. 4). We have, however, found it displaced away from the lesion for a distance of 2.5 to 3 centimeters (Fig. 5). When the gross lesion is on the left side, the pineal shift occurs to the right. The shift has been present whether the growth has been frontal, parietal, or occipital. With lesions of the posterior fossa or base which produce a high degree of intracranial pressure from an internal hydrocephalus, the lateral ventricles, both right and left, have been uniformly dilated. The pressure is so uniformly distributed, that the mid-line structures have not been dis-

Fig. 1. Frontal section of brain showing a metastatic tumor with fresh hemorrhage into it. Note the great increase in volume of this hemisphere and the dislocation of the mid-line to the opposite side.

Fig. 2. Diagram showing the position of the head.
torted and the pineal retains its true mid-line position. No shift occurs. These experiences have been true in 15 cases proved by operation or autopsy.

**ILLUSTRATIVE CASES**

The following illustrate the pineal shift in cases with obvious signs of localization:

**CASE 1.** Pineal shift away from tumor (Fig. 4). E. W. University of California Hospital. No. 46667. Female, age 37. Diagnosis: glioma right frontal—cystic partly calcified. Cyst evacuation. This patient had a proved cystic glioma of the right frontal region. The roentgenogram is of interest in showing both the tumor partly calcified and the pineal shift toward the opposite side.

**CASE 2.** Marked shift of pineal to right with left temporoparietal tumor (Fig. 5). M. L. J. University of California Hospital. No. 46035. Female, age 55. Brain tumor left parietal, not proved. Patient entered hospital with a right hemiplegia and complete aphasia of gradual onset over several months. Choked discs and stupor were present. Neurological examination showed no involvement of cranial nerves, but the usual findings of a hemiplegia. Localization of lesion presented no problem but marked shift of pineal shadow to right was of interest.

**CASE 3.** No shift of pineal shadow with internal hydrocephalus. F. V. University of California Hospital. No. 45892. Female, age 37. Acoustic neuroma proved. Tumor removal. This patient gave the characteristic chronologic sequence of symptoms with typical findings. The fifth and seventh nerves were involved along with the eighth. The cerebellar signs were pronounced and a high degree of intracranial pressure evidenced by highly choked discs. Marked internal hydrocephalus was proved by ventricular puncture.

The X-ray report noted—Pineal shadow in mid-line. No shift.

**Fig. 3.** Normal skull. A true postero-anterior projection showing the calcified pineal in the mid-line just above the frontal sinuses.

**Fig. 5.** Marked shift of the pineal shadow.
As an indication of the determining value of the method, the following is one instance.

Case 4. E. F. Patient seen in consultation, May 24, 1924 with Drs. Fred Fairchild and Harbinson at the Woodland Sanitarium, Woodland, California. The patient was in stupor with slightly swollen optic discs and evidence of intracranial pressure. From the history his condition was presumably due to brain abscess. His state prevented perimetric fields, sensory tests, etc. There was a story of difficulty in the use of the left hand. It proved impossible for us to determine by examination of the patient whether we were dealing with an involvement of tracts in the right cerebral hemisphere or with a left cerebellar lesion. The roentgenograms previously taken in the usual manner gave no localizing information. It was noted, however, that these plates showed a calcified pineal. The patient was returned to the X-ray room. Films were taken in the manner here described, and it was found that the pineal shadow was in the exact mid-plane. Its position argued against a right cerebral lesion and for an internal hydrocephalus. With this aid a diagnosis of a left cerebellar abscess was made, found at operation and evacuated with recovery.

Reviews of a considerable number of X-ray plates have been undertaken with a view to determining in just what percentage of individuals the pineal gland is calcified. Various factors affect these figures, principally the age of the patient and the character of the roentgenogram itself. The percentage of calcified pineals is, of course, much decreased if any large number of children is included. In patients of greater age, a larger percentage of positives is obtained. The following figures are based on a study of 215 consecutive cases:

<table>
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<th>Total skulls</th>
<th>Percent</th>
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<tr>
<td>Pineal calcified</td>
<td>215</td>
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<tr>
<td>In 45 cases under 20 years of age, 7 were calcified, or</td>
<td>45</td>
</tr>
<tr>
<td>In 96 cases over 20 years of age, 56 were calcified, or</td>
<td>58</td>
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In general it has been found that in something like 50 per cent of cases, the pineal gland is sufficiently calcified to be of diagnostic value. The two essentials for the use of this method of diagnosis are of course, first, that there is sufficient pineal calcification to cast a shadow; and, second, that intracranial pressure is present. It is doubtful whether any considerable dislocation of the gland will occur if there is not sufficient pressure to give intracranial signs. If, however, intracranial pressure is present as indicated by papillitis or choked discs, or possibly in more acute cases by an actual rise in the spinal manometer reading, it offers great help. Subacute and acute conditions such as abscesses and haemorrhages, have given the characteristic shift. Stereoscopic plates are of decided help and permit one, without any great difficulty, to recognize even slight dislocation of the shadow from the mid-line. Studies are now being made from lateral views of the skull to determine the normal position of the gland in horizontal and vertical planes with reference to the skull as a whole. It is hoped that further observation and study may enable us so to standardize the lateral roentgenograms of the skull that we can detect an anterior or posterior or an up and down deviation of the gland from its normal position. It is also possible that if such conditions as transient oedema or swelling of one-half of the brain occurs, this method may be of value in detecting it.

Inasmuch as about 50 per cent of all cases showed calcified pineals and possibly 20 per cent or more of the intracranial gross lesions cannot be localized by clinical methods alone, this method will give us localizing information in one-half of these.

CONCLUSIONS

When the pineal gland is calcified (in about 50 per cent of all skulls), its position gives diagnostic information in cases with intracranial pressure. The shift has been found with brain tumors, brain absceses, and in certain cases of brain swelling consequent upon a vascular block.

A position of the pineal to the right of the mid-sagittal plane indicates a left sided lesion above the tentorium.

A position of the pineal to the left of the mid-sagittal plane indicates a right sided lesion above the tentorium.

A position of the pineal in the mid-sagittal plane in the presence of intracranial pressure indicates equal pressure on the two sides. In the chronic form of intracranial pressure as due to tumor or abscess this means internal hydrocephalus. This has been found occurring in lesions of the posterior fossa and distortion of the third and fourth ventricles.

In the roentgenological development of this method and the observations on most of the proven cases, I desire particularly to thank Howard Ruggles and Lloyd Bryan for their interest and aid. For additional observations and statistics on pineal calcification, I am indebted to James Thom, J. Rehfisch, and A. E. Elliott.

REFERENCE