

TRAUMATISMS AND TRAUMATIC ANEURISMS OF  
THE VERTEBRAL ARTERY AND THEIR  
SURGICAL TREATMENT, WITH THE  
REPORT OF A CURED CASE.

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I.

THE operative surgery of the vertebral artery may be truly said to be an acquisition of the latter part of this century.

Up to 1860, but a few names would have sufficed to cover the whole bibliography, the names of Dietrich, Velpeau, Nunziantè Yppollito, Sedillot, Fraeys, Chassaignac, Laudi and Maisonneuve, would have completed the list of the most important authors who had given any personal attention to the subject. The majority of the great writers of the period referred to, such as A. Cooper, Lisfranc, Larrey, Vidal, Malgaigne, Guerin, Beraud and Follin taught practically that the vertebral artery was of scarcely any interest to the surgeon.

The spirit of the times was reflected by Sanson, of Paris, in his Treatise on Traumatic Hæmorrhages, which was published in 1836. In commenting upon a case of injury to the vertebralis, he said: "The vertebral artery cannot be ligated, on account of its great depth, nor compressed, because of the osseous canal which protects it; it can still less be cauterized. The wounds of this vessel are beyond the resources of art."

In 1853, the accomplished Maisonneuve<sup>1</sup> proved that this teaching was erroneous, for, in a remarkably daring search (for the period, it was a very bold feat) for the bleeding vessel in a wound of the neck, he, aided by Favrot, successively ligated the inferior thyroid and the vertebral as it entered the canal of the transverse process of the sixth cervical vertebra. This had never been done before and the gravity of so unparalleled a procedure as the ligation of the vertebral artery, can be gleaned from Maisonneuve's and Favrot's report, when they say, with a solemnity which sounds somewhat strange to our *fin de siècle* surgery, "It was suspected that the hæmorrhage came from the vertebralis. In the presence of so grave a contingency, for the relief of which the records of surgical experience suggested no remedy, we hesitated, and for a moment felt uncertain as to the proper plan of action. But the life of the patient was involved and we had to stop the hæmorrhage at all hazards," and this they did admirably and with perfect success.

We find that as early as 1833, Velpeau<sup>2</sup> suggested that the ligation of the vertebralis, in its first portion, was a feasible operation and could be effected by an incision in the space between the sternal and clavicular heads of the sterno-cleido-mastoid, as previously suggested by Sedillot for the ligation of the common carotid. Dietrich,<sup>3</sup> in 1831, proposed two methods for the ligation of the upper part of the vertebralis, one for tying the artery in the occipito-atloid region and the other in the atlo-axoid, or first intertransverse space. In 1834, Respoli,<sup>4</sup> of Naples, while witnessing the ineffectual efforts that were being made by a colleague (Ramaglia's case), to control the bleeding

<sup>1</sup> Maisonneuve and Favrot: *Journal des Connaissances Medico-Chirurgicales*, Paris, 1852, 2 s., Vol. II, p. 181.

<sup>2</sup> Velpeau: *Nouveaux Éléments de Médecine Opératoire*, Paris, 1839, T. 2me p. 221.

<sup>3</sup> Dietrich: *Das aufsuchen der Schlagadern*, etc., p. 81, 1831, Neurenberg. Vide also Chelius' *Surgery*.

<sup>4</sup> Respoli: Quoted by Nunziante Yppollito, *Annali Clinici*, Napol, 1835. Also in pamphlet on "*Ligatura dell' Arteria vertebrale nei casi di aneurismi della stesa*," 1838. Also quoted by A. Gherini in *Memoire on "Ferite dell' Arteria Vertebrale"*, Milano, 1867.

from a stab-wound of the vertebral artery, suggested that this vessel should be ligated *en masse* by passing a curved needle through the bleeding intertransverse space thus enclosing all the soft parts within the ligature.

In 1835, Nunziantè Yppolito,<sup>1</sup> who had also had personal experience with the difficulties in the way of completely controlling the bleeding in injuries of the vertebral artery, concluded, after an able study of the subject, that the ligation of the vertebral in its first portion, was perfectly justified for the control of hæmorrhage, and that a ligature could best be thrown around it by making an incision on the outer border of the sterno-mastoid. Unfortunately, he had no experience on the living subject with his method, though it was almost identical with the procedure independently adopted by Smythe, of New Orleans, in his memorable case, and which is now frequently referred to as "Alexander's method."

In 1848, Fraeys,<sup>2</sup> of Gand, described a method of securing the vertebral by making an incision on the inner border of the sterno-mastoid, which was very much enriched by the admirable topographical suggestions of Chassaignac, whose masterly studies on the importance of the anterior tubercle of the sixth cervical vertebra as a guide in this operation, caused it to be named after Chassaignac rather than in honor of its true originator—Fraeys.

Finally, the lamented Barbieri, of Milan, whose "Monograph on the Vertebral Artery" will ever remain an imperishable monument to his prodigious erudition, summarized, in 1867, all

<sup>1</sup> Vide supra, loc. cit.

<sup>2</sup> Smythe's operation was performed as follows: The head of the patient was thrown backward and turned slightly to the left, an incision two inches long was made from a little above the clavicle along the posterior border of the sterno-mastoid muscle. The edge of the muscle having been exposed and drawn aside, the prominent anterior tubercle of the transverse process of the sixth cervical vertebra, was readily felt and taken for a guide, the artery lying vertically below it. A layer of fascia was divided, some loose cellular tissue with lymphatics and the ascending cervical artery was pulled to the inner side of the scalenus anticus and longus colli muscles which were separated from each other close to their insertion into the tubercle, when the artery and vein became visible. The vein was drawn to the outer side (a point of importance, according to Dr. Smythe), and the needle was passed round the artery from without."

the arguments in favor of the ligation of the vertebral and laid down all the details of the technique for its *typical* ligation, in ignorance, however, of the successful demonstration of the practicability of this operation on the living subject that had been given to the surgical world in 1864, by Andrew W. Smythe, of New Orleans. This operation is the most towering landmark in the surgical history of the vertebralis, and in conjunction with the first successful ligation of the innominate artery for the cure of subclavian aneurism, with which it was performed as an auxiliary measure is justly recorded in the classics as one of the most brilliant achievements of American surgery.

The operation performed by Smythe, although classical, deserves more than passing mention because it was the first systematic and carefully premeditated, as well as successful, attempt to control the vertebralis at the point of election in the root of the neck. The object of the ligature of the vertebralis was, in this case, to cut off the collateral supply from the circle of Willis to a subclavian aneurism.

The patient was William Banks, a mulatto, aged thirty-two years, who consulted Dr. Smythe for the relief of an aneurism of the right subclavian artery, which filled the posterior-inferior triangle of the neck, and which had resulted from muscular strain in the efforts made by the patient to save himself from drowning in a collision at sea. On May 15, 1864, a silk ligature was placed on the innominate artery, a quarter of an inch below its bifurcation and another ligature was also applied to the common carotid, an inch above its origin. Repeated and profuse secondary hæmorrhages took place at various intervals, which threatened the life of the patient, as in all previous cases in which the ligature of the innominate had been attempted and in spite of the ingenious method of hæmostasis resorted to by Dr. Smythe, viz., the filling of the bleeding wound with fine shot. In view of the impending danger and being satisfied that repeated occurrence of the bleeding in the fatal cases of this operation could all be accounted for by a retrograde current through the vertebral, the hæmorrhage coming directly from the brain, the bold operator decided to ligate this all-important collateral.

He says: "Having satisfied myself by repeated attempts on the subject that the vertebral artery could be ligated just before it enters the foramen of the sixth cervical vertebra, through an incision made along the outer edge of the sterno-mastoid muscle, and the aneurism having diminished enough in size to permit of the operation, I determined to try it, and, on July 8 (fifty-three days after the ligation of the brachio-cephalic), with the assistance of Dr. P. C. Boyer, a ligature was placed on the vertebral artery.<sup>1</sup>

No further hæmorrhage took place. The ligature came away from the vertebral artery on the tenth day and on the fifteenth day of September, the wound had healed, and the *first* successful typical ligation of the innominate and vertebral arteries recorded in the annals of surgery, was an accomplished fact.

After the publication of Smythe's brilliant operation, the ligation of the vertebralis soon became one of the classical acquisitions of surgery, especially since the safety of the aseptic procedure has been so frequently demonstrated in the heroic, but ineffectual attempts to cure epilepsy by the ligation of both vertebrals, as first practiced by Alexander, of Liverpool, who, alone, operated thirty-six times, with only three deaths, and who has been followed by Bernays, of St. Louis, Chalot, of Toulouse, France, and others.

## II.

The class of injuries which are about to engage our attention are fortunately of great rarity<sup>2</sup>—fortunately indeed, for when

<sup>1</sup> New Sydenham Society's Biennial Retrospect for 1885-6, From N. O. Medical Record, and Mott's Velpeau, Vol. II, p. 229; also New Orleans Charity Hospital Report for 1876.

<sup>2</sup> Some idea of the comparative rarity of the wounds of the vertebral can be obtained when we consider that in the sixty years that have elapsed from the foundation of the New Orleans Charity Hospital, from 1832 to 1892, during which period 463,894 patients have been treated within its walls, but one case of wound of the vertebral has been recorded in the Annual Reports, and that was the traumatic aneurism that came under my observation, and that has been described in this paper at some length. Stone's case was treated in his private infirmary, and would be the second recorded case from New Orleans, up to 1893.

In consulting the surgical history of the War of the Rebellion, second volume, we find that out of a total of 2235 cases of arterial hæmorrhage of head, neck, chest,

they do present themselves for treatment they are well calculated to cause no little worry to the surgeon whose judgment, courage and resources are usually taxed to the utmost by a combination of complications and obstacles that experience teaches are thrown in the way of his curative efforts, in a manner that is hardly paralleled by any other class of vascular injuries. It is hardly necessary to dwell long upon the reasons for the peculiarly grave character of the traumatisms that involve the vertebral artery. A glance at the surgical anatomy of this vessel as it lies deeply hidden in the skeleton of the neck, only escaping at very short intervals from its osseous canal, to become immediately invested by very important and vital cervical nerves as they issue from the spinal foramina, will at once remind us of the magnitude of the purely technical difficulties in the way of its atypical ligation, and of the errors of diagnosis that must be incurred, owing to the proximity of so many large arterial trunks.

Furthermore, its unique termination in the cranial cavity, where, anastomosing directly with its fellow artery, it becomes continuous with the carotid system through the circle of Willis—will also convince us of the unreliability of the ligation of this artery, whether proximately or distantly applied, as a permanent means of controlling the blood supply of any aneurismal tumor that may be situated between either one of its cervical extremes.

One of the initial difficulties that are usually presented by aneurisms of the cervical portion of the artery is that of their differential diagnosis from similar tumors connected with the carotid trunk and its branches. That this difficulty is not fanciful, but real, is most eloquently proved by the fact that in more than sixteen out of thirty-six traumatisms of the vertebral artery (or  $44\frac{2}{3}$  per cent.), hæmostasis was attempted by ligation of the common carotid as the presumed source of hæmorrhage; in

trunk, and upper and lower extremities in which the bleeding vessels were indicated by name, only two cases (one a primary injury, the other a secondary) are attributed to the vertebral (Table C, XXIV). These hæmorrhages were furnished by a grand total of 245,790 gunshot wounds, and 922 sabre and bayonet wounds, which were inflicted during the Civil War, from 1860 to 1865.

these cases either the carotid alone, or together with some other artery (the inferior thyroid, Maisonneuve ; the occipital, Fenger) was ligated first, instead of the culprit vertebral, the error being recognized only *post operationem*. The necessity for correct differentiation is, therefore, manifest, and its importance cannot be over-estimated, especially when we consider that the ligation of the common carotid, under these circumstances, is fraught with especially harmful consequences. As Timothy Holmes<sup>1</sup> correctly stated : " In the first place, by throwing the strain of the anastomosing circulation on the vertebral, it tends to aggravate the disease it was meant to cure, and in the second, if the circulation in the wounded vertebral artery is interrupted before the operation (which to some extent it almost certainly must be), the stoppage of the supply from the carotid artery is rendered doubly perilous to the nutrition of the brain."

The explanation of the frequency with which this error of ligating the common carotid for the vertebral has been committed is solely to be accounted for by the topographical relationship between the two arteries, and the facility with which pressure upon the common carotid at the root of the neck will control the circulation of the vertebral. This fact was distinctly pointed out by Fraeys, of Ghent, in 1848,<sup>2</sup> and can be easily demonstrated by repeating this observer's experiments on the cadaver. " After having removed the skull cap and the contents of the cranium, taking care to cut the vertebral arteries below their junction in the basilar, tie the axillary arteries and the upper part of the abdominal aorta, then inject water through the arch of the aorta. The liquid will be shot out through the two internal carotids and the two vertebrales at the base of the skull. But as soon as even slight pressure with the finger is put on the course of the common carotid, in the space extending between two or three inches above the clavicle, between the trachea and internal border of the sterno-mastoid, the jet will no longer flow from either the internal carotid or vertebral, on the side com-

<sup>1</sup> Surgical Treatment of Aneurism in its various Forms, London Lancet, July 26, 1873.

<sup>2</sup> Annales de la Societe de Medecine de Gand, 1848, p. 211, Vol. XXI.

pressed, but will recommence as soon as compression is removed. If both sides are compressed at once *all* the arteries cease to squirt. If pressure is made with the same force on the common carotid *above* the "carotid tubercle" (*i. e.*, the anterior tubercle of the transverse process of the sixth cervical vertebra), the space below that tubercle being left free, the jet from the internal carotid wholly ceases."

As stated by T. Holmes, "the surgeon who, knowing the true position of the transverse process of the sixth cervical vertebra, and knowing that pressure applied along the course of the carotid anywhere below this, *i. e.*, for two inches, at least, above the clavicle, will most probably stop the pulsation in the vertebral also, will not conclude that the aneurism affects one of the carotids, or some branch of the external carotid, until he has seen that pressure also stops the pulsation when applied on a higher level, or when applied to the carotid by lateral pinching of the sheath through the relaxed sterno-mastoid muscle, as recommended by Rouge, and effectually practiced in the case here reported.

The importance of Rouge's lateral method of compression should not be forgotten, when we consider that the vertebral not infrequently takes an anomalous course in front of the vertebral column, and avoids the sixth transverse process to enter into a transverse foramen much higher up, selecting even that of the third and second vertebræ. Under these circumstances direct compression backwards upon the common carotid, no matter how high above the carotid tubercle, would be sure to compress the vertebral, as well as the common carotid arteries, and thereby make the experiment fallacious.

Another lesson that is reinforced by experimental evidence is the demonstration of the great freedom of the collateral circulation of the vertebral through the circle of Willis. If the vertebral be exposed through its whole length in the neck by laying open the vertebro-transverse canals with a costotome and gouge forceps, and the artery be divided in the middle of its course, an injection of water into the aorta will immediately cause a flow

<sup>1</sup> *Loc. cit.*



through both the divided *distal* and *proximal* ends by streams of equal size and velocity. If a separate receptacle is attached to each end of the divided artery, both will fill up at the same time, proving that the supply of blood from the distal and proximal end is simultaneous and practically equal. The bearing of this experiment upon the treatment of traumatic aneurism by the ligation of the vertebral trunk at its origin is obvious.<sup>1</sup> No definitive cure could always be expected by such a procedure, since the supply from the cranial side would be as great as from the proximal side; the only rational hope for success by systematic ligation would be to attempt the combined ligation of the distal end, in the sub-occipital triangle, by Dietrich's method, and that at the proximal end by either Smythe's or Alexander's method. But the ligation of the vertebral artery on the distal side in a case of traumatic aneurism is not only impracticable but tantamount to the Antyllian operation, for in the vast majority of cases the aneurism already occupies the sub-occipital space, and the artery can only be secured by the incision and evacuation, or displacement of the aneurism. The cases of aneurism, in which the tumor occupies a region far enough from both the points of election to make the ligation practicable, have not yet presented themselves, and it is probable that such a procedure will never be realized, or if it is at all carried into execution, it is very doubtful that it will be associated with less traumatism than that which is connected with a direct attack upon the aneurismal sac by any of the modifications of the method of Antyllus.

So much, therefore, for the *a priori* experimental and anatomical evidence. Let us now listen to the teachings of experience.

### III.—REMARKS ON PRIMARY BLEEDING FROM INJURIES OF THE VERTEBRAL ARTERY.

It is impossible for us to draw any definite and safe conclusions as to the best course to pursue when confronted by so grave

<sup>1</sup>In cases of wounds of the vertebral in which the artery has been completely divided both ends of the artery may bleed with equal vigor, as, *e. g.*, was well demonstrated by Kocher's patient (No. 15; Table II).

an injury as a wound of the vertebral artery without consulting the lessons of the past and gathering from all reliable sources those teachings of actual clinical experience which are most rational and have furnished the most salutary results. To satisfy my own inquiries I have searched all the available literature at my command for reports of cases, and have succeeded, with the valuable assistance of the distinguished librarian of the Surgeon-General's Office, Dr. Billings, in collecting fifty-three cases of lesions of the vertebralis.<sup>1</sup>

These observations I have grouped in three tables, thus: Table I, in which only endo-cranial aneurisms of the vertebralis are considered. They number eleven cases. Table II embraces only the extra-cranial or cervical aneurisms. They number twenty cases. Table III is a collection of wounds or lesions of this artery, involving its surgical or extra-cranial portion. This embraces twenty-two reported cases.

We are at once forcibly struck by the great mortality of this class of injuries, for out of a total of fifty-three cases we find that forty-five died in direct consequence of the lesion of the vertebral artery or complicating circumstances associated with it.

We should at once eliminate the table of endo-cranial aneurisms, as these lesions were all, with one exception, of purely pathological interest, having resulted from degenerative changes in the endo-cranial arteries and appertaining to a domain entirely foreign to our present subject. We will only add that all these cases, without exception, ended fatally—100 per cent.

Of the twenty cervical aneurisms which are grouped in Table II six recovered, leaving a mortality of 70 per cent. for this class of injuries. These aneurisms were all traumatic, with the exception of Case No. 7, which was reported by Stubbs. In Table III, which exhibits the non-aneurismal injuries, twenty-two in number, we find that all but three were the result of traumatism, chiefly stab, punctured or gunshot wounds. We note that of these twenty-two cases only two recovered, leaving a mortality of 90 per cent. for the non-aneurismal traumatism. If we add

<sup>1</sup> I have references to several other cases, but they are so lacking in detail they are useless for purposes of study or tabulation.

the nineteen wounds of Table II, which gave rise to the nineteen traumatic aneurisms and the twenty-two non-aneurismal wounds of Table III, then we will have forty-one cases of wounds, with a total mortality of 80.69 per cent., and a percentage of recoveries equal to 19.31 per cent., which gives a more approximate idea of the general results of the traumatisms of this dangerous artery.

We notice that in all the tables the males have preponderated by a large majority.

As to age, we note also that while the endo-cranial or pathological lesions of the vertebral occurred in subjects averaging 39.10 years of age, the traumatic aneurisms presented themselves in patients averaging 22.10 years.

In considering the influence of the weapon with which the injury was inflicted, on the career of the case and the final mortality, we observe that fourteen out of twenty-four punctured or stab-wounds terminated in fourteen traumatic aneurisms, and that only four out of fourteen gunshot injuries terminated in aneurisms. One man who was gored by an ox (Pirogoff's case) died from an aneurism of the vertebral, resulting from the injury. Two deaths, which were caused by erosion of the vertebralis by tubercular abscesses, terminated without aneurismal formation, and another pathological erosion of the artery (Küster's case) terminated by cerebral and other complications, after the bleeding had been permanently controlled, without aneurismal formation.

This would seem to indicate that while the final mortality is practically the same for either class of injuries (stab and punctured, 79.16 per cent., and gunshot injuries, 78.14 per cent.), there appears to be greater prolongation of life after stab and punctured injuries than after those caused by firearms. This must be due to the multiple and more complicated character of the injuries caused by the last class of weapons, which often end the life of the patient too soon to allow of the provisional hæmostasis implied by an aneurismal formation.

If we now investigate the immediate causes of death in the forty-three tabulated cases of injury of the vertebralis, we will readily recognize five essential factors which, in the order of their frequency and importance, I would put down as follows: (1)

Hæmorrhage; (2) Shock; (3) Sepsis; (4) Exhaustion; (5) Cerebral complications.

Very rarely did one of these conditions alone cause death; almost as a rule, the fatal result was due to the association of two or more of these lethal elements.

In the majority of the cases hæmorrhage was the dominant factor; in some cases alone, but usually combined with one or all the other conditions. In at least 35 per cent. the hæmorrhage was not definitely controlled before the other complicating elements fatally closed the career of the cases. It is nevertheless an encouraging fact that in as many as twenty out of the forty-three tabulated wounds of the vertebral, or nearly one-half of the traumatisms, the physiological resources of nature, with very little external aid, were sufficient to control the primary bleeding from the artery and circumscribe it within the limits of an aneurismal cavity. It is probable, indeed, that in the simplest or least complicated types of this injury the *primary* hæmorrhage from the bleeding artery can be controlled by the natural methods of hæmostasis, if only aided by some comparatively simple external treatment—such, for instance, as superficial pressure over the wound applied digitally, by suturing the wound, or by bandaging or plugging it externally.

This is conclusively proved by the case reported by L. Stromeyer,<sup>1</sup> which is worthy of citation here:

A soldier was wounded in the neck in the battle of Idstedt, July 25, 1850. He was taken to Gottorp, near Schleswig, where Dr. Herman Schwartz extracted the ball, which could be distinctly felt in the nucha. News came that the battle had been lost, and to avoid capture the patient fled on foot eight miles to Kiel, where he died on July 29, four days after the injury, with meningeal symptoms.

At the autopsy it was found that the ball had penetrated the right cheek half an inch from the angle of the mouth, going inward in the direction of the posterior wall of the pharynx. It grazed the tongue, barely touched the internal carotid, and, after penetrating the posterior pharyngeal wall, fractured the transverse process of the

<sup>1</sup> Maximen der Kriegs Heilkunst, Hanover, 1861, pp. 443-553; also by Pirogoff in his Kriegs Chirurgie, 1864, p. 563.

first cervical vertebra, lacerating the vertebral artery at this point and lodging finally under the skin of the sub-occipital region.

The absence of hæmorrhage in this case is remarkable, and the explanations given by the findings in the autopsy by Prof. Webber, of Kiel, are worth noting. He says: "The wounded vertebral had not bled and was not likely to bleed. The two divided extremities had completely retracted, the upper end was cut on a level with the transverse process of the atlas, the lower end, much retracted, was filled with a resistant thrombus an inch and a half in length. There was no notable extravasation of blood in the vicinity; the upper end was likewise completely plugged with a thrombus."

It is true, nevertheless, that in the majority of the cases, or at least 50 per cent., the conditions of the wound, or rather its complications, are such that the natural hæmostatic process is entirely insufficient, even in a merely provisional sense, and that surgical assistance of the most determined and skilled sort must be immediately appealed to if danger to life from hæmorrhage *alone* is to be averted.

If we now analyze the table of twenty-two cases of wounds which did not become aneurismal, we will observe that in some the hæmorrhage was so sudden and profuse that death came on before any skilled assistance could be rendered; in others, and these were more numerous, the fatal hæmorrhage was never controlled, even when the patients were opportunely taken to hospitals or to competent surgeons.

As has already been stated, in over 44 per cent. of the injuries of the vertebral artery in which any surgical treatment was attempted, errors of diagnosis were almost invariably committed, so much so that in sixteen out of thirty-six cases the common carotid artery was ligated by mistake.

This error was always of very serious consequence, for it not only increased the shock by adding to the traumatism, but it aggravated the hæmorrhage by increasing the strain on the vertebral circulation, and, furthermore, greatly increased the risk of secondary cerebral complications.

It must be stated also that from the standpoint of hæmorrhage alone the cases in which the injury to the artery has been inflicted through the mouth are of still greater gravity, especially if the bleeding is taking place in the pharynx, where it is almost impossible to control the bleeding orifice by plugging it or by other direct procedures. This is well shown by Case 2, Table III, reported by L. J. Sansom.<sup>1</sup>

In July, 1830, an adult male was admitted in the Hotel Dieu, of Paris, to be treated for a gunshot wound in the head and neck. The ball had penetrated by the right nostril, had fractured the palate, and was lost in the pharyngeal region. Slight bleeding had taken place from the nose and throat immediately after the injury, but it had stopped spontaneously. About the tenth day after the affair very abundant hæmorrhage took place. The course and track of the bullet did not lead the attendants to suspect a lesion of the vertebral. A wry neck had supervened, but it was attributable to independent causes. Preparation was made to ligate the carotid, but the patient died before the operation could be attempted. At the autopsy it was discovered that the ball had fractured the transverse processes of the upper cervical vertebra, and had injured the vertebral in its course.

The fatal cases reported by Voisin, Thurot, Kade and Peters emphasize the fact that the syncope and exhaustion of surgical anemia from frequently repeated and profuse hæmorrhages of the vertebralis, is to be regarded as of primary importance in influencing the mortality.

In all wounds of the vertebralis there is always a certain amount of shock, which varies in intensity with the extent, importance and multiplicity of the structure involved, and shares the responsibility, equally with hæmorrhage, in determining the final issue, or may even exceed it in importance.

This is especially true of the cases of injury of this artery in which death is practically instantaneous.

Types of this class are the cases reported by Jolly, of Clermont, France, Carter, of Bombay, and Saviotti, of Milan.

<sup>1</sup> Des Hæmorrhagies Traumatiques, Paris, J. B. Bailliere, 1836, p. 352, 8vo.

In Jolly's case (a wound in the neck caused by the penetration of a load of wadding from the discharge of a pistol loaded only with powder), death was instantaneous. The autopsy revealed that the transverse processes of the second and third cervical vertebræ had been torn away *en masse* and that the fourth had been fractured into fragments. The vertebral artery was completely torn away; a terrific hæmorrhage had taken place through the wound and the spinal meninges were exposed and covered with clot.

In Saviotti's case, a man aged thirty years was stabbed in the neck. He fell almost unconscious immediately, but shortly after the injury he picked himself up and succeeded in dragging himself up to the stairway of the Ospedale Maggiore of Milan, where he dropped dead as he attempted to ascend the stairs. In the autopsy it was discovered that the fatal wound had completely severed the vertebral artery in the inter-transverse space between the third and fourth vertebræ. An extensive extravasation about twelve centimetres in length filled up the retro-pharyngeal space and pressed important structures.

In Carter's case, a native Naique policeman, aged twenty-five years, was stabbed in several places by another policeman and died about one hour after sustaining his injuries. In this case the vertebral artery had been severed in the inter-transverse space between the third and fourth cervical vertebræ. Here the phrenic and other structures had been injured.

In another group of cases we find that while the patients have survived the primary hæmorrhage and shock, the repeated bleeding from the vertebral and a septic condition of wound, which is maintained by the manipulations and the various styptic and other applications that are made to the wound with a view of controlling the hæmorrhage, finally exhaust the vitality of the sufferer and cause death by the combined influences of anemia, shock and exhaustion.

The observations reported by Barbieri and Monti, Prichard and Pirogoff illustrate the characteristics of this group.

Another group is distinguished by *the* most fatal form of complication, viz.: a disturbance in the cerebral circulation and secondary encephalic lesions from septic causes—such as cerebral embolism, meningitis, softening, etc. Typical examples of this

group are: Stromeyer's case, already cited, in which meningitis carried away the patient after the hæmorrhage from the wounded vertebral had been completely controlled, four days after the injury. Maisonneuve and Favrot's remarkable and now celebrated observation in which we notice that, after a most laborious and intrepid search, these operators ligated the vertebralis and arrested an obstinate hæmorrhage from a stab-wound of the neck,<sup>1</sup> only to lose the patient one month after the operation from septic cerebral embolism, due to infection of the wound. The case of Watson, in which the jugular and common carotid were ligated and the subclavian was compressed for a complicated vertebral hæmorrhage. The patient rallied after a most terrific ordeal and was apparently going to improve, when cerebral symptoms set in, and the patient died in coma, three days after the injury.

Still another group of cases may be separated from the others, in which the distinctive feature lies in the pathological origin of the injury to the vertebralis. In these cases the artery is eroded by perivascular suppurative foci, usually tubercular, sometimes septic, and always secondary to other traumatisms or diseases.

Typical of this group are the cases reported by Perrin, Neuretter, Van Buren and Küster. This is an essentially unfortunate group as far as the ultimate prognosis is concerned, for the vertebral injury is usually the last act of a long tragedy. The patients are generally exhausted by long-existing disease or extensive traumatisms to the cervical skeleton, and when the hæmorrhage comes there is little strength and vitality left in the patients to stand any further drafts on their blood supply or their nutrition. Küster's case is especially interesting in this group, not only as a type of the condition referred to, but also because it occurred in the practice of an eminent contemporary surgeon, who was able to cope with the difficulties in his way with the resources of modern surgery. His case is also one of the few in which the hæmorrhage from the bleeding vessel was

<sup>1</sup> In this case the vertebral was ligated *in situ* for the first time in the history of surgery.



permanently controlled, and although the patient finally died from cerebral disturbance, the method pursued in controlling the bleeding artery is worthy of remembrance in the treatment of similar cases.

*Observation.*—A dyspeptic female, aged thirty-five years, very marasmic and addicted to morphine, developed a tubercular abscess of the neck, on a level with the fourth cervical vertebra. The patient's condition was so unfavorable that Küster declined to open the abscess. As the abscess threatened to burst spontaneously and hectic began to manifest itself, he decided to open it. After extirpating the walls of the sac, he discovered a sinus which could be traced to one of the transverse processes and which had to be dilated with a dressing forceps. This allowed the finger to detect the exposed portion of the second cervical vertebra, which was loose and necrosed. The sequestrum was pulled out with forceps, but at that instant a stream of arterial blood poured out of the wound, which was quickly stopped by the immediate reintroduction of the finger into the sinus. After a short delay the finger was partially removed and the blood again poured out. It was now evident that the *arteria vertebralis* had been injured. As the strength of the patient did not allow of any loss of blood, no further experiments were tried with the finger, but in its stead a tampon of iodoform gauze was introduced and insinuated until it was firmly packed in the corresponding inter-transverse space. The hæmorrhage then stopped at once and never returned. A compressing bandage around the head and neck added to the secure retention of the plug. The tampon was allowed to remain *ten* days. When removed it had a distinct odor of iodoform and the wound was entirely free from inflammatory reaction. In the meantime diverse disagreeable symptoms had developed, which were at first attributed to iodoform poisoning. On account of this sublimate gauze was substituted for the iodoform, temporary improvement followed, but vomiting and cerebral symptoms ensued, which terminated by the sudden death of the patient nineteen days after the operation. The autopsy revealed an aseptic wound in the neck and complete laceration of the *vertebralis* in the transverse process of the axis, but both ends of the divided artery were effectually closed with a strongly adherent thrombus, showing very advanced organization, the lower of which extended three centimetres

and the upper extended to the level of the foramen transversum of the atlas.

Setting aside the explanation of the manner of death which, as the author says, might not be quite simple, we learn from this observation that an iodoform tampon can effectually and permanently arrest a hæmorrhage from an artery of the caliber of the vertebralis, and remain in place for *ten* days without calling forth local disturbances. This is the essential feature of the modern antiseptic tampon, as contrasted with the plug used by the older operators, who not only used materials that were far from being aseptic, but actually saturated this material with styptic agents which irritated the wound and favored the development of septic suppuration, thus interfering with the proper organization of the clot.

The great value of the tampon, especially the aseptic or antiseptic tampon; systematically applied in the very depths of the wound and directly against the bleeding point in the arterio-vertebral canals, in permanently arresting vertebral hæmorrhage, is not only demonstrated by Küster's case, but is still more strikingly emphasized by the fact that in the only two cases of primary vertebral hæmorrhage that recovered, out of the twenty-two collected cases, the only agent employed was a tampon. In J. Mason Warren's case ordinary sponges were first used and subsequently sponges dipped in styptic solutions, and in King's case oiled lint and graduated carbolized compresses were used; if we add, that three of the six traumatic aneurisms (see Table III) that recovered, were also saved by systematic plugging of the bleeding orifice, making in all five out of the eight permanent recoveries in the whole collection of forty-three injuries that are due to plugging, we will appreciate still more forcibly the value of the tampon as a hemostatic agent. We shall again refer to this invaluable aid in the treatment of vertebral hæmorrhages when we reach our practical conclusions.

We must now hasten to the consideration of the traumatic aneurisms of the vertebral artery, which we have separated in a distinct group of twenty cases for special consideration.

## IV.—TRAUMATIC ANEURISMS OF THE VERTEBRALIS.

While a traumatic aneurism of the vertebral artery is only a sequel to the primitive injury that originated it, the clinical difference between a primary bleeding wound of this artery and the false aneurism that may follow it, is of sufficient practical importance in the treatment to justify a separate consideration of the two conditions.

While a traumatic aneurism may develop so promptly after an injury, and the extravasated blood may diffuse itself so rapidly and widely that immediate surgical action may be demanded for the salvation of the patient, it is the rule that the concealed and progressive hæmorrhage which causes the aneurismal state, is so well circumscribed by the resistant perivascular tissues, that a temporary respite is given to the patient, and more time is gained by the surgeon for deliberation and the application of conservative measures of treatment. It is by this delay, which gives time for preparation, that the prognosis is improved and the ultimate chances of recovery are increased in traumatic aneurism.

If we now inquire into the facts of clinical experience, we will again observe that while the prognosis of traumatic aneurism is always very grave, that the number of recoveries is greater than in the primary bleeding injuries of this artery; for, in a tabulated record of twenty reported cases of traumatic aneurism, six patients recovered, or 30 per cent., while in a collection of twenty-two primary non-aneurismal injuries, only two recovered, or 9.2 per cent., which would result in a difference of 20.+ per cent. in favor of the traumatic aneurisms.

We have already stated that in a collection of thirty-one reported cases of aneurism of the vertebral artery gathered up to 1893, twenty were cervical and eleven intra-cranial. We need not again refer to the intra-cranial for the reasons previously given, but referring to the twenty cervical aneurisms we will observe that fourteen were caused by punctured wounds, four by gunshot injuries and two were not specified. In eleven out of twenty cervical aneurisms of the vertebral, the common carotid artery was ligated by mistake, and in a large majority the initial curative efforts were directed toward the control of the carotid

circulation. Finally, of these twenty cervical aneurisms only six recovered.

These six successful cases are most instructive and interesting from the standpoint of surgical therapeutics, and deserve individual mention. Chronologically we will consider them as follows:

OBSERVATION NO. I. BY MÆBUS.<sup>1</sup>

On December 27, 1827, the author was called to attend a man, aged twenty-three, who had been stabbed in the neck, and who was apparently dying from hæmorrhage. The patient was almost pulseless and bathed in a profuse icy perspiration. The wound had ceased to bleed spontaneously when M. arrived. The wound was situated in the inferior right half of the occipital region, and was directed downward and forward in the direction of the mastoid. It measured two inches and three lines in depth. A firm plug or compress was packed into the depths of the wound, and the plug held in place by a firm bandage. Ether, opium and cinchona were administered to restore the patient.

The patient improved steadily until the fifteenth day, when secondary hæmorrhage took place from the wound, which had not yet completely healed, but this was arrested by firm pressure. On the seventeenth day a pulsating tumor the size of a bean was detected at the wound; an alum solution was directly applied to bottom of the it with the help of a firm compress, and bandaged. On the twenty-seventh day the tumor was very much larger in spite of local astringent applications and ice poultices, which were now applied for the first time. The tumor soon measured five and one-quarter by four and three-quarter inches in size. The diagnosis of vertebral aneurism was made after testing the effect of pressure on the carotid circulation. An operation was proposed, but patient would not consent to it. Ice poultices were now constantly applied, while the patient was kept in bed. On July 26, or about fifty-nine days after the injury, the tumor became perceptibly harder, and the pulsations diminished. Improvement rapidly followed, and by March 6 the patient was entirely well.

This case, therefore, demonstrates that a traumatic vertebral aneurism may be completely controlled by *cold, direct pressure,*

<sup>1</sup> Graefe's and Walther's Journal, Vol. XIV, p. 98.

and general as well as local rest, which were the only therapeutic agents resorted to by the medical attendant.

OBSERVATION NO. 2. WARREN STONE,<sup>1</sup> New Orleans, La.

A negro slave, aged thirty years, was brought to Stone's Infirmary *five months* after he had been stabbed in the left side of the neck. He bled profusely at the time of the affray, but the hæmorrhage was arrested. A swelling commenced soon after, which gradually increased "until the integuments were about to give way." A careful examination showed that the carotid artery and jugular vein were not wounded. Auscultation gave no sign, and Stone came to the conclusion "that either the external jugular vein or one of the cervical arteries had been wounded." He says: "I concluded to open the tumor, empty the sac, and secure whatever had been wounded. The opening was made, when a small portion of the coagulum was discharged and a sudden gush of arterial blood took place. I placed my thumb upon the carotid artery, but with no effect; the incision was enlarged, the whole coagulum was forced out, and it was found that the vertebral artery had been wounded. For a moment a finger was thrust between the transverse processes, by which means the violence of the bleeding was controlled. Lint was stuffed in place, granulations shot out luxuriantly, filled up the wound and plugged up the wounded artery." The patient was shortly after discharged, entirely well, from the hospital.

This is the first recorded case in which operative interference in a traumatic aneurism of the vertebralis was followed by recovery.

OBSERVATION NO. 3. Reported by TH. KOCHER,<sup>2</sup> Berne.

A. S., aged forty-two, was wounded three weeks before admission to Kocher's clinic. He had been stabbed four times in different parts of the body, a wound in the neck being considered the only serious one of the four. Examination revealed a wound between the fifth and sixth cervical vertebræ to the left of the spinal column. The wound had not healed kindly, and it was for this reason that the patient consulted Kocher. Upon raising the scab that covered the

<sup>1</sup> New Orleans Medical and Surgical Journal, Vol 1, p. 555, 1849.

<sup>2</sup> Ueber Verletzung und Aneuryma der arteria vertebralis, nebst mittheilung eines glücklich verlaufen. Falles, Archiv. f. Klin. Chirurg., Berlin, 1871, Vol. XII. p. 867.

granulations, the wound bled. The introduction of the finger excited a more considerable arterial hæmorrhage. The index finger was re-introduced its whole length into the wound, and easily penetrated through a semi-solid mass of coagula until it touched the posterior surface of the transverse process. As the finger failed to arrest the hæmorrhage, the wound was enlarged three inches, and a quantity of coagulated blood was expelled. The exploring finger now discovered a spacious cavity, the size of a small apple, in the deeper parts of which the transverse processes of the vertebræ could be felt. After enlarging the wound the interior of the cavity could be easily inspected. It was then discovered that the bleeding came from the inter-transverse space between the fifth and sixth transverse processes of the cervical vertebræ. A strong arterial stream from the lower, and another of equal size from the upper foramen in the transverse process poured out of the wound. Pressure applied to either orifice controlled the bleeding. A ligature could not be applied to the divided artery because of its retraction to the level of the vertebral orifices, and there was nothing to hold the thread. For this reason a round charpie plug, the size of a pea, which had been previously dipped in a perchloride of iron solution, was introduced into the upper and lower vertebral arterio-transverse orifices and tightly packed into the osseous canals. Hæmorrhage was immediately and perfectly arrested. A firm compress was applied, and the head was immobilized with a stiffened cravat to secure absolute rest to the wound. The plugs were removed four days after their introduction, and no hæmorrhage followed.

Erysipelas set in, however, but it was subdued with turpentine, and the patient finally completely recovered and was discharged about five weeks after admission.

OBSERVATION No. 4. Reported by CHRISTIAN FENGER, Chicago.

G. C., a male cook, aged nineteen, robust and well nourished. Had always enjoyed good health until January 6, 1881, when, while intoxicated, he was shot in the neck with a 32-calibre revolver. A large stream of blood spouted from the wound, and in fifteen minutes his face, around the lower jaw, became so swollen that he was unable to open his jaws for more than half an inch. On admission to the Cook County Hospital an external bullet wound was found to exist an inch external to the left of the posterior nuchal median line, on

<sup>1</sup> Medical Standard, Chicago, March, 1887, Vol. 1, No. 2.

a line with, and two inches behind, the mastoid. There was great swelling of the corresponding side of the face and neck, showing great interstitial effusion of blood. Five days after admission, while straining at stool, the patient felt something give way behind the angle of the jaw. This was followed by intensely agonizing pain, accompanied by decided pulsation in the left sub-auricular region. Four days later a decided aneurismal *bruit* was detected over this. As there could be no doubt of the existence of a traumatic aneurism at this point, Dr. E. W. Lee ligated the left common carotid artery. The patient felt well with the exception of a slight headache and slight sensation of pulsation below the left mastoid process. No aneurismal *bruit* was detectable on stethoscopic examination.

Three days subsequently, while undergoing cross-examination in court, the sensation of pulsation increased, and, on return to the hospital, a decided thrill, but no *bruit*, could be detected behind and below the left mastoid process. "By February 9, the pain and pulsations had markedly increased. As it was obvious that a traumatic aneurism had recurred and was endangering life, I decided to make the radical operation, and began by securing the external carotid. An incision was made, three inches in length, along the entire upper half of the sterno-mastoid, the tissues were carefully separated, a careful watch kept for the pulsating vessels around the border of the pulsating tumor, with a view of ligating them before opening the aneurismal sac. When pulsation on pressure, in various places, had been apparently felt, and the aneurismal pulsation seemed to cease, an aneurism needle, armed with heavy aseptic silk, was passed successively around the area of the tissues involved, and ligature applied *en masse*, but in vain.

I then determined to lay open the sac and catch up the supplying artery *in loco*. A transverse incision, two and a half inches in length, was made, extending from the upper end of the former incision backward from the mastoid process through the skin and insertion of the sterno-cleido-mastoid, in order to secure the posterior occipital artery, possibly the source of the aneurism. On removal of the sterno-cleido-mastoid, the pulsations were more markedly felt. After a thin layer of the deep nuchal muscles had been cut through, the aneurismal sac was opened and found filled with dark clots, on removal of which arterial blood spurted out. This hæmorrhage could be controlled only by pressure on the bottom of the cavity at its deepest part. The squama ossis occipitis was found denuded, and in

the internal wall, formed by the atlas and axis, some splinters of bone were felt. The tissues were cut through downward along the transverse processes of three or four cervical vertebræ and the whole sac laid open, which necessitated the removal of the upper fourth of the sterno-mastoid muscle. Artificial respiration and injections of whiskey were required at this stage, as respiration had ceased. When the respirations again began search was made for the vertebral artery, which was finally taken up, at its curvature around the axis, and ligated. The bleeding stopped. The vertebral artery was nearly as large as the internal carotid. During ligation the respirations had stopped, and the patient was pulseless and seemed dead. After dressing the wounds, eight ounces of defibrinated blood were transfused. The patient rallied rapidly, and on April 7 left the hospital entirely well.<sup>1</sup>

OBSERVATION NO. 5. REPORTED BY DR. ROBERT F. WEIR.<sup>2</sup>

“On December 8, 1883, a man named Robert Adams, aged twenty-eight, was brought into my ward at the New York Hospital, having received a short time previously a stab-wound in the right side of the neck, from a knife held in the left hand of his opponent, who faced him when striking at him. The patient said he had bled very freely, but his clothes were not much stained with blood, nor was he weakened or exsanguinated. When first seen by the house surgeon, no farther bleeding was taking place from the wound, which was situated about three-quarters of an inch below the lobe of the right ear, and just anterior to the sterno-cleido mastoid muscle, transverse in direction and about half an inch in length. There was below this point and extending several inches downward an ovoid,

<sup>1</sup> This is the first and only case in which the vertebral artery has been ligated *in situ* with *permanent* success in a case of traumatism or traumatic aneurism of this artery. Maisonneuve and Favrot, in 1852, were the first to ligate the artery *in situ* in a case of gunshot injury of the vertebralis, but the patient died seventeen days after the ligation of the artery of septic embolism. These are the only two recorded cases in which a ligature has been applied to an injured vertebral artery. Attempts have been made to ligate this vessel *in situ* in several cases mentioned elsewhere, but the local conditions and urgency of the symptoms compelled the operators to resort to immediate plugging or some other measure to arrest the bleeding. Fenger is in error when he says (*loc. cit.*) that his is the fifth case. “in which vertebral artery ligation for a wound involving a traumatic aneurism of the vertebral artery has resulted in recovery.” His was the second case of *ligation*, the others were simply illustrations of effectual plugging.

<sup>2</sup> Archives of Medicine, Vol. XI, No. 1, February, 1884.



soft, non-pulsating tumor, running and posterior to the mastoid muscle. All exploration of the wound was avoided and an iodoform dressing applied and secured by a compress and firm bandage.

December 10.—Tumor has almost entirely subsided; wound nearly healed; patient yesterday afternoon suddenly experienced almost complete paralysis of sensation and motion of the left arm and hand; this was preceded by a “queer” confused, not painful feeling in his head, momentary in duration; consciousness not lost.

December 15.—Tumor has disappeared; wound entirely healed; paralysis is slowly disappearing; at a point two inches below and one inch posterior to lobe of right ear palpation discovers a faint pulsation slightly expansive in character, and on auscultation a slight bruit is audible.

December 25.—Since the last record all the signs of aneurism have developed at the point indicated in last note; pressure on the carotid just below the level of thyroid cartilage does not affect the pulsation in the tumor, but pressure over the tubercle of sixth cervical vertebra controls it at once, nor does it react as long as the compression is continued. Ice-bags and pressure were ordered to be applied alternately every three hours over the tumor.

January 1.—The signs of aneurism, including pulsation, thrill, tumor and bruit, are still more pronounced; no appreciable effect has followed the treatment by ice and pressure; the area of pulsation is now nearly two and a half inches in diameter; the paralysis of the left arm is becoming less marked.

January 3.—To-day digital pressure was resorted to at the lower anterior edge of the aneurism, where yesterday it was found that compression arrested all pulsation; this was continued for seven hours by the house staff, assisted by relays of students; considerable force was necessary at first to control the circulation in the sac, which occasioned some pain and discomfort, and required morphia, gr.  $\frac{1}{3}$ , hypodermically to keep the patient quiet; no cerebral symptoms occurred at any time during pressure; after two hours there was great diminution in force of pulsation, and slight pressure controlled it without further discomfort to the patient; after three hours the pulsation could not be felt and all signs of the aneurism, save the resistance due to the tumor on palpation, had disappeared; pressure was continued lightly until 7 P. M. (in all seven hours), at which time a firm graduated compress was applied; no cerebral symptoms were noticed during the treatment; no return of symptoms; a solid

tumor can be appreciated at site of aneurism; paralysis of arm has almost completely disappeared; general condition excellent.

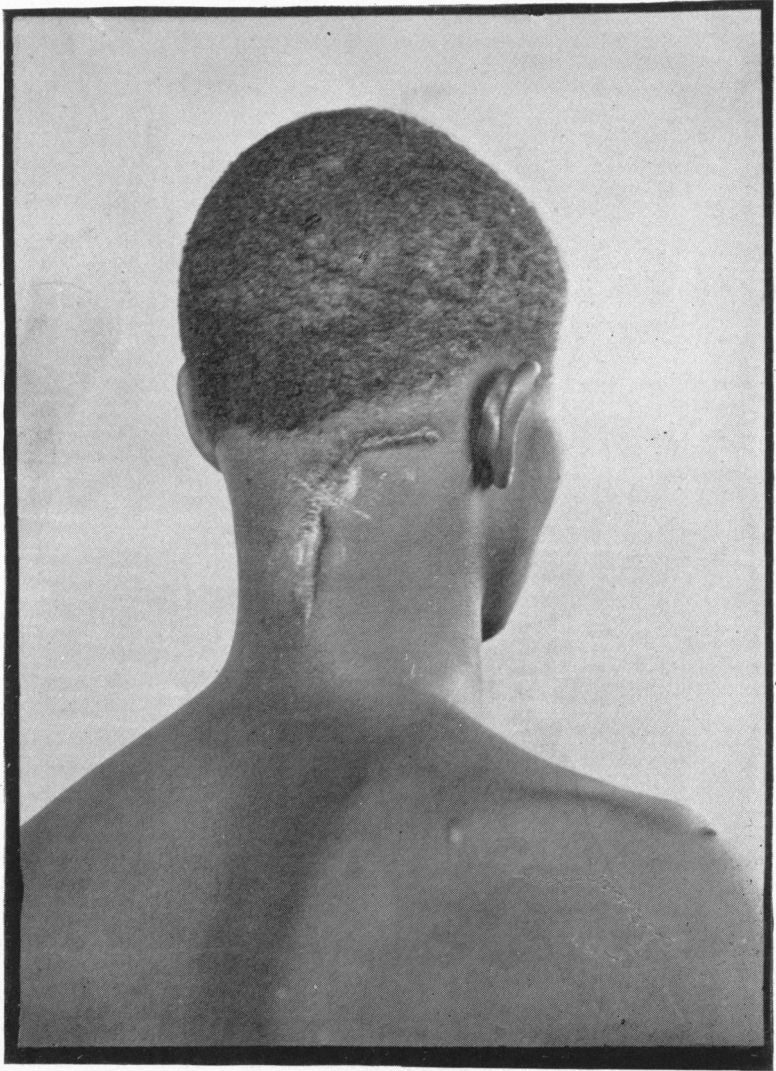
January 12.—Since last note patient has been up and about; no return of sign of aneurism; only a slight trace of the swelling can now be felt; the patient was to-day discharged from the hospital as cured.

This case so happily terminated by a bloodless procedure is especially interesting on account, not only of the variety of the mode of termination, but also because of the method employed, which is unique in the record of this class of arterial injuries.

OBSERVATION NO. 6. BY THE AUTHOR.

*Traumatic Aneurism of Right Vertebral Artery Occupying the Sub-occipital Triangle Caused by Gunshot Injury and Involving the Artery in the Atlo-axoid Space. Incision; Extirpation of Sac; Plugging of Bleeding Point; Recovery*—The patient, Vance J., is a bright mulatto youth, aged twenty-one, a native of Louisiana, admitted to Ward No. 2, Charity Hospital, July 6, 1888. He states that about two months before admission he was accidentally shot in the back of the neck by another person who stood about seven feet away from him, the injury being inflicted by a revolver (Smith & Wesson) which carried a forty-four calibre bullet. He says that immediately after being shot he became paralyzed in his right arm and leg and also became quite numb in the corresponding side. His arm and leg was almost "lifeless," but about ten days after the accident he began to recover some control of his arm and hand and has been steadily improving since, so much so that now he can "use" his limbs almost as well as before the injury. He furthermore states that he bled very profusely from the bullet wound at the time of the injury and that he has bled more or less freely from it ever since. The orifice made by the bullet has apparently healed at various times, but it "broke" open again as often and bled each time profusely, so much so that he was so weak that he could only with great difficulty sustain the fatigue incident upon his travel to the hospital. These repeated hæmorrhages alarmed him more than all his other symptoms and have caused him to seek the assistance of the hospital surgeons.

*Status Præsens.*—The patient is anæmic and his pulse is weak and compressible, it averages 100; temperature 99°. He was immediately put to bed and examined. A prominent pulsating tumor was



MATAS—Line of scar resulting from the incision in case of Traumatic Aneurism of the Vertebral Artery.

at once recognized in the upper post-cervical region. The swelling is diffused in the right sub-occipital space extending from the posterior border of the sterno-mastoid in front to the median line posteriorly. It reaches the inferior occipital curved line above and descends to the level of the fourth cervical vertebra below. A perforation, in the centre of a circular bluish cicatrical spot, indicates the aperture of entrance. This opening is situated three inches below the external occipital protuberance and one and a half inches to the *right* of the same point and about three inches in a horizontal line behind the mastoid process. These measurements were taken with the head midway between flexion and extension. The pulsations of the tumor, which is diffusely spheroidal, are visible to the eye at a considerable distance and are associated with a moderate thrill on firm pressure. The swelling is reducible under firm pressure, though the pulsations are so strong that a four-pound weight is easily lifted up and down synchronously with them. A very low *quasi*-placental bruit is heard over the tumor under stethoscopic examination. Firm pressure over the common carotid at Chassaignac's carotid tubercle (sixth cervical transverse process), sufficient to arrest all temporal pulsation, exercises no influence on the pulsations. Even very hard pressure below this point, with the view of controlling the vertebral, has little effect in arresting the aneurismal pulsation. Simple compression of the carotid above the tubercle of the sixth cervical vertebra had no effect in arresting the pulsations of the tumor. Rouge's method of compressing the common carotid by pinching the sheath between the thumb and index through the relaxed sterno-mastoid succeeded in arresting temporal pulsation, but had *no effect* on the aneurism. In view of this unequivocal evidence it was plain that the tumor was not connected with the carotid and that consequently it must be a traumatic aneurism of the upper vertebral artery (probably diffused), involving this artery shortly before its entrance into the cranium. My colleagues in the surgical service, Drs. Miles, Parham, Laplace, Chassaignac and Michinard, who saw the case with me likewise concurred in this opinion.

*Treatment.*—The patient was at once put to bed and given the benefit of complete rest. He was informed of the nature of his condition in order that the necessity for complete repose, especially of his neck and head, be more thoroughly impressed upon him. An ice-bag was applied over the swelling.

On July 9, a three-pound weight, wrapped up in cotton and

gauze, was applied directly over the tumor and held *in situ* with an elastic (Martin's) bandage wound around the forehead.

July 10.—Patient complained that the pressure of the elastic bandage was intolerable and that he could not stand it longer. The tumor pulsed almost as vigorously as ever apparently unaffected. The elastic was removed and an ordinary roller gauze bandage substituted to hold the weight which was replaced over the swelling.

July 11.—Patient can only stand the weight intermittingly; compelled to relieve him of the solid weight altogether, and substitute a bag of bird shot (No. 6) weighing five pounds, which is adapted much better to the contour of the swelling and causes less complaint. This weight the patient can stand, without the addition of retaining bandage, for one or two hours at a time, when he removes it and rests for half an hour or more. In the intervals of rest the ice-bag is applied.

Thus far very little impression has been made upon the swelling. At times I fancy the pulsation is less vigorous. The dimensions and appearance of the swelling have certainly been unaffected. Patient complains of greater soreness and is growing tired of treatment.

July 13.—Two long electrolytic needles are connected with the negative pole of a McIntosh eighteen-celled galvanic battery. The current furnished by twelve cells was applied; the needles were introduced as deeply as possible in the softest parts of the tumor. This application lasted about an hour without any very perceptible result when the needles were withdrawn. Ice-bag and weight were continued intermittingly.

July 20.—A marked change has taken place in the tumor since yesterday. The wound of entrance which, since the application of the shot weight had closed cicatricially, is now swollen and projects upward as a distinct conoidal swelling rising about one inch above the level of the tumor. Just in the centre of this elevation, at the point corresponding to newly-formed cicatrix, the skin is purplish and threatens to tear open at the least provocation. The tumor proper appears to be more diffused and pulsates vigorously, though not with so strong an impulse as on the day of admission. On the other hand the pulsating area appears to have been extended over a larger surface, so that it is now very close to the external occipital protuberance, and is advancing over the median line in spite of the natural barriers to further progress in this direction. The general appearance of the swelling indicates that it is ready to burst through.

the original wound, and in view also of the increasing restlessness and impatience of the sufferer it is plain that operative interference cannot be deferred much longer. The direct compression of the tumor is now abandoned altogether, and I decided to run the risk of opening the sac with deliberation and thorough preparation rather than expose the patient to the great danger of accidental rupture without the benefit of immediate assistance. After preparing a considerable quantity of iodoform gauze and other antiseptic material that might be required in permanently packing the wound, I decided to immediately cut into the newly-formed nipple-like swelling and then through it make a digital exploration of the interior. This acuminate point was, therefore, punctured; an opening, large enough to insinuate the index finger into the tumor, was made. A jet of dark sero-sanguinolent fluid shot out of the opening the moment the incision was made, and the pointed or nipple-like swelling collapsed. Before the index finger could be well introduced into the opening, the flow of the bloody fluid had entirely ceased, and it was evident, much to our surprise, that there was going to be no immediate hæmorrhage. The cavity of the aneurism *proper* had evidently not been opened, and the "tit"-like swelling communicated only with an encysted bloody accumulation which had been emptied by the first incision. The tumor, however, continued to pulsate, showing that the aneurism proper existed, but not as actively as before. I now proceeded to avail myself of the wound just made to explore the aneurism proper and to familiarize myself with its topography. I found that the newly enlarged wound of entrance led into a sinus that freely admitted the left index. The exploring finger could also be swept over and around a smooth, spheroidal, pulsating and well-defined tumor, apparently about two inches in diameter. The tumor appeared to be distinctly separated from the surrounding parts at its periphery, and gave the impression that it was a tense globiform sac. The free portion of the tumor appeared to be directed toward the suboccipital triangle, but it doubtless originated in the inter-transverse atlo-axoid space. Toward the mesial line it reached the ligamentum nuchæ, and upward it distinctly reached the inferior curved line which had been exposed by the dissection of the tumor. Further down, deeper than this, the finger could not explore without risk of injuring the sac. I was pleased to notice that, after the withdrawal of the exploring finger, no hæmorrhage followed, showing that my fear of immediate rupture had been unfounded. Dr. La-

place was also able to confirm these topographical data by a cautious repetition of my exploration.

By this operation we had obtained several important data :

(1) The aneurism was not diffused, but distinctly circumscribed and was contracting.

(2) Its topographical relation to the vertebræ and probable origin between vertebral transverse processes had been very approximately obtained.

After consultation I decided to go no further, but to avail myself of the newly-made opening to directly compress the aneurismal sac by carefully and systematically packing the sinus that led to it with iodoform gauze and then apply a firm compress and external retaining dressing. By this means I hoped to obtain a complete solidification of the contents or, in the event of failure to obtain this, to still further circumscribe the sac so as to enable me to reach the wounded artery more readily when attempting a radical operation at a later moment.

July 21.—The patient was quiet and comparatively comfortable ; the dressings were clean ; no hæmorrhage. The packing had evidently served its purpose well. I decided not to delay further action. The packing could not permanently remain in the wound, and, as it had to be removed at some early time, it was best to make a systematic and well prepared attempt to secure the wounded vessel outside of the sac by exposing the transverse processes of the vertebræ above and below the sac and ligating it in the inter-transverse space in the manner suggested by Gherini and Dietrich ; or, in the event of failure to do this, to simply lay the sac open, following Syme's modification of the operation of Antyllus, then seek the bleeding orifices and plug them in the vertebral canals, as had been done successfully before by Lücke and Kocher in two similar cases. I was encouraged to believe in the feasibility of the first plan, viz., the ligation in the inter-transverse spaces, because I had reason to suppose that the firm packing against the sac which had been maintained during the preceding twenty-four hours would have some effect in shrinking the tumor and probably solidifying it, thus permitting an unobstructed exposure of the transverse processes of the vertebræ and a comparatively easy dissection of the artery. I, furthermore, prepared to follow or expose the artery in case of need in the vertebral canals themselves by chiseling or biting off the transverse processes with rongeur forceps which form the walls

of the canal containing the artery, immediately above or below the sac. With this plan in mind the patient was brought to the amphitheatre, where with the able assistance of several members of the staff, the operation was undertaken. After the removal of the dressings, excepting the plugs in the wound, the parts were subjected to the usual antiseptic preparation and the patient anæsthetized and the wound of entrance at once enlarged by a longitudinal deeply-made incision through the integument to the level of the sac downward and parallel with the spine, about four inches in length, and then upward to the external occipital protuberance. When this incision was completed the globular surface of the aneurism could be distinctly seen as it projected upward, apparently partially released from the cramped confinement in which it had been held by the strong muscles (trapezius, splenius and complexus) which covered it. The exposure of the tumor was now helped by an additional transverse incision, which starting nearly at right angles from the vertical incision extended outward through the thickness of the posterior cervical muscles to the mastoid, terminating on a level with the posterior origin of the sterno-mastoid. This incision involved the occipital artery, which began to bleed profusely, but was promptly clamped and gave no further trouble. By these two incisions a thick and triangular musculo-cutaneous flap was obtained which when reflected downward, permitted a very clear view of the tumor which, at this juncture, was seen pulsating, though very feebly as compared with its vigorous movements on previous days. This proved that the direct pressure, exercised by the packing, had been quite effectual in consolidating it. The exploring index, introduced at this moment in the depths of the wound, very readily circumscribed the tumor which appeared to spring up from the space between the atlas and axis, the transverse processes being readily recognized. While engaged in this exploration, preparatory to the denudation of the transverse processes in question, I noticed that the tumor apparently gave way, became partially collapsed and was without any assistance bodily lifted out of its nest; at the same time a profuse gush of arterial blood flooded the wound, and no doubt a very alarming hæmorrhage would have occurred had I not seized a handful of very small aseptic sponges that had been held in readiness for the occasion and immediately and tightly packed them in the bottom of the wound, in the inter-transverse space and *into the orifices of the canal* from which the hæmorrhage appeared to come. Over these small sterilized sponges



a thick packing of iodoform gauze was applied and the flap was held with two deep silver sutures over the packing, thus giving firm support to it. A careful sublimate dressing was applied externally and the whole firmly held in place by an elastic woven bandage wound over the forehead and neck. No further attempt was made to seek the artery, because the patient, who was already anæmic from previous losses, could ill afford to stand more hæmorrhage. At any rate the sequel happily proved that further search was unnecessary and that in this case, as in those of Lücke and Kocher, Stone, Warren and Küster, King and Simes, careful plugging was all that was really necessary to permanently relieve the condition. About five hours after the patient had been brought to bed the elastic bandage was removed and a gauze roller bandage substituted. The patient continued to do well.

On July 26, five days after the operation, the dressings and tampon were removed. The wound looked perfectly clean; no pus visible. Only three of the six small sponges were removed; the remaining three were left as grafts in the inter-transverse space, and were soon entirely amalgamated with the rapidly-growing granulations.

Eleven days after the wound was entirely healed, and on August 24, 1888, the patient was discharged entirely well.

About eleven months afterward the patient returned to the hospital with his wound entirely cicatrized and entirely free from any aneurismal lesion, but he stated that a few weeks after leaving the hospital (after the preceding operation) the scar, corresponding to the lower end of wound had "festered," and that a physician whom he had consulted had discovered the ball that had caused all the trouble and had extracted it. The ball had evidently grazed and possibly fractured one of the vertebral transverse processes and given rise to traumatic caries. At any rate the patient was now well and entirely rid of his aneurism.

The aneurismal sac, which was removed *in toto* at the time of the operation, presented the appearance of a spheroidal sac measuring about two and a half inches in diameter. It was very firm in all its surface except that portion which was evidently connected with the artery; here the walls were very thin. The sac walls consisted almost entirely of very compact and finely laminated active clot; the interior was partially filled with soft, dark, grumous passive clot; a considerable mass of clot blocked that portion which has been

attached to the artery. These clots were of very recent formation, and I do not doubt *proved the efficacy of systematic compression*. The sac had shriveled considerably, and surely did not represent when removed the full dimensions of its active period. The specimen was kept for a long time in the Pathological Museum of the Hospital, but about a year ago, owing to some misunderstanding, was thrown away together with a lot of spoiled specimens.

In the fourteen fatal traumatic aneurisms the immediate cause of death may be summed up, as in the case of the non-aneurismal wounds of the vertebralis, viz.: (1) Hæmorrhage; (2) Shock; (3) Sepsis; (4) Exhaustion; (5) Cerebral complications. The cases are worthy of individual mention:

(1) CHIARI, 1829. The common carotid was ligated without effect; patient succumbed with cerebral and septic symptoms.

(2) Prof. CATTOLICA, of Naples, 1861. The common carotid was ligated; six days after, the aneurism burst spontaneously, and the patient died of hæmorrhage before assistance could reach him.

(3) Prof. CATTOLICA, also 1861. Exposed the course of the common carotid, but before closing the ligature tested the effect of temporary compression of the artery. As this did not arrest the pulsation of the tumor, the ligation of the artery was abandoned, and the incision was allowed to heal *per primam*. Two months after this attempt the patient succumbed to "gastric fever," with his aneurism pulsating (?) and unruptured.

(4) Prof. NUNZIANTE, 1838? Cold; compression; aneurism ulcerates and patient dies of uncontrolled hæmorrhage.

(5) GHERINI, 1861. Cold; compression; perchlorid of iron injections; ligation of common carotid by Monti; then plugging of wound. Thirty-six hours after ligation of common carotid patient succumbed to syncope from hæmorrhage and exhaustion.

(6) RAMAGLIA, 1834. Common carotid was exposed and ligation applied but not tightened when it was discovered that its compression had no effect on aneurism. This patient died finally from uncontrolled hæmorrhage.

(7) KLUYSKENS, 1848. Digital compression of common carotid totally arrested pulsation in tumor. The common carotid was, therefore, ligated, but after ligation the tumor continued to pulsate as vigorously as ever. Shortly after, the aneurism burst, and the patient died of hæmorrhage.

(8) A. BRANCO, 1862. Pulsation diminished markedly by compression of common carotid; this trunk was ligated, but ineffectually as regards tumor which grew much more rapidly. Patient died of exhaustion.

(9) A. LÜCKE, 1867. Carotid compression diminishes pulsation in tumor. This trunk was, therefore, ligated, but without benefit; on the contrary, marked aggravation. As the tumor threatened to rupture, injection of five drops of the iron perchlorid made into the sac in different places; slight sloughing of the skin took place and copious hæmorrhage followed, and the method of Antyllus had to be appealed to. A free incision into the sac was followed by "a frightful gush of blood," which nearly carried the patient's life away, but was controlled by a styptic plug insinuated between the occipital and atlas. The patient recovered from the immediate effect of the operation to die shortly after from cerebral complications which were in a great measure attributable to injection and the ligation of the common carotid.

(10) STROPPA, 1866. A hæmatoma connected with the vertebral artery is incised; plugging arrests hæmorrhage, but patient succumbs to repeated secondary bleedings.

(11) SOUTH, 1847. The common carotid is ligated under mistaken diagnosis; tumor rapidly enlarges and bursts into trachea.

(12) SIMES, 1888. This is a most interesting case and forcibly illustrates all the dangers and diagnostic difficulties that are liable to be thrown upon the surgeon while attempting to deal with the injuries which involve the vertebral. "Pressure upon the common carotid, while lessening the pulsation of the tumor, did not, however, perfectly stop it. Before tying the ligature, which had been passed around the carotid artery, the operator continued his incision upward over the swelling and threw a ligature round the artery above it. The ligature below was now tied, and instantly the most terrific flow of blood gushed out of the wound. The upper ligature was immediately tied, but had no control over the hæmorrhages; artery forceps and fingers were employed to seize any and all the bleeding points, but the blood continued to flow until finally Dr. Nancrede thrust his finger deep into the wound against the vertebræ, when the hæmorrhage at once stopped. Attempts to plug the vertebral foramen with a cork plug failed, but the hæmorrhage was finally controlled by packing the canal with a long strip of lint reinforced by systematic packing of the wound. While the patient was improving from the immediate

effects of the operation, and when all danger from hæmorrhage had ceased, cerebral symptoms developed and the patient died. In this case it is more than probable, as Dr. Nancrede stated in the discussion, that several vessels were involved in this injury; the distal end of the internal jugular and carotid were bleeding at the same time as the carotid. He did not think that the vertebral alone could have poured out this large stream of blood."

In addition to these cases there are three more that must be accounted for to complete the list:

(a) The case of F. VERARDINI, in which cold, rest and compression were systematically applied without much benefit, the patient escaping the observation of the surgeon and probably dying from spontaneous hæmorrhage.

(b) The case of STUBBS, of Liverpool, in which a very rare case of idiopathic cervical vertebral aneurism was mistaken for a carotid aneurism and this artery ligated without benefit, the patient succumbing to hæmorrhage.

(c) The case of SYDOW, also idiopathic, of which I only know that it resulted fatally, though not from what cause.

Other observations in which injuries involving the vertebral artery are recorded may be found scattered here and there in the general literature, but they are mere passing references which cannot be quoted with any advantage to the reader as they are too meagre in details for classification or instructive inference. Indeed, several, even many, of the cases that are included in my tables have been very insufficiently described, and I have found it often difficult to secure sufficient data for simple tabulation.

#### CONCLUSIONS.

*A. Treatment of Traumatic Aneurisms.*—(1) There are certain favorable cases (Mœbus, Weir) of traumatic aneurism in the upper and more superficial portion of the artery, in which recovery is possible, *without operative interference*. Rest, direct compression and cold, being apparently sufficient to arrest the circulation in the tumor.

(2) That in every case, when the danger of rupture of the

sac is not immediate, good results may be expected, if only as adjuvants to future radical treatment, from the systematic application of cold, local and general rest, combined with direct pressure on the sac or digital pressure over the artery below the carotid tubercle, using for direct compression ice-bags containing shot, which are easily adapted to the contour of the affected region.

(3) That in the majority of cases, the natural tendency of the aneurism is to progress rapidly to a fatal termination, in spite of the preceding measures, the sac usually rupturing in the direction of its weakest point, viz., the track of the wound that caused it.

(4) That this tendency to spontaneous rupture is markedly favored by the increased tension caused by the ligation of the carotid trunks, so frequently and unfortunately done under the impression of a mistaken diagnosis.

(5) That this deplorable result should always be avoided in case of doubt, by a careful observation of the effects of temporary compression of the carotid upon the circulation of the tumor, before applying the definitive ligature.

(6) That in almost all cases but one (Fenger's case), in which a deliberate and prepared attempt has been made to ligate the artery in the aneurismal region, or at the bleeding point, the efforts of the operator have been frustrated by the copiousness of the hæmorrhage, and temporary plugging of the bleeding spot and, at times, the more accurate plugging of the arterio-vertebral canal, have been forced upon the surgeon as methods of necessity, instead of the method of election.

(7) That, fortunately, this method of plugging, when combined with the free exposure of the bleeding region, and clearing out of the clots, has thus far given the most encouraging results, and that, the more aseptic and non-irritating the material used in plugging, the greater the simplicity of the after-career of the case, and, judging by the especially fortunate or excellent results which were obtained by Warren Stone, 1847, with plain charpie lint; J. Mason Warren, of Boston, with sponges; by King, of Hull, with oiled lint; by Küster, with iodoform gauze; by Simes,

with plain lint; and my own experience with well sterilized sponges, reinforced by iodoform gauze, it would be unnecessary to resort to styptic plugs (as in Lücke's or Kocher's cases), which have a tendency to inflame a wound and render its aseptic management most difficult. In addition, as in the writer's case, small fragments of sterilized sponge, if they are used only in plugging the canals, have the advantage that they may be allowed to remain *permanently* in the wound, where they are incorporated as grafts by the living tissues.

(8) That the use of coagulant injections is especially to be condemned; the perchlorid of iron (as in Lücke's case) having proved most pernicious. Ergotin (Langenbeck) injected into the periphery of the sac may aid in effecting a cure, but it is exceedingly doubtful if this material will distinguish itself more favorably in this region than in the treatment of other aneurisms; while the newly isolated physiological fibrin ferments (Wright) may prove less irritating, they will be likewise open to objection from the mechanical standpoint (embolism). Possibly, electrolysis and Macewen's aseptic method of securing the formation of white thrombi by "needling" may claim some success in the future, but this is very doubtful, and the most authorized opinion would point, at present, to

(9) The acceptance of the method of Antyllus, modified by the conditions of modern surgery, as the only reliable, if still dangerous, method of dealing with this always formidable condition, at least, in the majority of the cases. If this operation is decided upon, every preparation should be made to meet all emergencies. Saline infusion may be required, but a good supply of sterilized sponges, iodoform gauze and long-handled, strong hæmostatic (hysterectomy) forceps will be most useful, the latter especially in grasping bleeding points, or in applying strong pressure on the deep and unusually rigid tissues, in which they are found. The gouge, chisel, or "rongeur" forceps should not be forgotten; the rapid resection of a part of the transverse process may be required, in order to permanently secure the artery; though, usually, the plugging of the arterio-vertebral canal alone will be quite sufficient to accomplish permanent

hæmostasis, and should always be attempted first, if only as a provisional measure, or in cases in which the exhausted condition of the patient will not permit more radical procedures.

(10) In the extremely rare cases of idiopathic cervical aneurism and in the circumscribed traumatic aneurisms that are situated high up in the posterior portion of the neck, and which would not be encroached upon by any of the classical incisions for the ligation of the vertebral artery at its origin, a ligation on the Hunterian principle might be attempted with some prospect of success, especially if cold and pressure and rest were resorted to as adjuvants in the treatment. While the collateral flow from the circle of Willis is very rapidly re-established, more so even in the vertebral circuit, than in that of the carotid, it is nevertheless possible that the contents of the sac may be completely coagulated before this collateral supply has been re-established.

(11) In aneurisms that are situated lower in the neck, the Hunterian ligation, if applied by any of the classical incisions for securing the vertebral at its origin, will almost certainly end in an Antyllian operation, for it will be impossible to reach the trunk of the artery without involving the sac in the incisions.

(12) When the aneurism is well circumscribed, is high up in the neck, and the ordinary local treatment has failed, and the operator decides upon the method of Antyllus as last resort, then it is justifiable to make an incision parallel with the anterior border of the sterno-mastoid, and following the lines mapped out by Fraeys and Chassaignac, reach the vertebral below the anterior tubercle of the sixth cervical transverse process and under the sheath of the carotid compress the vertebral before it enters the foramen, with the finger of an assistant. In that way the arterio-vertebral circulation will be temporarily arrested until the wounded artery has been definitely secured at the bottom of the aneurismal cavity. By this procedure, there will be much less traumatism inflicted on the weakened patient than if a formal ligation had been attempted. In addition, the danger of secondary cerebral complication will be lessened.

*B. Treatment of the Primary Bleeding.*—(1) In the manage-

ment of bleeding wounds (non-aneurismal) of the vertebral artery, the principles of treatment are practically the same as in those which guide the surgeon in the open or Antyllian method of attacking the traumatic aneurisms of this artery.

(2) In some rare cases the nature of the injury is such that a direct attack on the bleeding point is practically impossible. This is notably true of those complicated gunshot injuries in which the missile has penetrated through the mouth, and the blood is pouring into the pharynx or retro-pharyngeal space. In these cases there is usually an associated wound of one of the carotid branches, especially the internal carotid, and the hæmorrhage is so violent that death takes place before any assistance can be rendered. The differential diagnosis cannot be attempted under these circumstances, and as plugging through the mouth is impracticable, the only hope for the patient lies in the immediate but provisional control of both the common carotid and the vertebral artery of the corresponding side, with a view of cutting off the entire arterial supply from the injured region. This result can be obtained without much difficulty by rapidly exposing the carotid sheath at the point of election and passing a ligature around the artery, which is not to be closed, however, but should be transferred to an assistant, who can control the circulation of the artery by simply pulling on the loop; the operator then presses with his finger in the depth of the wound at a point just below the anterior tubercle of the sixth cervical vertebra and in this way arrest the flow from the vertebral artery. A complete control of the two vessels is thereby obtained; the hæmorrhage is arrested and the differential diagnosis can be undertaken with more deliberation. The definitive ligature may then be applied to either one of the exposed arteries, or to both if necessary.

(3) In cases complicated with an injury of the internal jugular, high in the neck and communicating with the pharynx, the resources of surgery are reduced to a minimum. But the traumatism is so great that the shock of the injury alone will often kill the patient almost instantaneously, and if this is not the case the bleeding will be so profuse that life will ebb out long before any efficient assistance can be rendered.



(4) In the more common cases the difficulties and dangers are greatest in the lower cervical course of the artery before its entrance into the foramen of the sixth cervical vertebra, owing to the immediate proximity of vital structures, especially on the left side. Wounds of this portion are generally fatal before the surgeon is called upon to deal with them, owing to the rapidly lethal effects of associated hæmorrhage from the carotid and sub-clavian arteries and corresponding veins. In wounds of this and the remainder of the cervical portion of the vertebral artery the fundamental maxim in the treatment of hæmorrhage, viz., "to control the artery while bleeding and at the bleeding point," imposes itself as a first duty. This control can only be effected by the methods previously indicated when dealing with traumatic aneurism, and may be finally summarized in a general way as follows :

(a) If allowed by the position of the wound, deep and strong pressure should be made, by an assistant, below the carotid tubercle with a view of compressing the vertebral at this point.

(b) The wound should be freely enlarged in order to more directly expose the artery.

(c) Direct pressure with the finger in the wound should be applied to the bleeding point.

(d) Pressure on the bleeding point with strong hæmostatic (hysterectomy) forceps holding a small sterilized sponge, or by actually clamping the bleeding point *en masse*, as a substitute for the finger, and allowing the hæmostat to remain *in situ* for several days, if ligature is impracticable.

(e) Denudation or exposure of the artery in the inter-transverse space, or, if necessary, by biting with "rongeur" or gouging out the antero-external portion of the bony canal in which the artery is contained. This last procedure is perfectly practicable in any part of the vertebral canal, provided a free exposure of the transverse process is obtained and the bleeding be provisionally controlled by digital or forci-pressure.

(f) Careful attention to antiseptic, systematic packing with iodoform gauze being the best protection against infection which in this class of injuries is especially liable to fatal consequences, long after hæmostasis has been secured.

TABLE I. INTRA-CRANIAL ANEURISMS OF THE VERTEBRAL ARTERY.

NUMBER.	SITUATION OF ANEURISM.	AGE	SEX.	CAUSE OF INJURY.	OPERATIVE AND OTHER MEASURES OF TREATMENT.	NAME OF OPERATOR OR REPORTER.	DATE AND TITLE OF PUBLICATION IN WHICH FOUND.	RESULT.	REMARKS.
I. 1.	Intra-cranial.	24	Male.	Idiopathic.	None.	Henry J. Gore, 1826, 1849.	Journal Morbid Anatomy, London, 1828, p. 22.	Died.	Discovered at autopsy.
2.	"	"	"	"	"	"	Am. Journal Med. Sciences, Phila., 1849, No. 3, xviii, 122.	"	No history; specimen presented to Dr. J. Neill, University of Pennsylvania.
3.	"	61	Female.	"	"	Sydow.	Torh. Svens. Lak. Sallsk. Sammank, Stockholm, 1865, 1866, 191.	"	"
4.	"	67	Male.	"	"	M. E. Echeverria.	Med. Rec., N. Y., 1869, 1870, IV, 1.	"	Discovered at autopsy.
5.	"	19	"	"	"	Lorne.	Bull. Soc. Anat. de Paris, 1869, 20, XIV, 455.	"	"
6.	"	45	"	"	"	Sevestre.	Bull. Soc. Anat. de Paris (1872), 1874, 2 s, xvii, 415.	"	Cerebral tumor; syphilitic.
7.	"	49	"	"	"	V. G. Fontarbe.	Un cas d'hémiplegie alternée par Aneurysme de la vertébral, 4th Paris, 1874, Paris, Thèse.	"	Discovered at autopsy.
8.	"	56	"	Traumatic.	"	F. Schultze.	Arch. f. path. Anat., Berl., 1875, LXV, 585.	"	"
9.	"	63	Female.	Idiopathic.	"	E. Leclaire.	Presse Méd. Belge, 1876, xxviii, 153.	"	Discovered at autopsy.
10.	double.	25	Male.	"	"	"	Guy's Hospital Reports (1890).	"	Cerebral hæmorrhage; discovered at autopsy.
11.	"	30	"	"	Potass. iodid.	Anderton.	Trans. N. Y. Path. Soc., 1886, IV, 180.	"	"

TABLE II. TRAUMATIC ANEURISMS OF THE VERTEBRAL ARTERY.

NUMBER	SITUATION.	AGE	SEX.	CAUSE OF INJURY.	OPERATIVE OR OTHER MEASURES OF TREATMENT.	NAME OF OPERATOR OR REPORTER.	DATE AND TITLE OF PUBLICATION IN WHICH FOUND.	RESULT.	REMARKS. ERRORS IN DIAGNOSIS, IF ANY.
1.	Cervical.	23	Male.	Punctured wound.	Cold applications.	Mecubus, 1827.	J. d. Chirurg. und Augenheilk. Berlin, 1830, XIV, 96.	Recoverd.	The common carotid was compressed, but no ligature tied because it was observed that pulsation of aneurism was not arrested thereby.
2.	Cervical first and second vert.	28	"	"	Ligature of common carotid.	Chiari, 1829.	Chassaignac: <i>Traite clin. et pract. d'oper. chir.</i> , 1861, 334. Translated from <i>Il Fil. latre Sebezio</i> , Ann. 3, fasc. 2, and also reported, as Caroscilli's case by Barbieri.	Died.	
3.	Between second and third vert.	20	"	"	The carotid artery was exposed, and a ligature placed around it, but not tightened.	Ramaglia, 1834.	Arch. gen. de Med. Paris, 1834, 25, v, 138-140. Translated from <i>Il Filatre Sebezio</i> , 1834.	"	
4.	Behind angle of inferior maxilla.	"	"	"	Ligature of common carotid.	Cattolica, 1836.	Gaz. Med. de Paris, 1836, 2, 134.	"	
5.	Behind angle of inferior maxilla.	"	"	"	Compression and styptic application.	"	"	"	
6.	Below and behind apex of mastoid.	30	"	Stab.	Cold compression of common carotid, and plugging ulcer created by opening Professor Respoli suggested ligature of the vertebral in the intertransverse space, <i>en masse</i> , but not done.	Professor Nunziante, <i>Yppolitico</i> , 1838.	Monograph "I. ligatura dell'Arteria vertebrale nei casi di Aneurisma della stessa," 16 pp. 1838. Quoted by Cherini, <i>Atti in his monole</i> , "Favite dell'Arteria Vertebrale," Milan, 1867.	"	Diagnosis suspected in course of operation only.
7.	Between fourth and fifth vert.	40	Male.	Idiopathic.	Ligature of carotid.	H. Stubbs, 1846.	Liverpool Med. Chirurg. Journal, 1847, 1, 110-112.	"	Supposed at first to be an aneurism of internal carotid.
8.	Upper cervical region.	"	"	wound?	Ligature of common carotid.	South, 1847.	Chelius' Surgery, Vol. 1, p. 1067, 6th Ed., quoted by P. Holmes and Barbieri, <i>vide infra</i> .	"	Fifteen days after ligature of carotid the aneurism burst into the trachea. Diagnosis made post-mortem.
9.	One inch below mastoid.	23	"	Punctured.	Ligature of common carotid.	Kluytstiens, 1848.	Ann. Soc. de Men. de Gand, 1848, XXI, 217.	Recoverd.	This was a non-pulsating tumor, and was supposed to be an abscess, and incised.
10.	Back of neck.	30	"	Stab.	Incision; plugging in intertransverse process.	Stone, 1849.	New Orleans Med. and Surg. Journal, 1849, 18 <sup>o</sup> , VI, 555.	"	It was first diagnosed an abscess, and afterwards an aneurism of the carotid or one of its branches.
11.	Between second and third vert.	29	"	Punctured wound.	Ligature of carotid.	A. Branco, 1862.	Gaz. Med. de Lisbon, 1862, x, 597.	Died.	

TABLE II.—CONTINUED. TRAUMATIC ANEURISMS OF THE VERTEBRAL ARTERY.

NUMBER.	SITUATION.	Age.	SEX.	CAUSE OF INJURY.	OPERATIVE OR OTHER MEASURES OF TREATMENT.	NAME OF OPERATOR OR REPORTER.	DATE AND TITLE OF PUBLICATION IN WHICH FOUND.	Result.	REMARKS. ERRORS IN DIAGNOSIS, IF ANY.
12.	Between atlas and occiput.	23	Male.	Punctured wound.	Ligature of carotid; aneurism injected with perchlorid of iron.	A. Lücke, 1867.	Arch. f. klinische Chirurg., Berl., 1867, viii, 78.	Died.	.....
13.	Between fourth and fifth cerv. vert.	..	"	Gunshot.	Incision; plugging; patient succumbed to repeated bleeding.	Stroppa, 1867.	A. Barbieri: Monograf. dell'Arteria Vertebrale, Milan, 1867-68, Gaz. Med. Lombard, 1867-68. Gherini: "Ferite dell'Arteria Vertebrale," Milan, 1867 (Mémotre).	"	This was originally an abscess which ulcerated the vertebral artery.
14.	Below atlas and axis.	20	Female.	Stab.	Cold; compression; ligature of common carotid by Monti.	Gherini.		"	On post-mortem exam nation the artery was found to be anomalous; entered the foramen of fifth cerv. vert., which accounted for temporary arrest of bleeding by compression over common carotid.
15.	Between fifth and sixth vert.	42	Male.	Punctured wound.	Incision and plugging of artery in transverse canal.	Kocher, 1871.	Schmidt's Jahrsbericht, Leipzig, 1872, clv, 191. From Arch. f. klin. Chirurg., Berlin, 1871, xii, 867.	Recovered.	.....
16.	Behind and below mastoid process.	33	Female.	"	Cold; pressure; electro-puncture.	Verardini, 1872.	Bull. Soc. Anat. d. Bologna, 1872, 58, xviii, 415.	Died.	Patient disappeared, and could not ascertain result, but he was not improved when he deserted.
17.	Two inches below, and one inch post. to lobe of right ear.	28	Male.	"	Digital pressure and compression.	R. F. Weir, 1884.	Archives Medicine, New York, 1884, xi, 157, 1162.	Recovered.	.....
18.	Between atlas and axis.	19	"	Gunshot.	Ligature of left common carotid; incision of sac, and ligation of vertebral artery.	C. Fenger, 1881.	Med. Standard, Chicago, 1887, 1, 339, 35, 1887.	Recovered.	Intra-venous transfusion was required to revive patient.
19.	Fifth cervical vertebra.	41	Female.	"	Ligation of common carotid, and plugging of vertebral in canal.	G. Henry Simes, 1888.	Proceedings Philadæ. Acad. of Surgery, June 4, 1888. Med. News, Vol. LVIII, 1888, p. 78.	Died.	Other vessels were involved in the injury.
20.	First and second cerv. vert.	21	Male.	"	Incision of sac, and plugging vertebral in canal.	R. Matas, 1888.	Annals of Surgery, November, 1893, p. 477.	Recovered.	.....

TABLE III. WOUNDS AND OTHER (NON-ANEURISMAL) INJURIES OF THE VERTEBRAL ARTERY.

NUMBER.	CAUSE OF INJURY, WEAPON.	AGE.	SEX.	SITUATION.	OPERATIVE AND OTHER MEASURES OF HÆMOSTASIS AND TREATMENT.	NAME OF OPERATOR OR REPORTER.	DATE AND TITLE OF PUBLICATION IN WHICH FOUND.	RESULT.	REMARKS, ERRORS OF DIAGNOSIS, IF ANY, ETC.
1.	Stab.	Adt	Male.	Between occiput and atlas.	and None.	Fabricius, 1750.	Fabricius, Philipp, <i>Conradus</i> , of Buzbach, in <i>Precipue in cautions in sectionibus et perquisitionibus cadaverum humanum observanda</i> . Bruckmann, 1750. A. Barbieri, <i>Monograf dell'Arteria Vertebrale</i> , Milano, 1867, vi. Des Hemorrhages Traumatiques, Paris, J. B. Bailliere, 1836.	Died.	
2.	Gunshot.	Adt	"	Extreme upper portion; R.	"	L. J. Sanson, 1830.		"	First bleeding stopped spontaneously; then secondary hæmorrhage set in on tenth day, which caused death before carotid could be ligated. True nature of injury only discovered after death.
3.	Stab.	31	"	Second cervical vertebra; R.	Ligation of common carotid by mistaken diagnosis; plugging of wound.	N. Volsin, 1841.	Operations Chirurgicales; Gaz. Med. Paris, p. 138, 2 s, Vol. IX.	"	Death from secondary hæmorrhage; exhaustion. True nature of injury only discovered after death.
4.	Gunshot.	58	"	Second and third cervical transverse process.	"	Jolly, 1841.	Gaz. Med., Paris, 1841, 2 s, ix, p. 138.	"	Death was instantaneous, and discovered after death.
5.	Stab.	Adt	"	Upper cervical.	Ligation of common carotid.	Thurat, 1848.	L'Ossieur: <i>Annal. Soc. Med. d'Emulation de la Flandre occidentale</i> , Roulers, 1848, II, 366.	"	Source of hæmorrhage only discovered after death.
6.	Gunshot.	Adt	"	First cervical vertebra.	"	Stromeyer, 1850.		"	Death instantaneous; other injuries.
7.	"	Adt	Female.	Sixth cervical vertebra; L.	Ligation of inferior thyroid and vertebral arteries in the wound.	Maison neuve and Favrot, 1852.	<i>Journal des Connaissances medico-chirurgicales</i> , Paris, 1852, 2 s, Vol. II, p. 181.	"	Death caused by purulent infiltration of neck and sepsis.
8.	Stab.	Adt	"	Below sixth cervical vertebra transverse process; L.	Ligation of common carotid artery, internal jugular vein, and attempted ligation of left sub-clavian artery.	J. Watson, 1853.	J. R. Wood: <i>N. Y. Med. Journal</i> , 1875, n. s., III, 40.	"	Cerebral complications and sepsis.
9.	"	25	Male.	Between third and fourth cervical transverse processes.	"	J. H. Carter, 1854.	<i>Trans. M. and Physical Society of Bombay</i> , 1853, 4, 1855, n. s., II, 313.	"	Died almost instantaneously; no time for surgical assistance; other injuries.
10.	Gunshot.	18	"	Fifth cervical vertebra; R.	Plugging? or pressure, superficially applied.	W. H. Van Burden, 1857.	<i>N. Y. Journal Medicine</i> , Vol. II, 3 s, 1857.	"	Other injuries; the hæmorrhage was secondary to ulceration of vertebral from retro-pharyngeal suppuration, etc.
11.	"	11	"	Second and third cervical vertebra.	Systematic plugging of wound with small bits of sponge dipped in styptic solution.	J. Mason Warren, 1861.	<i>Surgical Observations with Cases</i> , Boston, 1867, p. 553; also, <i>Boston Med., and Surg. Journal</i> , 1862, LXVI, p. 389.	Recovered.	

TABLE III.—CONTINUED. WOUNDS AND OTHER (NON-ANEURISMAL) INJURIES OF THE VERTEBRAL ARTERY.

NUMBER	CAUSE OF INJURY, WEAPON.	Age	SEX.	SITUATION.	OPERATIVE AND OTHER MEASURES OF TREATMENT.	NAME OF OPERATOR OR REPORTER.	DATE AND TITLE OF PUBLICATION IN WHICH FOUND.	RESULT.	REMARKS. ERRORS OF DIAGNOSIS, IF ANY, ETC.
12.	Ulceration of artery from tubercular spinal caries.	Adt	Male.	Fourth cervical transverse process.	Plugging of bleeding abscess cavity.	Perrin, 1861-2.	Bulletin Société de Chirurgie de Paris, 1861-2, 2 s, p. 97.	Died.	This injury of the vertebralis is entirely due to pathological causes.
13.	Gunshot.	Adt	"	Fourth cervical.	Plugging.	Kade, 1862.	Gazz. Med. de St. Petersburg, Vol. 11, 1862; Archiv. f. klin. Chirurg. Vol. 1, J. Laudi, Lezioni di Chirurgia Operatoria, Bologna, 1867, p. 231; quoted also by Barbieri, <i>loc cit.</i>	"	Other complicating injuries of mouth and pharynx; source of hæmorrhage ascertained only after death.
14.	Stab.	30	"	Between occiput and atlas.	Plugging; ligation of common carotid by mistake.	Pritchard, 1863.	Augustus Pritchard: Proceedings Bristol Branch British Med. Assn., British Med. Journal, 1863, L, 399.	"	True source of hæmorrhage only discovered at autopsy.
15.	Gored by ox.	Adt	"	Before entering the sixth trans. process.		Pirogoff, 1864.	Pirogoff. Krieg Chirurgie, 1864, p. 503.	"	Other complicating injuries; exact nature of injury only ascertained after death.
16.	Gunshot.	27	"	First cervical vertebra.	Pressure over carotid.	D. C. Peters, 1865.	D. C. Peters: Am. Journal Med. Sciences, 1865, N. S., XLIX, 373	"	The internal carotid, as well as vertebral, was injured; other complications added to the gravity of the injury.
17.	Stab.	20	Female.	Between first and second cerv. vert.	Ligation of common carotid by mistake.	Monti, Barbieri, 1861.	Arteria vertebralis, Milano, 1867, and Gazz. Med. Ital. Lombard. Milan, 1867, Vol. 11.	"	The autopsy alone revealed the true source of the hæmorrhage.
18.	"	30	Male.	Between third and fourth cerv. vert.		Saviotti, 1867.	Gherardini: F. dell'Arte Veneta, 1867, pamphlet, Tip. di Marini, Via Durini, No. 31 (Lanzo), pp. 43.	"	Death took place shortly after the injury, before assistance could reach patient; source of bleeding only discovered by autopsy.
19.	"	Adt	"	Between fourth and fifth cerv. vert.		Caspar-Liman, 1871.	Caspar-Liman: Prakt. Handbuch der gerichtlichen Medizin, 5 Aufl., Berlin, 1871.	"	This case is of interest simply because a protracted hæmorrhage appears to have followed the injury; other causes carried off the patient five days after the injury.
20.	Ulceration of artery from tubercular disease.	11	"	Second cerv. vert.		Neuretter, 1873.	Oestr., Jahrb. für prakt. Med., 1873.	"	In this case the vertebral was eroded by osseous tubercular disease.
21.	Stab.	25	"	Upper cervical region.	Systematic plugging and pressure.	King, 1885.	The Lancet, November 28, 1885.	Recovered.	One of the transverse processes was felt to be fractured.
22.	Pathological (tubercular) abscess of neck involving second transverse cervical process.	35	Female.	Second cervical.	Systematic plugging with iodine gauze after opening abscess.	Küster, 1883.	Berliner klinische Wochenschrift, No. 48, November 26, 1883.	Died.	Hæmorrhage from vertebral was perfectly controlled but patient died nineteen days after opening abscess, from some cerebral cause, and other complications.