Reflections on "The Subclavian Steal"

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Abstract:
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Reversal of blood flow in the vertebral artery, demonstrated by angiography, was reported ten years ago and immediately given the colorful name of "The Subclavian Steal." Since then, numerous articles have appeared, in English and other languages, reporting both clinical and arteriographical descriptions of the phenomenon.

A search of the literature has turned up a most interesting early report in which cerebrovascular symptoms were ascribed to the hemodynamic alterations. This case report appeared almost 100 years prior to the aforementioned article in the modern medical literature.

It was further suggested by the physician describing this case that ligature of the vertebral artery would be the treatment of choice in the relief of symptoms.

ADDITIONAL KEY WORDS

brainstem ischemia  subclavian artery  vertebral ligation  reversal of blood flow

In 1961, Reivich and associates published a report of two patients in whom they observed retrograde blood flow in the left vertebral artery. Each had been noted to have clinical signs suggesting obstruction in the left subclavian artery. In the same issue of the journal, there appeared an editorial by C. Miller Fisher entitled "A new vascular syndrome—'the subclavian steal,'" During the nine years which have passed since then, numerous articles have appeared in both the English and foreign language literatures describing from one to as many as 15 cases with similar findings. These reports include both clinical and radiographical descriptions of the phenomenon and suggest methods of surgical treatment.

As was pointed out by Patel and Toole in 1965, many colorful names have been used to describe this syndrome, and this has added to the difficulty of finding case reports. The terms which have been used include "brachio-basilar insufficiency syndrome," "le syndrome de suppléance vertébro-sous clavière" (vertebro-basilar substitution syndrome), "brachio-vertebral syndrome," "le syndrome de l'effacement de l'artère sous clavière" (the syndrome of subclavian rubbing out), "syndrome de succion subclavia" (subclavian suction syndrome), and "vertebral grand larceny."

Virtually all the material has been written as though the authors were astonished to find such a spectacular and rare syndrome, and several offer hypotheses to explain the related effects on the central nervous system. The "discoveries" have been accomplished with the latest and most modern diagnostic equipment and measuring devices. Lest we forget that these have not always been available, the author hastens to call to the reader's attention some very enlightened conclusions reached by our forbears through intuitive deduction. Drawing heavily on those powers of observation provided by Nature, they were often led to some remarkable discoveries. The following narrative illustrates the point exceedingly well.

Original Communications
Art. II.—Successful Operation in a case of Subclavian Aneurism, by Andrew W. Smyth, M.D., House Surgeon, Charity Hospital, New Orleans, Louisiana.

From the University of Texas, Graduate School of Biomedical Sciences, Division of Continuing Education, St. Anthony Center, 6301 Almeda Road, Houston, Texas, 77021.
"WILLIAM BANKS, a mulatto, born in the State of Florida, in 1832, was admitted into the Charity Hospital, New Orleans, La., on the 9th of May, 1864, affected with aneurism of the right subclavian artery. He had been employed in the capacity of steward, on the United States steam transport Suffolk, and dates the commencement of his ailment, from a collision of this ship with the steamer Continental at Sabine Pass, in the month of February last. In his efforts to save himself, he tried to board the latter ship, and, holding by the anchor, he sustained, for a time, his own weight and that of another man who clung to him in a similar attempt. To this over-exertion he attributed the origin of his disease. He felt pain in the shoulder from that time, and in about a month he noticed a small throbbing tumor making its appearance above the clavicle.

"This tumor, gradually enlarging, had reached the size of a small orange at the time of his admission into the hospital, was circumscribed and round in shape, filling up the posterior inferior triangle of the neck; strong pulsatory movement was visible even at some distance, and on applying the ear to its surface, a loud bellows sound was heard accompanying the arterial beat. No difference was detected in the pulsation of the two radial arteries at the wrist, and there was nothing abnormal in the sounds of the heart.

"He complained a good deal of severe pain and numbness in the fore-arm and hand; for the past two months he had been unable to lie down or stand erect, but was compelled to lean forwards continually for relief, and to sleep sitting in a chair with his head resting on the side of the bed or on another chair placed opposite.

"The case was seen by a large number of medical gentlemen, none of whom entertained any doubt as to the nature of the tumor, or the necessity of an operation for the patient's relief. Some diversity of opinion did, however, exist as to the best method of proceeding to adopt.

"Dr. D. L. Rogers, of New York, who was present, strongly urged the ligature of the innominate and carotid arteries at the same time, as being an improvement on former operations. The tying of the latter artery would intercept a certain quantity of blood, and thereby cause syncope rapidly, and ceasing of its own accord. At least sixteen ounces of blood must have been lost in the space of three or four minutes. To prevent its recurrence the wound was filled with lint, and a small weight placed upon it to effect compression. Slight haemorrhage, however, to the extent of two ounces at a time took place on the two following days, and was stopped by the nurse pressing the lint firmly into the wound.

"Finding that something more was necessary to check the bleeding, the idea suggested itself to me of filling the wound with small shot, as a more effectual means of compressing the artery. This expedient, although not exempt as I could see from dangerous consequences, at the same time offered some advantages, the principal among which was, that the pressure of the shot on the artery might possibly aid in effecting its occlusion. In removing the lint for this purpose haemorrhage recurred, and I found that the shot fully answered my expectations in checking it—so much so, that wishing to remove the ligature from the innominate, believing it now to be a useless source of

promised at least relief from present pain, while any attempt to arrest the circulation through the aneurism by ligature on the distal side, might not have accomplished even so much. The aneurism continued to increase from the date of admission; and, six days after on the 15th of May, assisted by Dr. Rogers, Drs. Holliday and Boyer of this city, Surgeons Bacon and Orten, of the United States army, and the resident students of the hospital, I performed the operation suggested by the first-named gentleman.

"A longitudinal and transverse incision having been made after the method of Mott, no difficulty was experienced in placing a ligature on the innominate artery a quarter of an inch below its bifurcation, and another on the carotid, an inch above its origin. On tying the former all pulsation stopped in the tumor. The temperature of the arm and hand was immediately increased, and in about forty-eight hours after the operation a perceptible undulatory motion was discovered in the arteries of the wrist. But little diminution was yet apparent in the size of the aneurism, and, except some slight febrile action, soon subsiding, no other constitutional disturbance was observed. The patient was now able to lie down for the first time in two months, and all went on favorably until the 29th. He complained, however, for the first few days of a burning pain in his arm, different (he said) from the numbness experienced before the operation. The ligature had come away from the carotid artery the day before.

"On the 29th of May, fourteen days from the time of operating, a severe haemorrhage occurred, causing syncope rapidly, and ceasing of its own accord. At least sixteen ounces of blood must have been lost in the space of three or four minutes. To prevent its recurrence the wound was filled with lint, and a small weight placed upon it to effect compression. Slight haemorrhage, however, to the extent of two ounces at a time took place on the two following days, and was stopped by the nurse pressing the lint firmly into the wound.
irritation, I felt safe in pulling it away even against some resistance.

"A slight oozing, sufficient to stain the lint placed over the surface, followed for the two subsequent days, when it ceased, and all went on well for a fortnight more. The patient felt some difficulty in swallowing and an occasional desire to cough, about which, however, he made little complaint. The aneurism diminished rapidly in size, and pulsation became quite distinct at the wrist.

"The shot sinking gradually in the wound, I began to entertain some fears of its getting out of reach, and, on the 17th of June, I picked about half of it out with forceps, but in five hours, haemorrhage returning, it was immediately replaced. Slight bleeding, however, still recurred at intervals of two and fifteen days and was checked without difficulty.

"On the night of July 5th, being sent for with the announcement that the patient was dying, I discovered, on getting to his bedside, that he had had a terrific haemorrhage exceeding in quantity the first, on the 29th of May; he had fainted, was pulseless and gasping in a frightful manner. The bleeding having ceased, I placed a compress of lint over the wound and added the paper weight used before as additional security.

"In the morning, on visiting the wards, I was surprised to find him fanning himself; he was very pale, his pulse was 140, and weak, his voice however was strong, and he observed that if the bleeding could only be stopped he would yet do well.

"In endeavoring to discover the probable source of haemorrhage I found, on referring to Mr. Erichsen's work on surgery, a great deal of valuable information on this question, which led me to form a most important practical conclusion regarding it. In the chapter on aneurism of the subclavian, after giving statistics of ligature of this artery in the first part of its course, Mr. Erichsen says: 'This table is, to my mind, conclusive as to the merits of the operation, the patient having in every case but one been carried off by secondary haemorrhage from the distal side of the ligature, in consequence of the close proximity of numerous collateral branches; and in this exceptional case the operation, although performed with the utmost delicacy and skill, proving fatal from pericarditis and pleurisy before the period at which secondary haemorrhage might have been expected. Mr. Liston, in one case ligatured the root of the common carotid as well as that of the subclavian,' an operation very analogous to the present, hoping in this way to diminish the risk of the supervision of this fatal haemorrhage by arresting the current of blood which, by sweeping into the carotid past the mouth of the subclavian, necessarily washed away any coagulum that would otherwise have formed in this artery. But his expectations were not realized, haemorrhage taking place as usual, and from that portion of the (subclavian) artery which lay on the distal side of the ligature, the blood having been carried into this part of the vessel in a retrograde course through the connection existing between its vessels arising from it at this point and those on the opposite side of the head and neck.'

"It is evident, on examination of these vessels, that the vertebral is by far the most important, from its size and communication with its fellow of the opposite side, in carrying on this fatal retrograde current, and its direct connection with the brain offers an explanation for the peculiarly rapid occurrence of syncope after bleeding, so well marked in the present case. In this way, no doubt, haemorrhage was arrested in previous cases, for its repetition has been a striking feature in almost all of them.*

"The danger of secondary haemorrhage to be apprehended from a collateral branch carrying on the anastomosing circulation close to the distal side of the ligature has also been noticed by Mr. Erichsen.

"In mentioning the accidents after ligature, he remarks: 'I think, however, that the presence of a collateral branch in close proximity to the distal side of the ligature—more especially if it be one that serves to carry on the anastomosing circulation—will be found to have a decided tendency to prevent the formation of an internal coagulum.'

That the vertebral carries on almost the entire anastomosing circulation into the subclavian artery, is yet more clearly shown by the occlusion of the common carotid which has taken place after ligature of the innominate. I was ignorant of this fact at the time of operating on the present case, but it is readily understood by supposing that the current in the larger carotid was completely checked by that from the more active vertebral, for these currents oppose each other in the subclavian when carrying on the retrograde circulation. If this is the explanation, it is interesting in showing how occlusion may sometimes be brought about.*

"The fact that the duration of life has been greater after ligature of the innominate than after that of the subclavian near its origin, can also be accounted for by the greater distance from the seat of ligature in the former operation of the anastomosing collateral branch.

"From all these considerations I resolved to tie the right vertebral artery,* before, if possible,
another haemorrhage should take place, at the same time entertaining great fears of the result, owing to the patient's reduced condition.

"On July 8th, fifty-four days after the first operation, with the assistance of my friend, Dr. P. C. Boyer, of the Hotel Dieu, and the students of the hospital, I placed a ligature on the vertebral artery. . . ."

"No constitutional disturbance whatever was observed after this operation, which was much facilitated by the empty state of the vessels. On the following morning all the shot was removed from the first wound (having remained thirty-eight days) and was found to weigh two and a half ounces. It had gone deeply into the neck and had probably ceased to press on the artery.

"A marked decrease in the circulation of the arm was now apparent, the slight pulsation at the wrist disappearing; coldness and oedema supervened and the brachial artery became occluded, feeling corded throughout its whole extent. I was somewhat alarmed for the safety of the limb, but in a few days these unfavorable symptoms began to subside and slight pulsation was again perceived in the radial artery.

"No further haemorrhage having taken place after the second operation, the new wound healed rapidly; the ligature coming away on the tenth day. The first wound also closed, though more slowly, and the patient at present, September 15th, is entirely well, excepting that he yet lacks perfect command over the muscles of his arm, which, however, he is rapidly regaining.

"The aneurismal sac has almost disappeared, but there still exists some noticeable swelling above the clavicle.

"The lessons drawn from this first successful case must be of great importance in future operations for the cure of subclavian aneurism. We have twenty recorded cases, in which ligature of the innominate or of the subclavian artery in the first part of its course, without that of the vertebral, have proved fatal, and it is reasonable to suppose that it would always prove so.

"In the present case it would have been a difficult matter to have reached the vertebral at the time of the first operation, owing to the size of the aneurism. Still I think it was possible (it would always be so in the upper part of its course), and the early occurrence of secondary haemorrhage in some of the fatal cases shows the danger of delay.

"If the innominate and vertebral arteries should be tied at the same time, it would not do to omit ligature of the carotid also, since we have seen that its occlusion in other cases was only owing to the current from the vertebral. But if an interval should be allowed to elapse between the operations, it is a question whether the carotid might not be left to this occlusion. Statistics being so imperfect on this point it is impossible to decide.

"It is highly probable that ligature of the vertebral will also render safe the operation on the subclavian in the first part of its course, and this might appear preferable in some cases to tying the innominate, as it would leave the carotid free."

In the article immediately following this description by Dr. Smyth, there is a letter addressed to him by Dr. M. Morton Dowler of New Orleans,7 in which he comments on “this coup de maitre . . . in operative surgery.” He states, further, that this report must cause the name of Dr. Smyth “to resound from the lips of every future surgical lecturer,” and his name to be imprinted “in the pages of every future systematic treatise on surgery.” Unfortunately, this prediction by Dr. Dowler failed to be realized and, instead, the report became buried in an obscure journal.

The first report of an attempted operation to obliterate a subclavian aneurysm by proximal and distal ligature was that of Dr. Valentine Mott, a “celebrated New York surgeon,” which was reported by him in the American Medical Times in 1818. Dr. Mott reports that there were no immediate untoward results but that the patient suffered attacks of syncope and on the 23rd day a hemorrhage came on, which reappeared at different times during the following days, up to the 26th day, when the patient died. The hemorrhage was furnished by the distal end of the artery beyond the occluded portion.

In many cases between that of Mott in 1818 and Smyth in 1864, reappearance of the radial pulse was reported, showing that collateral circulation had been re-established, but in all of these cases death resulted from hemorrhage at the distal end of the subclavian artery between nine and 28 days following surgery. In 1864, in a volume entitled “A Compendium of Surgery,”8 there is described in vivid detail the anastomotic circulation in the neck and thorax which is available following ligature of the proximal portion of the subclavian artery. This description includes the following quote: “. . . the vertebral by its junction in the cranium with that of the opposite side, in order to form the basilar trunk, very readily permits in their connection a retrograde circulation.”*
In 1869, Dr. Smyth, in response to a request from the Surgical Section of the American Medical Association, reported a follow-up of his patient, Banks.

“At the present time, May 15th, 1869, five years from the date of the operation, the patient is enjoying the best of health, having gained nearly twenty pounds in weight during the last two years. He has the full use of the right hand, although the arm is not quite so muscular as the left, and in every way the cure is complete and perfect.” (On May 6th, 1869, the patient was exhibited before the American Medical Association at its annual meeting in New Orleans.)

By way of summary, Dr. Smyth concluded his report to the American Medical Association with this paragraph.

“The ligation of the principal communicating branch with the distal end of a ligated artery, to arrest secondary haemorrhage from it, is an entirely new operation (the present instance of ligation of the vertebral being no doubt the first), and it is one of some value to general surgery.”

It is of interest to note that as early as 1837, and perhaps even earlier, it was realized that retrograde flow could take place through collateral channels into the distal portion of the subclavian artery beyond a more proximal occlusion. Smyth, in 1864, however, was the first to suggest that the “peculiarly rapid occurrence of syncope after bleeding” was most likely the result of a retrograde current in the vertebral artery by way of communication with its fellow of the opposite side.

The author submits that this was the first recorded description of the “subclavian steal,” but without such a colorful name.

Ashhurst reported in 1889 that the only instance of recovery following ligation of the innominate artery was the case in which Dr. Smyth also tied the carotid and vertebral. Smyth’s patient survived ten years and then died of hemorrhage from the sac into which blood had found its way through the subscapular artery.

References
6. Ibid, p 171
10. Ibid, p 469

*Author's italics.
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