PHYSIOLOGICAL EFFECTS

PRODUCED UPON THE BRAIN

BY THE

Ligature of Both Primitive Carotid Arteries,

WITH THE STATISTICS OF THIS OPERATION.

BY GEO. C. BLACKMAN, M.D.

Professor of Surgery in the Medical College of Ohio, Surgeon to the St. John's, and Commercial Hospitals, Cincinnati; Fellow of the Royal Medical and Chirurgical Society of London.

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This interesting inquiry engaged the attention of Galen, Valsalva, Morgagni, and Van Swieten, and from their experiments on animals they came to the conclusion that in these the carotids might be obliterated without producing any serious result. The more modern experiments of Maunoir, Bichat, Mayer, Sir Astley Cooper, Dr. Kellie, Dr. Mott, M. Jobert, and Prof. Porta, of Pavia, in the main corroborate the conclusions derived from those made at an early period. True, a discrepancy exists in the opinions formed by Sir Astley Cooper and Prof. Porta as to the comparative influence of the carotid and vertebral arteries; the former believing that in animals the carotids are intended rather for the supply of blood to the external parts of the head than to the brain itself, and that it is only when the latter organ becomes more developed, as in man, that the carotid arteries acquire greater importance. Prof. Porta, on the other hand, whose extensive investigations on this subject have never been surpassed, if, indeed, equalled, is of the opinion that in their influence upon the brain the vertebral are of no higher importance than the carotid arteries. The weakness of the extremities, dyspnœa, and nervous symptoms which Sir Astley Cooper regarded as indicative of a defective supply of blood to the brain, according to Prof. Porta are but the results of the depressing influences which accompany every severe operation, and not of cerebral anæmia. It is remarkable that in upward of a hundred cases of ligature of one or both carotids in

dogs, sheep and goats, no evidences of a deficient supply of blood to the brain were manifested. It is difficult to account for the difference in the results of the experiments of this Italian surgeon and of Prof. Mayor, of Bonn. In his essay, *Ueber das Gehirn, das Ruckenmark, und die Nerven*, etc., he states that most of the dogs, rabbits, pigeons, horses, goats, and marmots, in which he tied both carotids, died. Even when but one artery was tied, he found that the operation produced slight insensibility and loss of power. But it is not our purpose to explain the variable results obtained by the different experimenters already mentioned, and with M. Dubreuil we are disposed to believe that the differences in the size and development of the brain, as well as in the circulatory apparatus of this organ, should destroy the force of arguments drawn from the results of experiments on animals. Of far different import, however, were the instances in which the carotid arteries in the human subject were found obliterated by Haller, Baillie, Petit, Pelletan, Darrach, Jadelot, Davy, Velpeau, and others. These were sufficient to demonstrate that one or both of these arteries may be completely obstructed without destroying the life of the individual. But even these are no longer required to determine the point in question. The operation of tying one of the primitive carotids has now been performed in *hundreds* of instances; and although delirium, convulsions, adynamia, phlebitis, thoracic and cerebral troubles of various kinds have in some cases followed, yet in the aggregate the result has been more fortunate. Mr. Wardrop, indeed, boldly asserts (*Cyc. Pract. Surg.*, vol. i., p. 263,) that the sources of supply are so abundant after the ligature of the carotid, that there is not the slightest danger to the parts, either within or without the cranium, from which the main stream has been diverted, "and no one now entertains the slightest fear for the intellectual and other functions of the brain." Although his doctrine has the sanction of Sir Astley Cooper, Samuel Cooper, Manec and Miller, it was conclusively shown by Mr. Norman Cheevers, in his elaborate paper published in the *London Medical Gazette* for October, 1855, to be both erroneous and dangerous. Mr. James Miller, of Edinburgh, seems to have taken a very unwarrantable view of the subject, in his article "On Ligature of the Carotids," published in the *Lond. and Edinb. Monthly Journal*, January, 1842. In reply to the question—"May both

be tied at once without immediate danger to the brain ?" he asserts that in view of the results obtained by M. Jobert in his experiments on animals, in future the surgeon need not hesitate to secure both common carotids by ligature, simultaneously, should circumstances imperatively demand such a severe proceeding. He adds, it is very improbable that there will be any deficiency of supply to the brain, since even in the horse, in which the vertebrals are remarkably contracted in size, they are still sufficient for this supply ; and in man, the comparatively greater size of the brain, and greater capacity for arterial blood, will be fully compensated by the comparatively larger size and full anastomotic circulation of the vertebral arteries. Now there can be no question that, as was maintained by Hodgson, the brain has been endowed with a double circulation to guard against the ill effects which might arise from the obstruction of one or more of its vessels ; but we are disposed to believe that too much importance has been attached to the influence of the vertebral after the ligature of both carotid arteries. The same opinion has been advanced by Prof. Porta, of Pavia, in his magnificent work, *Delle Alterazioni Patologiche delle Arterie per la legatura e la tarsione*, Milan, 1845. At page 292, after alluding to what he believes to be erroneous views on the part of Mr. Hodgson, he remarks that it is more probable after the obliteration of the carotids the blood would seek those channels which admit of more easy distention than the vertebral arteries; and these channels are formed by the other branches of the subclavian, as was proven by his experiments on dogs. Although the vertebrals may enlarge, he continues, yet their junction at the base of the cranium is too remote to enable them to supply all the external parts of the neck and head, whilst they may suffice for the brain. Instead of these, the inferior thyroid, supra-scapular or transverse cervical and the superior intercostal arteries seem intended by their inosculations to supply the external parts of the head and neck. According to Prof. Porta, the anastomosis alone between the superior and inferior thyroid arteries, naturally ample, short and direct, should by its augmentation form the principal medium of transmitting a considerable portion of the blood which passed through the carotids before their obstruction. The dissection made by Dr. Mott, and reported in the second volume of his edition of *Velpeau's Operative Surgery*, p. 334, corroborates the

opinion above expressed. In examining the head and neck of a subject on which some months before he had tied one of the primitive carotid arteries, he found the ramus thyroideus, passing upwards to the thyroid gland, and anastomosing with the superior thyroid artery, was one great source of blood; its branches were large (thrice their natural size) and tortuous, communicating in every direction with those from above. They likewise form free anastomoses with the vertebral artery. In the account given by Sir Astley Cooper (*Guy's Hospital Reports*, vol. i., 1836) of the dissection of the second case in which he tied the common carotid artery, and which died thirteen years after the operation from *apoplexy*, no particular mention is made of the condition of the subclavian and its branches; but it is evident from his description of the cerebral vessels, that the brain had not derived its chief supply from the vertebral arteries. Doubtless in this case, as in that reported by Dr. Mott, the thyroid axis was one of the most important inosculating sources of blood. In no other manner than by the assistance of this, with the other branches of the subclavian specified by Prof. Porta, could life have been maintained in the case reported by Mr. Wishart, in the *Edinburgh Monthly Journal*, January, 1848, p. 496. In this an aneurism of the innominata was successfully treated by Valsalva's method pursued for six months. The patient, æt. 40, died from phthisis. For months before her death no pulsation could be felt in either carotid, and there were no indications of cerebral trouble. At the autopsy both carotids and the right subclavian were found impervious. The circulation to the right extremity was maintained by anastomoses between the branches of the thyroid axis and vertebral arteries of the left side with those on the right. The pneumogastric nerve was considerably stretched,—a fact worthy of note, as it has been asserted by Mr. Miller and others that where serious cerebral trouble has followed the ligature of the carotid, the obstruction of the arterial current was not the cause, but that it was due to the injury of the accompanying nerve or vein.

Again, in proof of our assertion, that too much importance has been attached to the influence of the vertebral arteries, we may quote the following case detailed by Dr. John Davy, in his *Researches, Physiological and Anatomical*, vol. i., p. 426. Here the left subclavian and carotid arteries were closed. The upper

part of the innominata was open, as were the right carotid and subclavian arteries. The patient, who survived for several years, did not suffer from paralysis of the upper extremities, and the senses were, ordinarily, unimpaired, though occasionally there would be some slight confusion of mind and a vertiginous feeling, especially in suddenly rising from the horizontal, or reclining, to the erect posture. The patient died suddenly, at the age of 55, from the rupture of an aneurism of the arch of the aorta into the pericardium. The intercostal arteries were found to be enlarged at their origin, and seemed to be the principal vessels which supplied the head.

The case in which the late Mr. Aston Key tied the right carotid artery is not without interest at this point. This patient fell into a comatose state after a severe fit of coughing, and died shortly afterwards, having never rallied from the coma. At the autopsy the left carotid was found obliterated by a coagulum. In this case the vertebral arteries were inadequate to furnish a supply of blood sufficient to maintain the functions of the brain. The period which elapsed in this case, from the time of the operation until the patient's death, was too brief to warrant the supposition that death was occasioned by the white *ramollisement* of the brain which was observed by Dr. Todd in an instance that he has reported in the twenty-seventh volume of the *Med.-Chir. Transac.* (London), and which condition he regarded as analogous to senile gangrene. In this instance the right carotid and right vertebral arteries were completely obstructed by a dissecting aneurism of the aorta and innominata. This gave rise to syncope, hemiplegia, and softening of one side of the brain. Dr. Todd explains the serious effects of obstructing the middle cerebral artery by the fact that it is the principal branch of the carotid within the cranium, and has a less free communication with the corresponding ramifications of the opposite side, than any of the other arteries of the brain.

Perhaps in Mr. Key's patient the branches of the subclavian were obstructed by fibrinous deposits, brought from a distance, as in the cases which formed the basis of the paper by Mr. Kirkes, of St. Bartholomew's Hospital, and read before the Royal Medical and Chirurgical Society of London, May 25th, 1852 (*vide* Med. Chir. Trans., vol. xxxv.) Similar cases have also been reported

by Dr. Ruhle, a notice of which may be found in the *Brit. For. Med.-Chir. Review*, for July 1853, p. 209. Mr. Key's patient, 61 years of age, died, evidently, from innervation, the result of a deficient supply of blood to the brain. The operation was Brasdor's for aneurism of the innominata, and it is exceedingly probable, that, as the left carotid was found obstructed by a coagulum, branches of one or both subclavian arteries had suffered from the same cause. Sir Astley Cooper's second patient died from apoplexy thirteen years after the operation, and the cerebral vessels on the side of the obstructed carotid were of preternatural size! We may refer to other cases in which the patients have died from cerebral congestion or inflammation. Abernethy's patient died thirty hours after the operation from inflammation of brain (*Surg. works*, vol. ii.); Langenbeck lost a patient twenty-four hours afterwards from the same cause (*Archiv. Gén.*, t. 19.); Mayo, another on 13th day (*Med. Quart. Rev.*, vol. i.); Miller, another on 8th day (*Lond. & Ed. Month. Journ.*, vol. xi.); and others have been reported by Zeiss, Vincent, Randolph and O'Reilly. In the case published by Petit, (*Mem. de l'Acad. Roy. des Sciences*, 1766, p. 758,) of spontaneous obliteration of the right carotid, the patient died seven years afterwards from apoplexy.

In Professor R. D. Mussey's first case of ligature of both carotids, some sixteen or seventeen months after the operation, venesection was required to relieve the patient of symptoms of repletion of the vessels of the head.

There can be but little doubt that in many of the cases of spontaneous obliteration of large arterial trunks, especially by coagula, fibrinous deposits, etc., the other vessels in the vicinity do not escape, and it is to this cause, as we have already stated, that the innervation must be referred, when the carotid or vertebral arteries have been found obstructed. In one instance we tied the right subclavian for aneurism of the innominata (Brasdor's method). The patient died on the eighth day from hæmorrhage at the seat of ligature, the result of imprudent efforts which the patient attempted in defiance of our injunction. The left subclavian and the left carotid were found completely obliterated and condensed into solid cords. The branches of the right subclavian and right carotid were pervious; and from them the brain must have derived its chief supply of blood. What would have been the results,

had we, as we contemplated, applied a ligature to the right carotid? An instance has been reported in which both the carotid and subclavian were tied by Rossi of Italy, for aneurism of the innominata, and after death the left carotid and subclavian were found obliterated. For six days the patient survived with a supply of blood to the brain from the right vertebral and other branches of the subclavian on that side. Darrach has given the account of another case, in which, after spontaneous obliteration of the innominata and left carotid, life was maintained by the branches of the left subclavian. It can hardly be supposed in either of the last named instances, that life was supported by the right or left vertebral alone. We have been at some pains to enumerate the facts already detailed, as we believe they tend, in the main, to corroborate the doctrine, that after the obstruction of the carotids by ligature, the brain is supplied with blood from other sources as well as from the vertebral arteries.

Although Scarpa and Allen Burns may have been the first to demonstrate, by their injections, that the brain might receive a due supply of blood even after the obstruction by ligature of two of its main arterial trunks, yet to Dr. Mott belongs the credit of being the first to carry out this practice on the living subject. In describing his celebrated operation on the innominata, (May 11th, 1818) he truly observes: "The brain in no operation had been deprived of so large a quantity of blood as in this, and yet it suffered no inconvenience (Mott's *Velpeau*, vol. ii., p. 325). Graefe, of Berlin, repeated this operation in 1822, and no cerebral disturbance followed. The first operation of tying both primitive carotid arteries on the human subject, from all the information we can obtain, was performed by Dr. McGill, of Hagerstown, Maryland. An account of it was communicated by Dr. Cohen, of Baltimore, to the late Dr. J. Kearney Rodgers, of New York, and by him furnished to the New York *Medical and Physical Journal*, vol iv., 1825, p. 576. From the imperfect history of the case thus given, we learn that it was performed for fungous tumors of both eyes, with an interval of one month, and that "some interesting phenomena were observed during the progress of the case," but what these were is not stated, nor are we informed of the precise date of the operation. Professor Mussey's first operation was performed September 20th, and October 2nd, 1827, after an interval of

twelve days. This case was reported in the *American Journal of the Medical Sciences*, vol. v., 1829, p. 316. The patient had an erectile tumor of the scalp. The immediate effects of the operation are thus described :

"The face was a good deal paler after the operation, but the functions of the brain were not disturbed. There was neither nausea nor faintness ; the patient rose from the table, stood up, and while standing put on his vest and coat, and tied on his cravat ; he then walked down two flights of stairs, got into a carriage, and rode into a distant part of the village without feeling the least symptom of faintness, or manifesting signs of inconvenience."

This patient is believed by Prof. Mussey to be still living. Some sixteen or seventeen months after the operation, as we have already stated, it was necessary to resort to venesection to relieve him of the overloaded vessels of the head. Within the past two years Prof. Mussey has had another successful case, and in this no cerebral disturbance followed the operation.

Moeller, of Copenhagen, tied the right primitive carotid on the 3rd of September, 1831, and on the 28th of January, 1832 (an interval of 147 days), tied the left. The patient was four years of age, and was suffering from an erectile tumor in the nose. Paralysis of the right arm followed the first operation, and slight somnolency and pectoral disturbance the second, but these symptoms soon disappeared (vid. Porta, *Delle Alterazioni Patologiche delle Arterie*, etc., p. 293, or *Rust's Magazin*, B. 28, H. 2, s. 230). According to Prof. Porta, p. 293, Buenger, of Marburg, is reported in *Froriep's Notizen*, 1832, B. 36, s. 173, to have performed this operation, but with what result is not stated.

Kuhl, of Leipsic, on the 24th of May, 1834, tied the left carotid on a patient, aged 53, who had a vascular tumor of the scalp, accompanied with much hæmorrhage. On the 14th of August of the same year, after an interval of seventy-three days, he secured the right. The hæmorrhage ceased ; the face became pale, and he experienced a shivering sensation. About the third day there were cephalea, dysphagia, and paralysis of right arm. The intellect remained unimpaired, and after this no further cerebral trouble was manifested.

In August, 1838, according to Prof. Hamilton, of Buffalo, his brother, Dr. T. H. Hamilton, of Saugerties, N. Y., tied the right

carotid on a patient affected with epilepsy. In March, 1839, he tied the left carotid. The last operation was followed by palsy of the tongue, which lasted three days. Ophthalmia supervened in the left eye, which was finally destroyed. Dr. Freleigh, of New York, has informed us that he performed the last operation, but Prof. F. H. Hamilton has reported the case in the name of his brother (*Buff. Med. Journ.*, 1846, vol. ii., p. 119). A few months since we were assured by a gentleman residing in the vicinity of this patient, that the epilepsy was nearly cured by the operation, and that he was then in good health.

But not to dwell in detail upon the individual cases reported, let us examine the principal feature of interest which they have presented. The following table drawn up for this purpose, it is believed, contains all the cases of which anything like an authentic information can be obtained. We give them as nearly as possible in the order of their occurrence.

LIGATURE OF BOTH PRIMITIVE CAROTID ARTERIES.

SURGEON.	AGE.	DISEASE.	INTERVAL.	RESULT.
1. Macgill		Fungous tumor of orbit,	1 month,	Recovered.
2. Mussey	20 years,	Cirsoid aneurism of scalp,	12 days,	Do.
3. Mussey	28 years,	" " of scalp and ear,	28 days,	Do.
4. Mott and Eve			1 year,	Do.
5. Mott		Malig. dis. of parotid gland,	15 minutes	Died in 24 hours.
6. Mott		Malignant polypus,	Sev'l mos.	Recovered.
7. Hamilton	18 years,	Epilepsy,	6 months,	Do.
8. J. Kearney Rodgers and Van Buren	Young girl,	Cirsoid aneurism of scalp,	Sev'l years	Do.
9. Preston	51 years,	Epilepsy,	11 weeks,	Do.
10. Preston	Adult,	Epilepsy,	1 month,	Do.
11. Preston	24 years,	Epilepsy, [Felt very	5 weeks, weak after	Do. operation.
12. Moeller	4½ years,	Erectile tumor in the nose,	147 days,	Recovered.
13. Kuhl	53 years,	Aneurismal tumor of occiput, [Slight convulsion	73 days, after each	Do. operation.
14. Ellis	21 years,	Hæmorrhage from a gunshot wound in the neck,	4½ days,	Recovered.
15. J. Mason Warren.	23 years,	Erect. tumor of face, mouth, nose. [Slight faintness after	32 days, oper'n and	Do. drowsiness.
16. Robert	Young girl,	Cirsoid aneurism,	8 months,	Recovered.
17. Blackman	14 years,	Malignant disease of antrum,	21 days,	Do.
18. Willard Parker	42 years,	Malignant disease of the nose and orbit,	32 days,	Died about five days after operation.
19. Name unknown	Operation witnessed by Chelius, and mentioned in South Chelius, American edition, vol. ii., p. 566.			
20. Mott	Case reported in the circular of N. Y. University for 1855–6.			

It is stated in the circular of the Medical Department of the New York University (1856–6,) that during the past winter both carotid arteries were tied on a patient at Dr. Mott's clinique. If,

as it is to be supposed, this was performed by Dr. Mott himself, then it is the fourth case of the kind which has occurred in his practice. The result of the last operation is not mentioned.

We attended Dr. Parker's patient until his death. During the five months which he survived, he was almost constantly under our observation. For several weeks after the last operation the patient assured us that he was not aware of any unusual feeling in his head, and his intellect was undisturbed. At length, with the extension of his disease, his mind began to wander, and at times he would lose the control of the muscles of his lower extremities. For thirty-six hours before his death he became comatose, and from the whole aspect of the case for a month previously I suspected *ramollisement* of the brain.

In our own case, immediately after the application of the last ligature vision on that side was destroyed. In the course of half an hour it returned, and no unpleasant symptoms afterwards appeared. His memory, however, was for some months impaired, but is now good. Eight years have elapsed since the operation, and his health is perfect.

Langenbeck is erroneously included on the list of the surgeons who have performed this operation. Dr. Norris is guilty of the same mistake in his valuable statistical table on the ligature of the carotid arteries, published in the *Amer. Journal of Med. Sciences* for July, 1847 ; and the same observation applies to Mr. Erichsen (*Science and Art of Surgery*, Lond. Ed., p. 530.) By referring to the *Archives Générales*, tom. xix., p. 118, it will be seen that he tied the right superior thyroid to arrest the growth of a pulsating goitre, and that in consequence of secondary hæmorrhage from the seat of ligature on the eleventh day, he tied the primitive carotid of the same side. The patient immediately sank into a comatose state, and died thirty-four hours after the last operation.

Mr. Crosse, of Norwich, England, was called upon to tie one carotid, the other having been secured for the purpose of arresting the hæmorrhage produced by the extirpation of a parotid tumor ; but as compression produced unpleasant effects, he did not venture to apply a ligature. He refers to this in his "Retrospective Address" before the Prov. Med. and Surg. Association, July, 1856, (*vide* Transactions of that body, vol. v., 1837, p. 67,) and states that the patient fell a victim to the undertaking which he was

made to believe necessary to preserve his life. We have no positive information as to the application of a ligature to the other artery. Mr. C. was deterred from applying a ligature to the carotid of the opposite side by the "unpleasant effects" produced by compression. The following extract from Mr. Ferguson's *Practical Surgery*, third Lond. Ed., p. 630, shows that compression under similar circumstances is a test upon which we can not fully rely:

"Being about to place a ligature on the common carotid, some doubts were entertained as to the immediate results of the proceeding, in consequence of the singular symptoms caused by pressure in the course of the vessel. When the ligature was tightened, however, no similar complaints were made; and I conclude, therefore, that the peculiar effects of the previous compression in this instance were not dependent on the mere obstruction of the blood."

Our table embraces, including the one witnessed by Chelius, and the last reported of Dr. Mott, twenty cases; and of these the operation was followed by fatal results in but two instances. Dr. Mott tied both with an interval of only fifteen minutes, and the result was almost immediately fatal. This case is a sufficient refutation of the doctrine laid down by Mr. Miller, in his paper to which we have already referred, and which was published in the *Edinb. Monthly Journal* for January, 1842. After examining the results of the experiments of Mr. Robert on animals, Mr. M. asserts that in future we need not hesitate to secure both common carotids by ligature simultaneously, should circumstances imperatively demand such a severe proceeding.

The shortest period at which both carotids have been successfully tied is four and a half days. The operation was performed by Dr. John Ellis, of Grand Rapids, Mich., to arrest the hæmorrhage proceeding from a gunshot wound of the neck. The patient was 21 years of age. The left carotid was secured Oct. 28, 1844, and the right four and a half days subsequently. A slight coldness of the face on the side of the operation followed the application of the first ligature, and there was an occasional throbbing beneath the sternum. There was "slight paleness" after the second operation, and after twenty-four hours the patient began to suffer from a hacking cough and difficulty of breathing. These symptoms at length yielded to venesection, aconite and belladonna.

In June, 1845, the patient was enjoying comfortable health and attending to business (*N. Y. Journ. of Med Sciences*, Sept., 1845.)

In conclusion we may remark, the mortality following the ligature of both primitive carotid arteries, as shown by our table of cases, contrasts strangely with that in the one drawn up by Dr. Norris, of the ligature of one of these trunks (*Amer. Journal of Med. Sciences*, vol. xiv., 1847.) While his statistics show a mortality of 1 in 4·7 cases, our collection of both carotids exhibits but 1 in 20 cases. This estimate, of course, does not include Prof. Parker's fatal case, the cause of death in this being somewhat uncertain.