

# TORTUOSITY OF THE CERVICAL SEGMENT OF THE INTERNAL CAROTID ARTERY

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THAT the cervical portion of the internal carotid artery may in some cases be tortuous is mentioned in the recent editions of most of our standard text-books, usually in small type under the heading of peculiarities or of variations. The statements to be found in Gray (22nd edition, 1923) and Piersol (7th edition, 1919) may be mentioned as typical: according to Gray, "The course of the artery, instead of being straight, may be very tortuous"; according to Piersol, "In its cervical portion the internal carotid occasionally takes a somewhat sinuous course, and, especially in its upper part, may be thrown into a pronounced horseshoe-shaped curve."

A rather greater frequency than these statements imply is indicated by some of the earlier descriptions. Thus Hart, who wrote the article on the carotid artery in Todd's *Cyclopaedia* nearly 90 years ago, appears to have regarded a tortuous condition of the internal carotid in its cervical portion as normal; according to his description, the artery "mounts upwards and forwards in front of the three superior cervical vertebrae, and making a few contortions along the side of the pharynx, enters the foramen caroticum of the temporal bone." Harrison, about ten years later, accepted tortuosity as the rule rather than the exception; describing the internal carotid artery (*The Dublin Dissector*, 5th edition, 1847), he says: "This vessel, through its entire course, is remarkable for its tortuosity; in the neck it is very variable in this respect, but is generally bent into several curves." In this connexion it is interesting to note that certain text-books in other languages, for example, Poirier and Charpy and Rauber-Kopsch, in contrast to those in English, still describe a sinuous course of the artery as the normal.

Certain of the older text-books, in discussing tortuosity of the internal carotid, refer to actual cases which had been observed. Quain (6th edition, 1856) describes a case in which the artery "was observed, after having reached nearly to the base of the skull, to turn downwards for more than an inch, and then abruptly to ascend again, being thus twice closely curved or folded on itself." Ledwich (*The Practical and Descriptive Anatomy of the Human Body*, 1877) mentions an instance of "a very peculiar course of the internal carotid," which consisted in a similar though longer tortuosity. Certain of the clinical journals contain descriptions of further cases, among them being

those recorded by Edington (1901), Rowlands and Swan (1902), Smith (1902), Fisher (1915), and Schaeffer (1921).

**CASES OF TORTUOSITY OF THE INTERNAL CAROTID ARTERY  
OBSERVED IN THE ADULT**

The question of tortuosity of the internal carotid artery first came under my notice about eighteen months ago, and since that time I have personally examined these vessels in every subject that has been dissected in this department. The observations now extend over five terms, during which the head and neck have been dissected in 36 subjects. Of these, 10 showed definite tortuosity of the cervical portion of the internal carotid on one or both sides; in 2 subjects the condition was bilateral, while in the remaining 8 it was unilateral, existing on the right side in 6 cases, and on the left side in 2. Thus, of 72 internal carotids examined, 12 were found to be definitely tortuous. The main facts of these cases are indicated in Table I, the cases being numbered in the order of their occurrence; the specimens themselves are depicted (as seen from in front) in fig. 1, the number of the case being noted beneath each.

The examination of these specimens shows that in each case the tortuous segment of the vessel consists of two bends, which for convenience in reference

Table I

Case No.	Age	Side on which tortuosity present	Plane of tortuosity	Bend which is medial	Relation to pharynx and tonsil
1	83	Right	Approximately midway between sagittal and coronal	Second	Region of second bend is nearer pharynx than usual position of the artery, but the part of the pharynx to which it approaches is above and behind the tonsil
2	84	Right	First bend forwards in sagittal plane; second in coronal plane	Second	Ascending limb of second bend in contact with pharynx just above upper pole of tonsil
3	78	Right	Approximately midway between sagittal and coronal	First	The portion of the artery ascending to the first bend is in contact with the pharyngeal wall for about 1 cm. in region of tonsil
4	76	Right	Approximately midway between sagittal and coronal	First	The portion of the artery ascending to the first bend is in contact with the pharyngeal wall for about 1 cm. in region of tonsil
5	73	Right	First bend in coronal plane; second backwards in sagittal plane	Second	Junction of first and second bends is nearer pharynx than usual position of the artery, but the part of the pharynx to which it approaches is a short distance above upper pole of tonsil
6	78	Right	First bend forwards in sagittal plane; second in coronal plane	First	The portion of the artery ascending to the first bend is nearer pharynx than the usual position of the artery, opposite upper pole of tonsil
7	Old age	Both	On right side: first bend in coronal plane; second backwards in sagittal plane	Second	Medial aspect of second bend almost in contact with pharynx, a short distance above upper pole of tonsil
			On left side: first bend forwards in sagittal plane; second in coronal plane	Second	Ascending limb of second bend almost in contact with pharynx about 1 cm. above upper pole of tonsil
8	Old age	Left	First bend in coronal plane; second backwards in sagittal plane	Second	No part nearer pharynx than usual. (Tortuosity just below base of skull and entirely lateral to carotid canal)
9	72	Left	Approximately midway between sagittal and coronal	Second	No part nearer pharynx than usual. (Tortuosity just below base of skull and entirely lateral to carotid canal)
10	69	Both	On both sides: first bend forwards in sagittal plane; second in coronal plane	Second	On both sides, ascending limb of second bend in contact with pharynx for about 1 cm. on left side in region of tonsil, and on right side just above tonsil

we may term first and second, or proximal and distal, taking them in order as we follow the vessel along its whole length from its origin to its entrance into the carotid canal.

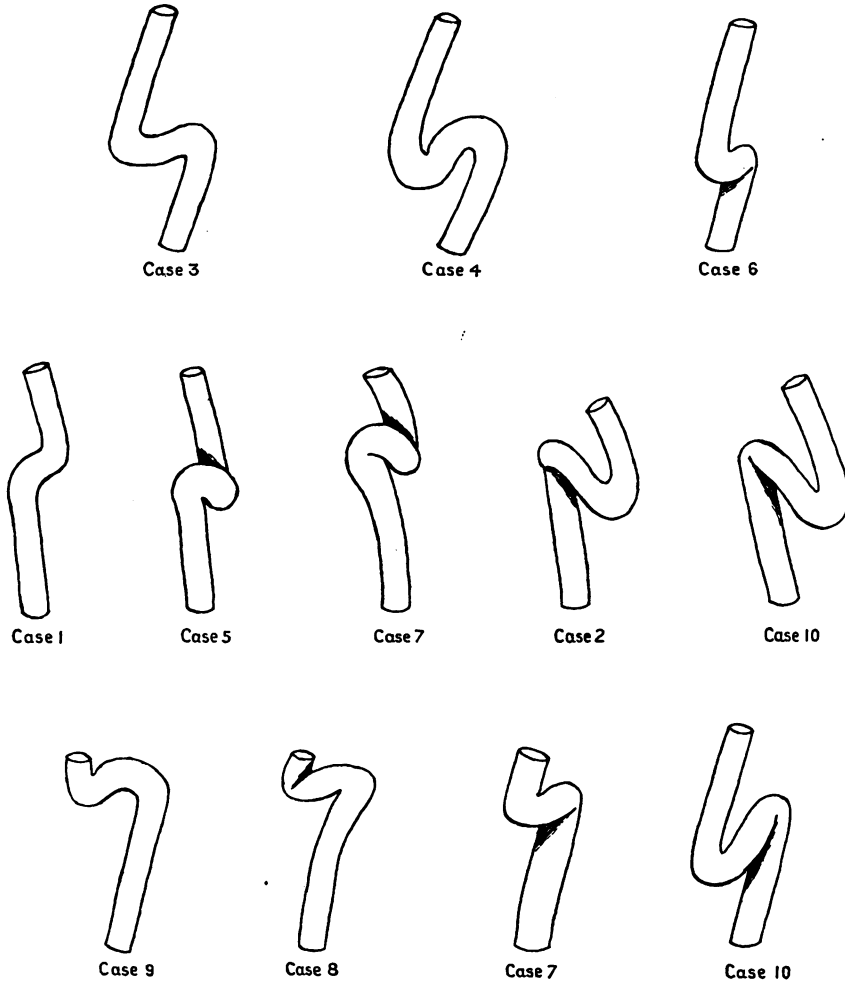


Fig. 1. Tortuous internal carotids in the adult (seen from in front).

Upper row: cases in which the first bend is medial; all specimens from right side.

Middle and lower rows: cases in which the second bend is medial; middle row are specimens from right side, lower row from left side.

In the cases which I have seen, the plane of the tortuous segment of the artery varies, three types being recognisable: in the first type, the tortuosity lies all in one plane, approximately midway between sagittal and coronal (cases 1, 3, 4 and 9); in the second type, the first or proximal bend is in the coronal plane, while the second or distal bend is backwards in the sagittal

plane (cases 5, 7 on the right side, and 8); in the third type, the proximal bend is forwards in the sagittal plane, while the distal bend is in the coronal plane (cases 2, 6, 7 on the left side, and 10). In all of these types one bend is in every case situated medial to the other; viewed as a series, however, the cases show some instances in which the first bend is the medial one and others in which the second bend is medial. In fig. 1, those specimens in which the first bend is medial are shown in the upper row, while in the other two rows are included those specimens in which the second bend is medial to the first.

With regard to the plane of the tortuosity, it should be noted that, while only the three types mentioned were observed in the present series, other types have been described. Fisher (1915) describes a case in which the tortuosity (present on both sides) was entirely in the sagittal plane, and quotes a case recorded by Stimson, in which a tortuosity near the origin of the vessel lay in the horizontal plane; while from the study of the literature it appears evident that cases have also occurred in which the tortuosity was entirely in the coronal plane. The case recorded by Smith (1902) is peculiar in that the vessel formed a complete circular coil.

#### THE RELATION OF THE NORMAL AND THE TORTUOUS INTERNAL CAROTID ARTERY TO THE PHARYNX AND THE TONSIL

Although it is now definitely established that the internal carotid artery normally lies behind and lateral to the tonsil and separated from it by an interval of about an inch, reference to earlier editions shows that some at least of our standard text-books have passed through a stage in which the internal carotid was described as lying directly lateral to the tonsil, separated from it only by the superior constrictor muscle of the pharynx. Of this fact Gray's *Anatomy* forms an interesting example. In the 11th edition (1887), the internal carotid is mentioned in three separate places as lying directly lateral to the tonsil: firstly, in the description of the artery; secondly, under the heading of the surgical anatomy of the artery; and thirdly, in the description of the tonsil. The 16th and 17th editions show these three separate statements in process of emendation. In the 16th edition (1905), in the description of the artery the tonsil is mentioned as one of the medial relations, and this relation is emphasised under the heading of surgical anatomy; in the description of the tonsil, however, the artery is stated to lie "behind and to the outer side of the tonsil, and nearly an inch (20 to 25 mm.) distant from it." In the 17th edition (1909), the statement under the heading of the surgical anatomy of the artery has also been corrected, with the result that only in the description of the artery does the former inaccuracy remain; in the more recent editions the discrepancy has been removed by the omission of the tonsil from the list of the medial relations of the artery. Quain's *Elements of Anatomy* shows a similar change; in this case, however, the relation is mentioned in only two places, and both statements are corrected in the 10th edition (1892 and 1896). Morris's *Human Anatomy* still shows a

discrepancy similar to that which existed for a time in Gray: in the 6th edition (1921) the artery is still described as being in relation on its medial side with the tonsil (separated by the superior constrictor), while a similar statement in the description of the tonsil was corrected in the 2nd edition (1898).

In the description of the tonsil in Poirier and Charpy, the correct relation of the artery to the tonsil is stated to have been demonstrated by Otto Zuckerkandl in 1887. The fact, however, that the artery is normally some distance away from the tonsil appears to have been known to English writers at least fifty years previously; thus Hart, in his description of the artery in Todd's *Cyclopaedia* (1835-1836) states that the artery lies external and posterior to the tonsil "at a distance of from six to eight lines in the natural state of the parts"; while Harrison, in his description of the tonsil in the *Dublin Dissector* (5th edition, 1847), states that "the internal carotid artery is posterior and somewhat external to it," and that the tonsil is separated from the artery "by the superior constrictor and by a considerable interval filled by cellular tissue." Among the French authorities, Cruveilhier (Tome II, 5th edition, 1874-1876), in describing the tonsil, mentions the relation of the internal carotid to it as follows: "Un rapport important est celui qu'elle affecte avec la carotide interne, mais ce rapport est très-éloigné."

That the internal carotid may sometimes be wounded during operations on the tonsil is mentioned by various authorities, the earliest reference to such a possibility in the literature at my disposal being in the article by Hart, who describes it as "an occurrence of which the records of experience are not without examples." During the stage in which the internal carotid was described as lying directly lateral to the tonsil, the explanation of such cases appeared obvious; thus Gray through several editions emphasises the practical importance of such a relation on the ground that "cases have occurred in which the artery has been wounded during the operation of scarifying the tonsil and fatal haemorrhage has supervened." In more recent years, since the normal position of the artery relative to the tonsil has become generally recognised, the text-books of surgical anatomy have in consequence come to regard any damage to the internal carotid during operations on the tonsil as a rather unlikely accident. The following sentence, occurring in the recent editions of Treves and Keith's *Surgical Applied Anatomy*, probably represents an accurate statement of the general opinion to-day: "The vessel is, indeed, about  $\frac{1}{2}$  of an inch posterior to that body, and is in comparatively little danger of being wounded when the tonsil is excised." A more extreme view is advanced by Campbell in his text-book of *Surgical Anatomy* (3rd edition, 1921): "The source of tonsillar haemorrhage is worthy of consideration since the internal carotid artery continues, in the minds of some operators, a possible factor in tonsillar haemorrhage....It is impossible to injure the internal carotid artery in tonsillectomy." Campbell's statement to the contrary, cases certainly have occurred in which, during the operation of tonsillectomy, skilled operators have wounded the internal carotid artery with fatal results; one such case

is referred to in the Paris letter of the *Journal of the American Medical Association* for February 19th, 1921; the patient was a young girl, and the operation was performed by an expert surgeon; "a judicial necropsy was held, and a large tear was discovered in the internal carotid artery."

The most reasonable explanation of the occurrence of such cases appears to consist in the recognition of tortuosity of the internal carotid as a factor in bringing the vessel nearer the pharyngeal wall—in the words of Schaeffer (1921), "occasional marked sigmoid tortuosity of the cervical segment of the internal carotid artery, whereby the vessel is forced into intimate topographic relationship with the palatine or faucial tonsil, the usual distance of 2.5 cm. between the tonsil and the artery being obliterated." This view, it may be noted, is not by any means new. It is mentioned by Cruveilhier (Tome III, 5th edition, 1877), and is well expressed by Testut (Tome II, 4th edition, 1900) as follows: "La carotide interne, généralement rectiligne, peut être plus ou moins flexueuse et décrire ainsi des courbes très variables par leur nombre, leur direction, leur étendue; l'une de ces courbes vient parfois se mettre en rapport avec la face externe de l'amygdale, dont l'ablation peut, dans ces cas, être fort dangereuse." Tortuosity as a factor in bringing some portion of the artery nearer the tonsil than usual was recognised by Harrison (1847), according to whose description the internal carotid artery is posterior and somewhat external to the tonsil, "and, when tortuous, very near to it"; and also by Macalister (1889) who, in describing the tonsil, wrote: "When the internal carotid artery is tortuous it lies close to its hinder and outer surface, separated therefrom by the superior constrictor muscle of the pharynx."

In the twelve cases of tortuosity of the internal carotid artery which I have observed in the adult, there were only two in which some part of the tortuous segment was not brought nearer the pharyngeal wall than the usual position of the artery; in these two instances, the tortuosity was situated just below the base of the skull and entirely lateral to the carotid canal. In the remaining ten cases, the plane of the tortuosity was such that the most medial portion of the tortuous segment was in all cases not only medial but also ventral to the usual position of the artery, in this way approaching, and in some cases coming actually in contact with, the pharyngeal wall.

In this series of cases, there are three in which the artery comes to lie directly lateral to the tonsil for an appreciable distance (in each case about 1 cm.), only the superior constrictor intervening; these are no doubt cases in which during life pulsation might have been left in the tonsillar field, and the position of the vessel might have added an element of risk in operations on the tonsil. It is, however, evident that the occurrence of tortuosity does not of necessity imply an intimate relation of the tortuous segment to the tonsil. Thus the observations of Kelly (quoted by Fisher, 1915) appear to show that, when the tortuosity is entirely in the coronal plane, it may cause pulsation not in the lateral wall but in the dorsal wall of the pharynx. Again,

the level of the tortuosity is an important factor in determining the relation of the artery to the tonsil; in my series, the majority of the vessels show tortuosity at a level which is entirely above the upper pole of the tonsil. In this connexion, the question of whether the proximal or the distal bend is the one nearer the pharynx assumes importance; thus, in cases 3 and 4, in which the first bend is medial, the portion of the vessel ascending to that bend lies directly lateral to the tonsil, while in case 2, in which the second bend is medial, the portion of artery ascending from that bend lies entirely above the tonsil. The lateral extent of the tortuous segment is also worthy of note; in certain of the cases recorded here, the tortuous segment did not come into contact with the pharyngeal wall but remained separated from it by an interval.

#### CAUSATION OF TORTUOSITY OF THE CERVICAL SEGMENT OF THE INTERNAL CAROTID ARTERY

Speaking generally, one may say that two views have been advanced to explain the occurrence of tortuosity of the cervical portion of the internal carotid: (1) the older view, favoured by Edington (1901), Rowlands and Swan (1902), and Moorhead (1902), to the effect that the condition is in all cases entirely due to arterio-sclerosis and increased arterial pressure occurring either in old age or as a result of disease such as chronic nephritis; (2) the more modern view, advanced by Fisher (1915) and by Schaeffer (1921), to the effect that the condition is congenital and probably represents a reversion to a more primitive type. From the clinical standpoint, the question of which of these opposing theories is correct is no doubt of considerable importance.

The older theory appears to have been the natural outcome of the fact that cases of tortuosity were observed entirely in dissecting-room subjects, in whom, on account of their advanced years, sclerosis of the arteries may safely be assumed in the majority of instances. For this reason the condition of tortuosity appears to have been regarded as nothing more or less than a condition likely to be seen more or less frequently in old age, a view that still finds a place in the latest edition of Morris's *Anatomy*. In the case recorded by Edington (1901), the age of the subject was only 34; the cause of death was, however, certified as chronic Bright's disease, and this fact led Edington to express the opinion that the condition "might perhaps be associated with the arteritis of chronic nephritis."

The fallacy of reasoning entirely from the ages of dissecting-room subjects in whom a tortuous condition of the artery is found was first pointed out, I believe, by Fisher (1915); in the majority of cases the subjects in whom tortuosity is present are no older than those in whom the condition is absent, and the dissecting-room as a rule offers little opportunity for making observations on younger individuals. In both of the cases which Fisher himself observed, sections of the vessels were examined microscopically, and were reported as showing that the evidence of atheroma was very slight indeed and quite insufficient to account for the tortuosity. In all the cases which

I have seen, there was certainly a complete absence of any visible and palpable change in the wall of the vessel such as one commonly sees in other arteries (e.g. the tibial and the radial) which have become tortuous; only one specimen was sectioned for microscopical examination, and in this case, though sclerosis could definitely be detected, it appeared insufficient to account for the marked tortuosity of the vessel. It must, I admit, be conceded that in the case of the cervical portion of the internal carotid, on account of the fact that the succeeding portion of the vessel is fixed in the carotid canal, less degenerative change might permit tortuosity to be produced than in the case of other arteries; on the contrary, however, I would suggest that to demonstrate arterio-sclerosis in a tortuous internal carotid from a subject of advanced years is after all of little value as evidence, since it is impossible to state whether the sclerosis is responsible for the tortuosity or whether it is merely an old-age change occurring in an already tortuous artery.

The evidence on which the more modern theory is based appears to consist in the main of the observation of pulsating vessels in the pharynx in the living subject. Fisher quotes Kelly as having shown that the presence of large pulsating vessels in the posterior wall of the pharynx in four cases was due to tortuosity of the internal carotid artery; one of the patients (in whom the condition was bilateral) was aged 22; Kelly's reasoning appears to have been based on the resemblance in shape and size between the tortuous vessels seen in the pharynx and tortuous internal carotids in a museum specimen. Schaeffer (1921) mentions Farlow as having observed large pulsating arteries in the pharynx, which he believed to be internal carotids, in patients as young as 14 years, and Wood as having reported similar large pulsating vessels in two children aged 5 and 7 years respectively.

In the hope of possibly supplying a little further evidence on this question, I recently dissected the internal carotid arteries in 20 foetuses of ages ranging from about five months to full term. Of these, four showed definite tortuosity of the cervical portion of the internal carotid, and in one instance the condition was bilateral, making a total of five cases of tortuosity in 40 internal carotids examined. The specimens from these cases are shown in fig. 2. This

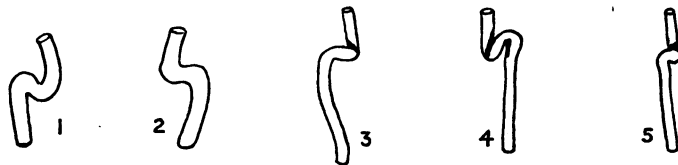


Fig. 2. Tortuous internal carotids in the foetus.

investigation certainly indicates that tortuosity of the vessel is not by any means limited to old age, but that, on the contrary, in some cases at any rate it is congenital. Whether the condition is as frequent in the young as in the old I am not in a position to state; while my personal observations show a



fairly close correspondence between the proportion of tortuous internal carotids in the foetus and the proportion in the adult of advanced years, the numbers of each class examined have been relatively few, and the examination of a much larger series would be necessary in order to provide figures on which further reasoning might safely be based.

If then it is admitted that in some cases (if not in all) the occurrence of tortuosity is congenital, we have still to enquire in what manner and due to what factors the tortuous condition of the vessel becomes developed. Fisher suggests that the explanation is to be found in the study of comparative anatomy; he points out that in many mammalia the internal carotid is more tortuous than in man, and quotes Chauveau's statement to the effect that in the seal the carotid artery is nearly forty times longer than the distance it has to traverse; from such considerations he concludes that "it would be surprising if we did not meet with great tortuosity of the internal carotid artery as a congenital abnormality in man." In the human subject, so far as I can ascertain, no reference to embryology throws any particular light on the condition.

#### SUMMARY AND CONCLUSIONS

1. Tortuosity of the cervical portion of the internal carotid artery is a condition which was definitely recognised at least nearly 90 years ago, and in most of our standard text-books is briefly mentioned as being occasional in its occurrence. Individual cases have been described by a number of observers, and twelve further instances, seen in the examination of 36 dissecting-room subjects, are presented here.

2. In the great majority of cases, the internal carotid artery when tortuous approaches nearer to the pharynx than its usual position, and in some instances comes to lie actually in contact with the dorsal or the lateral pharyngeal wall. In a certain proportion of such cases, but by no means in all, the artery becomes a directly lateral relation of the tonsil, only the superior constrictor intervening.

3. Cases have been observed in life, not only in adults but also in children, in which pulsation in the dorsal or the lateral pharyngeal wall has probably been due to tortuous internal carotid arteries, while the occasional relation of such a vessel to the tonsil no doubt explains the fortunately rare cases in which the internal carotid artery has been wounded by skilled operators during the operation of tonsillectomy.

4. A tortuous condition of the cervical portion of the internal carotid artery is, in some instances at least, congenital, as is shown by the observation of five instances in the examination of these vessels in 20 foetuses; but whether all cases occurring in subjects of advanced age are explainable on the hypothesis of the condition being congenital requires a much larger series of cases to determine.

In presenting these observations, I desire to record my thanks to Prof.

W. P. Gowland for permission to publish the cases which have occurred in the dissecting-room of this department, and for authority to examine the internal carotid arteries in a certain number of foetuses.

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