

ON THE ARTERIES FORMING THE CIRCLE OF WILLIS.<sup>1</sup> By BERTRAM C. A. WINDLE, M.A., M.D. (Dubl.), *Professor of Anatomy in the Queen's College, Birmingham.*

So far as I am aware, no attempt has been hitherto made to classify the abnormalities and variations of the larger cerebral arteries, as the result of observations made on anything like an extensive scale. Quain, in his otherwise exhaustive work, devotes but a very short space to these vessels, and other authors have followed his example. I have been for some time collecting statistics on this subject, and published a few years ago a preliminary note,<sup>2</sup> in which the conditions met with in sixty-five cases were described. The number of those of which I have information now amounts to 200, and the results obtained seem now to be worthy of record. I have examined the majority of these myself; for those which I have not seen I have to rely chiefly upon the careful notes made for me by friends who have occupied the position of pathologist to the General Hospital in this town, to whom, as to my friend and assistant Dr Hogben, who has also favoured me with information, I have to express my obligations. In seventy-six of the cases, the condition which obtained was strictly that which is described in the text-books as the normal arrangement.

In forty-three, however, of those reckoned as abnormal, the only deviation was a more or less well-marked disproportion between the posterior communicating arteries of the two sides. If we disregard this condition, we may say that in 119 cases out of 200, the normal number and arrangement of the arteries was present. I shall describe the variations under the head of each of the arteries forming the circle *seriatim*; in so doing it will be impossible to avoid a certain amount of repetition.

*Anterior Communicating Artery.*—In 159 cases this vessel

<sup>1</sup> Read before the Anatomical Society of Great Britain and Ireland, Nov. 22nd, 1887.

<sup>2</sup> *Birmingham Medical Review*, May 1884.

was normal. The most common abnormality was that of duplicity, which condition was met with in fourteen cases. Once three communicating arteries were found. In six cases there was an attempt at duplicity, or rather an incomplete form of this abnormality, in the shape of a second communicating artery placed behind the true vessel and falling into it, a triangular intervascular space being thus enclosed. In six cases there was no true communicating artery on account of a union of anterior cerebrals replacing it, a condition described by Quain as rare, and in two other instances this condition was associated with the presence of a normal communicating artery, the connection between the anterior cerebrals thus being double. In two cases there was no true communicating artery on account of the presence of only one anterior cerebral, and in one case there was none, from the complete fusion of the two anterior cerebrals. In nine cases a median artery arose from the anterior communicating.

*Anterior Cerebral Arteries.*—These arteries were normal in 181 cases. In nine instances a third branch was present, which may be described under the name of *A. cerebralis anterior media*. It arose in each case from the anterior communicating artery, and passed forward in the longitudinal fissure, between its two companion branches, for about two-thirds of the length of the corpus callosum. It then divided into branches for both the opposed surfaces of the hemispheres. Quain<sup>1</sup> mentions as a very rare variety a case of absence of anterior cerebral artery, which he quotes from a work of Arnold's,<sup>2</sup> which I have been unable to consult. The place of the missing vessel was taken by slender branches forming a communication between the single anterior cerebral artery and the internal carotid of the opposite side.

I have seen two similar cases. In both the missing vessel belonged to the right side. In one its place was, to a certain extent, supplied by fine twigs from the right middle cerebral; in the other by a thread-like branch, representing the missing vessel, which sprang from the right internal carotid. In another case, which may be regarded as an intermediate condition

<sup>1</sup> *Commentaries on the Arteries*, p. 510.

<sup>2</sup> *Bemerk. über den Bau des Rückenmark*, von Dr Friedrich Arnold, Taf. 2.

between the last and the normal, the vessel of the right side was double the size of that of the left. It is worthy of note that in Quain's case, as in the three just detailed, it was the artery of the right side which failed. In one case the two anterior cerebrals united to form a single trunk which ran as such to its termination in the longitudinal fissure, giving off branches on either side to the surfaces of the hemispheres. Lastly, it may again be mentioned that the anterior cerebrals in eight cases united for a short distance, six times replacing and twice accompanying the anterior communicating.

*Posterior Cerebral Arteries.*—In 173 cases these vessels were normal. The commonest variety in connection with these vessels is the derivation of one or other or both from the internal carotid instead of the basilar. In eleven cases I found the right thus derived, in nine the left, and in four both. In three cases there were two posterior cerebral arteries on the same side, once on the right, twice on the left. In each case one vessel, the smaller, was derived from the basilar, the other from the carotid; both took the course of the normal posterior cerebral, and the vessels were united by one or more small anastomosing branches. I may perhaps here mention that I once saw the third nerve divided into two portions, which afterwards reunited by a twig from the posterior cerebral artery.

*Posterior Communicating Arteries.*—If disparity in size be left out of consideration these vessels were normal in 175 cases. The anomalies consisted in absence of one or both vessels. That of the right side was absent in nine instances, of the left in thirteen, and both were wanting in three. A marked disparity in size is more common. In twenty-eight cases the right was much larger than the left, in fifteen the left was larger than the right. In seven cases both vessels were extremely small. Where one or both arteries were wanting, there was not always a complete want of communication between the two sides. On the contrary, in the majority of cases there was a slight anastomosis in the interpeduncular space between small twigs passing from the basilar and carotid to the base of the brain in that position.

It should be noticed that the left side suffered most, both in the cases where one artery was wanting, and in those where

one was smaller than the other. In this connection it may be remarked, firstly, that the facts show that the supply of blood to the left side of the brain is, on the whole, less complete than that to the right, which militates against a theory<sup>1</sup> which has been put forward to account for right-handedness by the superior nutrition of the left half of the cerebrum. Secondly, the relative frequency of absence or diminution of size of the posterior communicating artery of the left side may perhaps in some cases explain the lodging of an embolus in the left middle cerebral artery, rather than in the right.

The following instances of variations in connection with these vessels may be particularised:—

1. In this case two arteries sprang from the internal carotids in the position normally occupied by the posterior communicating. Instead, however, of joining the posterior cerebral, they passed to the under surface of the temporo-sphenoidal lobe which they supplied. A few filaments from each of these anastomosed with slender twigs from the posterior cerebrals.

2. In this case the artery of the left side behaved in a similar manner to those of the previous one. There was a very small but normally placed branch on the right side.

3 and 4. In these brains there was no artery on the left side, and a mere thread on the left.

5. The posterior communicating of the left side commenced at its carotid extremity as a trunk of nearly normal size, but by giving off numerous branches to the base of the brain, was reduced to a thread before inosculating with the posterior cerebral.

6. There was no true posterior communicating on the left side; the trunk representing it passed backwards beside the posterior cerebral, shared in its distribution, and was connected with it by a very slight anastomosis of twigs derived from both.

The following anomalies do not come under any of the previous heads.

1. Described by Quain. A large branch of the left internal carotid turned backward, and after perforating the basilar part of the sphenoid bone, joined with the basilar artery, forming in fact the anterior part of that vessel.

<sup>1</sup> Professor Rolleston, *Brit. Assoc.*, 1877, v. *Nature*, September 6, 1877.

2. This anomalous vessel occurred in a brain removed at a *post-mortem* examination; owing to the fact that it was not at once examined, I was unable to determine its origin. The right posterior communicating artery was absent, and the right posterior cerebral arose from the internal carotid. A vessel of unknown origin ran along the right side of the pons to the right crus, along which it coursed, and crossing the right optic tract, terminated in the right Sylvian fissure by inosculating with the middle cerebral artery. In this course it communicated with (1) right superior cerebellar artery; (2) by a branch running across the middle of the crus, with a branch from the end of the basilar, which probably represented the posterior communicating otherwise wanting; before turning into the Sylvian fissure, this vessel gave off a branch which, passing in front of the optic commissure, terminated in the anterior fissure.