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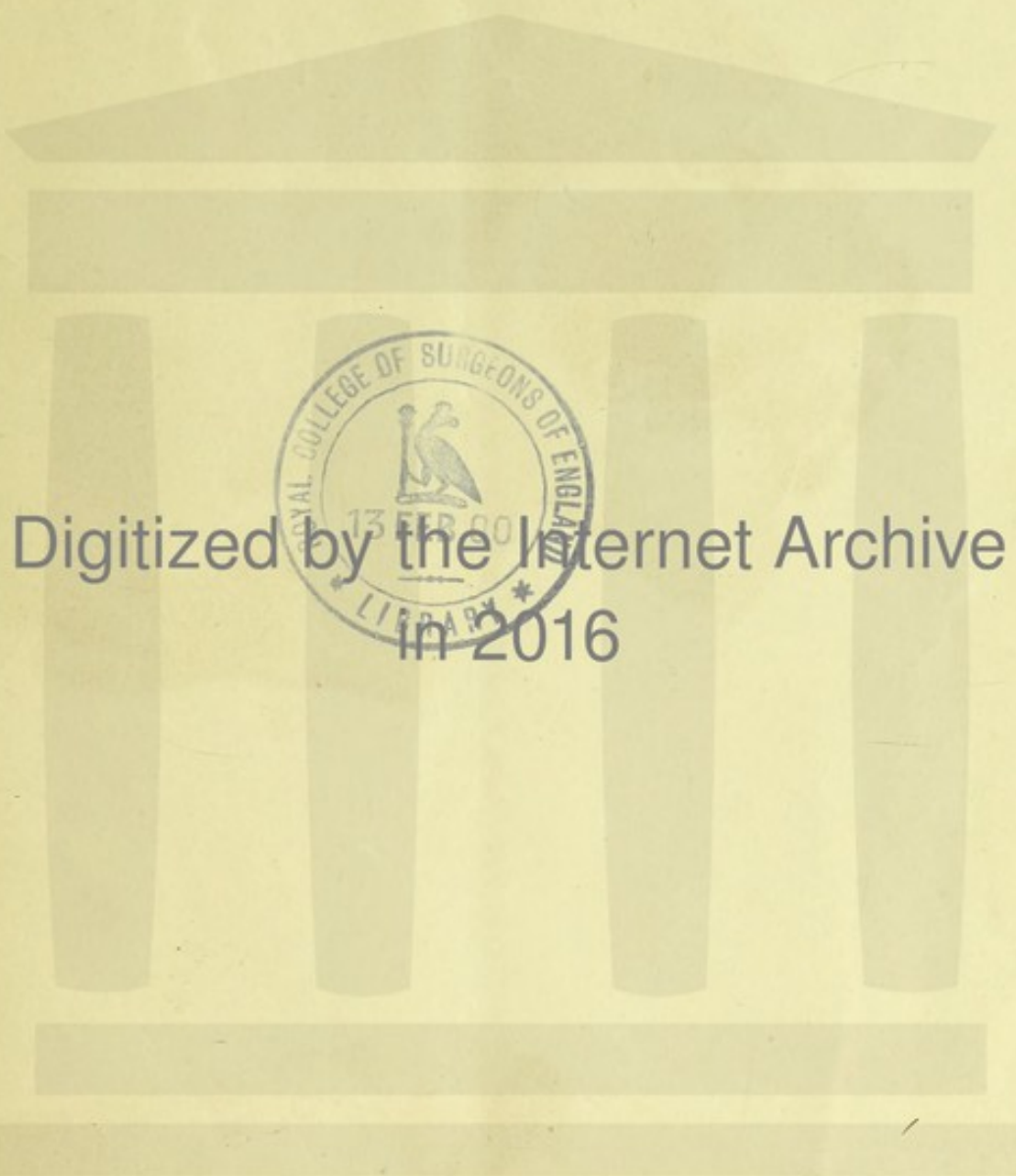
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Ligature of the Innominate Artery.

BY HERBERT L. BURRELL, M.D., BOSTON.







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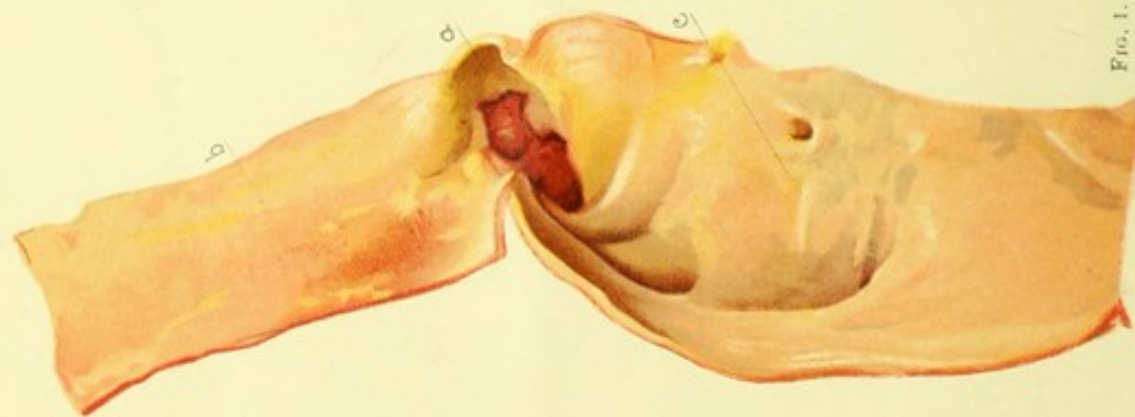


FIG. 1.

Carotid and subclavian arteries, with the occluded innominate. *a*, Distal ligature of innominate, with occlusion. *b*, Carotid. *c*, Subclavian.

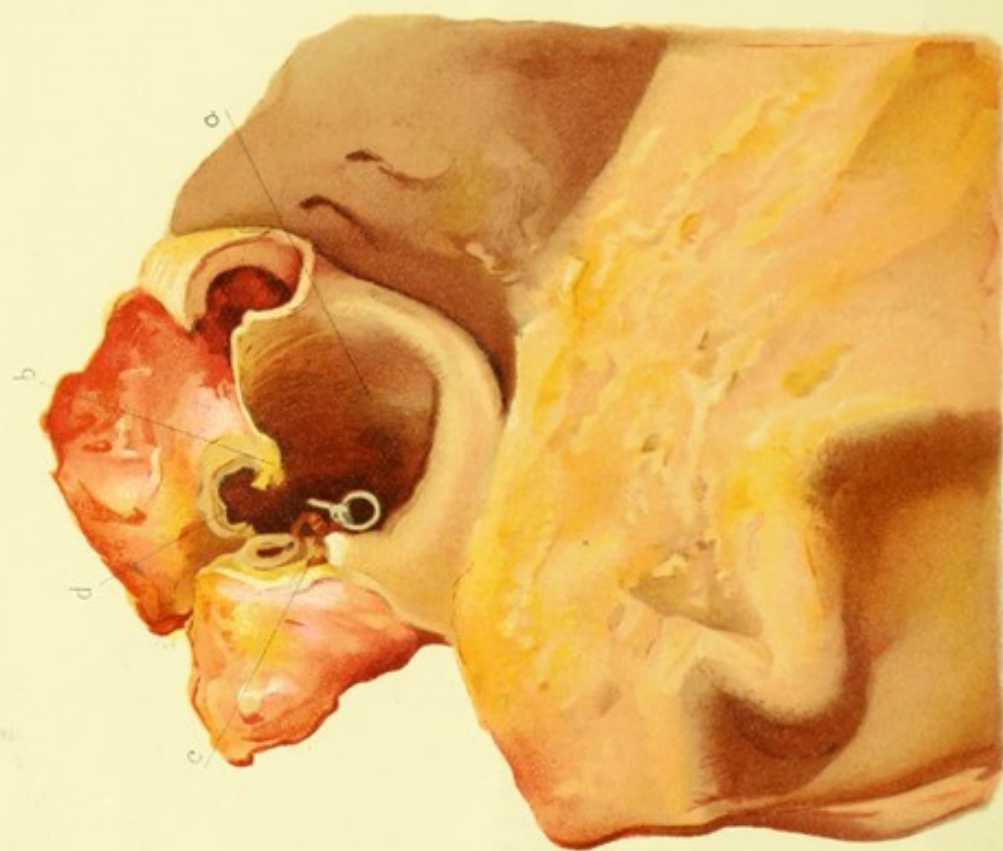


FIG. 2.

Portion of arch of aorta, showing innominate artery. *b*, Projecting spur where the ligature has cut through. *c*, Loop of ligature within the lumen of the artery. *d*, Lumen of the artery above ligature.

LIGATURE OF THE INNOMINATE ARTERY, WITH THE REPORT OF A CASE.¹

BY HERBERT L. BURRELL, M.D., BOSTON,

Surgeon, Boston City-Hospital; Assistant Professor of Clinical Surgery, Harvard University.

THE ligature of the innominate artery has been so fatal an operation that it had been questioned whether the operation is justifiable or not. This leads me to record this case. Some of the accounts of attempts to ligature the artery describe such difficulties of technique, as, for example, in the article by Mitchell Banks, that any surgeon hesitates before performing this hazardous operation. The literature of the subject is not large, but it is filled with an almost unbroken record of fatal results. The causes of death as the result of the operation have been three: first, shock; second, hemorrhage, usually from the distal end of the artery; and, third, sepsis.

The operation of ligature of the innominate artery has been done twenty-nine times, including my own case. Twenty-six were performed for aneurisms of the subclavian artery, generally involving the junction of the carotid and innominate arteries; and three times it was done for trauma — of these one was for hemorrhage from the subclavian, one for hemorrhage from the axillary artery, and one for secondary hemorrhage following ligature of the subclavian.

Three cases are reported as recoveries; the first was Smyth's of New Orleans, 1864. The patient lived ten years, but finally died from hemorrhage from the sac of the original aneurism. The second case was Lewtas', of India, 1889, who reported a recovery at the end of 43 days. The third was Coppinger's, of Dublin, 1893, who reported the patient well at the end of 42 days. Graefe, of Berlin, in 1822, reported a case which died on the 68th day of hemorrhage.

The success of an operation must be considered as applied to an individual case. If my own case had been reported at the end of 50 days, it would go on record as a successful case. In the light, however, of Graefe's case that died from hemorrhage on the 68th day, it is too early to report a recovery on the 42d or 43d day. In my own case the patient lived 104 days. He had been up and about for a number of weeks attending to his affairs, and died of hypertrophy and dilatation of the heart and general arterial sclerosis. The innominate artery was closed and the aneurism had shrunk. The patient might have lived for a long time so far as the ligation of the innominate was concerned.

The success of this operation may be measured by the question whether the patient lived longer and with more comfort than without operation. I believe (it is unfair to assert) that the patient lived as a result of the operation in more comfort and a longer time than he would have without operation. With the foregoing qualifying statement I beg to record the case as one of recovery, with death resulting from other causes on the 104th day.

Appended to this article is an epitome of the recorded cases of ligature of the innominate artery.

The various materials which have been used for securing the vessel are as follows: silk, hemp, catgut, ox-aorta, kangaroo tendon, and a clamp combined with acupressure.

In the majority of instances the method of exposing

the vessel has been the obvious one of making an incision along the inner border of the lower part of the sterno-cleido-mastoid muscle, combined with a division of at least a part of this muscle.

At the time this operation was done I supposed that the removal of a portion of the sternum and the sterno-clavicular articulation was a new procedure, but it has been found that Cooper, of San Francisco, twice used this method of exposing the artery. Bardenheuer has also a number of times resected the manubrium, the sterno-clavicular articulation and portions of the first and second ribs, in order to remove with safety large tumors at the base of the neck. He is convinced that ligature of the innominate artery cannot be done with safety unless a free access to the artery is obtained.

It seems clear that the removal of that part of the sternum which overlies the innominate artery must allow the operator accurately to place a ligature in a far more satisfactory manner than if the ligature is slid down in the dark behind the sternum.

The medical history of this case was the following: The patient, a male, R. F., was fifty-four years of age, married, a clerk, and was under the care of my colleague, Dr. A. L. Mason.

The family history was as follows: The father died of old age; the mother, a brother and one sister died of consumption; three sisters are alive and well.

The present history is as follows: The patient had always been well until two years ago when he noticed a little shortness of breath. He had never had any venereal disease, rheumatism or chorea. He had never worked very hard, nor was he of a nervous temperament. About eighteen months ago he noticed a "lump in his throat" on the left side, which, on exertion, seemed to throb and to choke him. There was no pain. The lump has increased in size but very little. About a fortnight previous to entrance he had to walk some distance, since which time he has had a good deal of dyspnea and the choking sensation has increased. The patient sleeps well, his appetite is good, his bowels are regular, and there is no palpitation of the heart.

Physical examination: The patient is well developed and nourished. The tongue is clean. The pulse is regular, of good strength and volume. The heart area is enlarged one finger's breadth to the right of the sternum. The apex is in the fifth interspace, one-half inch to the outer side of nipple. Over the entire precordium is heard a blowing systolic and a sharp diastolic murmur, especially well-marked over the aortic region. This is transmitted upward and outward into the axilla, and is heard also faintly over the back at the level of the sixth dorsal spine. There is a marked pulsation of the vessels of the right side of the neck, where there can be made out a well-marked, expansive thrill and a systolic bruit (Fig. 3, A).

Lungs: Good resonance and respiration over all.

Liver: Dulness from fifth rib to one inch below the costal border.

Spleen: Area not enlarged, edge not felt.

Abdomen: Lax, tympanitic, not tender.

Extremities: There is a well-marked pulsation in

¹ Read before the American Surgical Association, New York, May, 1895.

the vessels at both elbows and wrists, and also in the posterior tibial artery behind the internal malleoli, especially on the right side. At these places a faint systolic murmur can be made out synchronous with the heart's action. No edema.

Examination of eyes negative.

Urine: 1.016, pale, acid, no sugar, slight trace of albumin. No examination of sediment recorded.

Temperature normal.

After consultation with Dr. Mason it was decided to explain to the patient the serious character of his condition. The man was told that an operation could be done which might benefit him. He decided to do whatever was thought or found best for him to do. It was decided to expose the pulsating tumor in the neck, and to place ligatures proximally, if possible, distally, if necessary, to secure the closure of the aneurism.

On January 15, 1895, ether having been administered, and in the presence of my colleagues at the Boston City Hospital and a large number of physicians and surgeons, and the third class of the Harvard Medical School, the following operation was carried out with the co-operation of Dr. H. W. Cushing:

An incision was made at the anterior edge of the right sterno-cleido-mastoid muscle extending from the

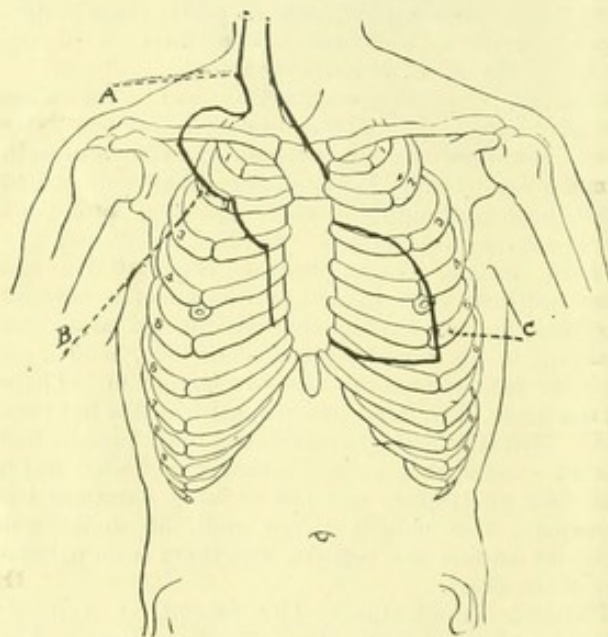


FIG. 3.

A. Limit of thrill. B. Line of dulness. C. Area of heart's dulness.

level of the cricoid cartilage to two inches below the upper border of the sternum. From this point another incision extended outward four inches in length to the junction of the outer and middle thirds of the clavicle. This skin flap with the fascia and platysma muscle was turned back. The sterno-mastoid was severed close to its insertion into the clavicle and sternum. The sterno-thyroid, sterno-hyoid and omo-hyoid muscles were also divided. This brought to view a fusiform aneurism in the right subclavian and right carotid arteries, extending down and on to the innominate. It was believed that enough of the innominate could be exposed to place a ligature between this fusiform aneurism and the aorta. By means of a half-inch trephine operated by a surgical engine the right sterno-clavicular articulation and the right half of the notch of the sternum for about an inch down from the top

were honeycombed. The bony parts were by this means weakened and the removal of the articulation and the piece of the sternum was easily completed by bone forceps. A flat copper retractor was slid underneath the sterno-clavicular articulation and the sternum while the trephine was being used to protect the underlying parts.

Throughout the operation, and especially in the removal of the bone, Dr. Cushing's advice and assistance were invaluable. When this block of bone was removed there was exposed the right innominate vein and the left innominate vein going down to form the superior vena cava, with the vagus and recurrent laryngeal nerves resting on the innominate artery, all plainly to be distinguished. The wound at this time was filled with bubbling air which had been sucked into the areolar tissue which surrounds the great vessels at the base of the neck. Its presence was ominous, and it was felt at this step by all of those who were present that if any large vein were pricked a fatal result would be inevitable. Precautions were taken to prevent the entrance of air by keeping the wound filled with sterile water.

The exposure which was given by the removal of a part of the sternum and the sterno-clavicular articulation was extremely satisfactory, and I can hardly understand how a ligature can be placed on the innominate artery with any safety without a clear view of the anatomical structures involved. The undulating innominate veins and vena cava, the important recurrent laryngeal and vagus nerves, the tracheal tug on the artery, the close proximity of the right pleura and the expansile pulsation of the artery itself, all make conditions which require delicacy in manipulation and accuracy in recognizing all structures.

The sheath of the vessel was opened and the innominate artery was isolated. Then came the problem of how the ligatures should be passed. The rule, of course, is to pass the ligature away from danger. This was impossible, owing to the size of the vessel and the fact that it was surrounded by important structures on every side. The separation of the sheath of the artery was finally completed by means of the forefingers placed on either side of the vessel. The artery was estimated to be one and a quarter inches in circumference. The ordinary curved aneurism needle was too small to pass about the vessel, and the blunt point of the aneurism needle, it was felt, might wound important structures posterior to the vessel. A flat (three-quarters of an inch in width) copper spatula, curved on itself, was passed about the vessel. As soon as this copper spatula was in position, a flat braided-silk ligature was passed around the vessel by an aneurism needle and tied in a square knot. It was feared that the extra turn in the first part of a surgeon's knot might tear the vessel. Fully three minutes were taken in securing the first ligature. Gradually it was drawn tighter and tighter until the circulation was completely cut off. The coats of the vessels were felt to give way while tying this first ligature which was placed three-quarters of an inch from the aorta.

The second ligature of silk was placed in the same manner one-half inch higher up, but was not drawn as tightly as the other, for the coats were felt to give way and the possibility of a tear of the innominate artery was recognized. Both ligatures were tied in square knots and cut short. It was my intention to

sever the innominate artery between these ligatures, to place the vessel at rest by avoiding the tracheal tug; but the size of the vessel and the feeling that came to my fingers while tying the second ligature that the artery was not completely closed at this point, led me to give up this step in the operation.

The overlying muscles were sutured in approximately their original positions, and the wound was closed as rapidly as possible. An aseptic dressing was applied. The operation lasted one hour and a half. The pulsation was gone from the neck and from the right carotid and radial arteries. The right arm was wrapped in cotton wadding, and bandaged to maintain its temperature. After the operation the right pupil was more dilated than the left and reacted more slowly to light. There was a relative anemia of the right tympanic membrane. Had very little shock, very little pain.

On the second day the patient was remarkably comfortable. He was given one-eighth of a grain of morphia every four hours to secure rest. Pressure on the finger-nails of the right hand showed a slight return of circulation. The right pupil had become the same in size as the left. The patient had a slight hacking cough.

3d day: Urine normal, with exception of high color.

4th day: The patient was comfortable; some mucus collected in the throat. It was feared that the efforts at expectoration would disturb the healing of the ligated artery. Free catharsis was established by salines.

5th day: The finger-tips of the right hand showed a pink color. The fingers could be moved a little.

6th day: The wound was dressed. Violent pulsation could be seen near the sternum. An extremely small, but yet distinct, radial pulse could be felt. A few sutures were removed. Union had occurred by first intention. The patient was remarkably self-contained and obeyed instructions.

7th day: The prickly sensations and numbness in the arm and hand which were present for the first three days had wholly disappeared.

8th day: The patient has had tincture of digitalis (ten drops every four hours) and atropine (one-hundredth of a grain three times a day) since operation. The digitalis was now administered every six hours. A feeble pulse in the right radial artery could be felt, but it was distinctly later than the pulse in the left radial. Subjective sensations of warmth and heat in the right arm and hand could be felt, also slight prickling sensations.

9th day: Some headache. Complained of general pruritus, which was relieved by alcohol baths. Atropia omitted; digitalis reduced to ten drops three times a day. Attempts were made to secure sphygmographic tracing of the right and left radial pulse, but the pulsation was so feeble on the right side that no record could be obtained.

10th day: Wound was dressed; all the sutures were removed; union by first intention had occurred except for a small granulating area at the angle of the wound over the sternum.

12th day: Patient has been reading papers for several days. Complained of some pain in the region of the wound, which he attributes to the incision.

16th day: The right arm was still in a protective dressing, but could be used considerably.

17th day: Wound of neck firmly closed.

19th day: The patient could now move about in

bed somewhat, and could lie on the left side. Arm still kept in protective dressing.

37th day: Patient wished to get out of bed, saying that he was relieved of all the symptoms for which he came into the hospital.

40th day: All cardiac stimulants were omitted. From the 43d to the 47th day the patient had a slight attack of tonsillitis, from which he quickly recovered.

52d day: All protection to the arm was removed.

53d day: The right arm was swollen. There was no pain, but there was still a sensation of numbness in the arm.

59th day: The arm remained swollen for three or four days. Patient sat up in a chair for four hours.

60th day: The loss of strength in the right arm was felt more than when he was in bed.

62d day: Walked up and down the ward without fatigue.

63d day: Complained of slight pain at the seat of operation. Could use his right arm to write.

69th day: Walked over to the operating theatre, and was shown at the clinic without inconvenience to himself.

73d day: The patient had been up and about ward for over a week; slight edema of the ankles occurred at night. A mitral and aortic murmur could be heard over the cardiac region. Just over the right sternal notch a pulsating tumor could be felt, which was probably the ligated innominate artery. Pulsation was not transmitted into the carotid. There was a fair pulse in the right radial, which was constantly increasing in strength and volume. No vertigo or other symptoms of cerebral anemia were present. He was discharged at his own request, and was ordered to take digitalis from time to time.

83d day: The patient walked about, attending to some minor matters of business. Yesterday he walked up and down a hill a quarter of a mile in length. He was feeling well and was gaining in strength daily.

100th day: Came to town again to-day. Complained of some swelling of feet and ankles. Slight dyspnea.

On the morning of the 104th day, having been perfectly comfortable during the preceding day, the patient sat up in bed, complained of shortness of breath, became very pale, his face was covered with profuse perspiration, and he died in twenty minutes.

The following is the account of the autopsy by Dr. W. T. Councilman:

The body is large, strongly built, well nourished and pale. There is a punctured wound, evidently made by the undertaker, on the left side of the sternum between the third and fourth ribs. A similar puncture in the abdomen to the left of the median line. No preservative fluid had been injected.

On the right side of neck there are two smooth cicatrices, one commencing 6 cm. above the clavicle and to the right of the sterno-cleido mastoid and extending a little below the upper extremity of the sternum in the median line. Another cicatrix of the same length commences at this point and extends along the upper edge of the clavicle. The skin is tightly adherent to a mass of indurated tissue, chiefly at the angle of junction of the two cicatrices. There is a slight depression corresponding to the right sterno-clavicular articulation.

The abdominal cavity contains a considerable amount of clear fluid. Peritoneum everywhere smooth, liver and spleen free from adhesions. Diaphragm in normal position.

The upper lobe of the right lung is free from adhesions, both the parietal and the visceral pleura smooth and glistening. The lower and middle lobes firmly adherent.

The left lung is adherent over lower lobe and the lower portion of the upper. In both lungs there is considerable induration of the apices. The surface is somewhat puckered, the pleura thickened, and bands of indurated tissue extend from the pleura toward the hilus. In this indurated tissue there are a few small caseous and partly calcified nodules. This condition is more marked in the right lung than in the left. The tissue of both lungs hyperemic and firm. The large vessels of lung and bronchi normal.

The pericardium is smooth. The heart is greatly hypertrophied. In the wall of the left ventricle there is a punctured wound made by the undertaker, which passes through the wall of the ventricle and has lacerated the aortic and mitral valves. The myocardium is normal. All the cavities of the heart, particularly on the left side, are dilated. The valves are smooth and normal. The coronary arteries are dilated, the lumen irregular, and here and there in the walls there is marked thickening of the intima. The aorta in its entire extent and the large arteries coming off from it are greatly dilated and thickened. The most marked dilatation of the aorta is in the ascending portion, and more on the right side. The thickening of the arteries is due to the formation of irregular hyaline masses in the intima. In places these patches are yellowish and opaque, but there is no calcification in any part.

The measurements of the aorta are as follows: Just above the orifice, 10 cm. in circumference; at the most dilated portion in the middle of ascending portion, 12 cm.; in the middle of arch, 10 cm.; and at the beginning of the thoracic, 8 cm.

The subclavian artery of the right side (Fig. 1) is thickened and greatly dilated. The intima is smooth, and shows a few yellowish foci. The dilatation affects the circumference of the artery equally. At the commencement of the axillary artery it is 2.1-2 cm. in circumference, and at the point of greatest dilatation is 4 cm. The left subclavian is 3 cm. in circumference, and the carotids on both sides 2 cm. There is a general dilatation of the iliac arteries; and in the right common iliac, just beyond its origin, there is a circumscribed dilatation affecting chiefly the posterior wall.

There is considerable firm cicatricial tissue around the innominate artery and the beginning of the right subclavian and carotid. The innominate artery is completely closed just at the origin of the subclavian and carotid (Fig. 1, a). A little firm fibrin is adherent to the artery at the point of closure. The orifice of the innominate artery (Fig. 2, a) is considerable dilated. Above the orifice it is still more dilated, the dilatation affecting equally the circumference of the artery. At the orifice it is 4 cm. in circumference, and at the greatest dilatation 6½ cm. The artery is thickened irregularly, the intima smooth and free from fibrin; 3 cm. from its origin the calibre is narrowed. At this point there is a sharp, angular projection of the wall into the artery (Fig. 2, b). In the angular projection the media of both sides, closely united to each other, can be made out. At the point of the angle they appear to fuse into one another and are lost in some hyaline cicatricial tissue. The angular projection is only seen on the anterior part of the artery. There is a line of cicatricial tissue which is continuous with the apex of the projection and extends around the entire artery. Toward the right side of the artery there is a ligature (Fig. 2, c) within the lumen of the artery. The ligature forms a loop with an inside diameter of 5 mm. There is a distinct knot, and the ligature is held by one end of the knot, which is embedded in the wall of the artery. Above this point there is a narrow part of the artery (Fig. 2, d), 1 cm. in length, which extends up to the point where the artery is closed.

The abdominal organs are normal, with the exception of a slight degree of chronic passive congestion and induration of the liver, spleen and kidneys. The right testicle shows a marked degree of chronic interstitial orchitis. The tissue is indurated with bands of fibrous tissue extending from the tunica into the tissue. The left testicle shows a slighter

degree of induration. A small amount of fluid in left tunica vaginalis.

The right sterno-clavicular articulation is removed. The end of the clavicle is united with the sternum by fibrous tissue. A part of the costo-clavicular ligament remains. A part of the clavicle and the right side of the upper extremity of the sternum are removed (Fig. 4).

ANATOMICAL DIAGNOSIS.

General arterio-sclerosis, with dilatation and thickening of aorta and large arteries. Circumscribed dilatation (fusiform aneurism) of right subclavian, innominate and right iliac. *Double ligature of innominate artery. Occlusion of artery by the upper ligature, severance of artery by lower ligature with following healing, the ligature remaining within the artery and the continuity of the lumen being restored.* Heart hypertrophy and dilatation. Relative insufficiency of the cardiac valves. Chronic passive congestion of lungs, liver, spleen and kidneys. Ascites. Pleuritic adhesions over lower lobes of both lungs. Old tuberculosis of apices of both lungs, with induration. Chronic interstitial orchitis. Cicatrices on neck from operation wound. Loss of substance of sternum and clavicle at articulation. Syphilis.

MICROSCOPIC EXAMINATION.

Sections were made from the aorta at various places, and from the innominate artery, including the projecting spur at the point where the ligature is adherent (Fig. 2, b). The sections of the aorta show the same general condition. The adventitia is thickened, and areas of round-cell infiltration are found around the vessels. Many of these cells have the character of lymphoid cells, others are larger and epithelioid in character. The media shows changes in various degrees. Small areas of round-cell infiltration similar to those in the adventitia are found and in places these extend from the adventitia into the media. The least alteration is found in the media adjoining the adventitia. Here the normal arrangement of the muscular and elastic tissue is preserved. Everywhere adjoining the intima there are various degrees of degeneration. The degeneration is most marked and extends deeper into the artery opposite the places where the intima shows the greatest thickening. In these degenerated places the muscular fibres are atrophic. The distinct lamination is lost and the single fibres run irregularly in the tissue. The elastic fibres cannot be made out. Between the degenerated muscular fibres there is an irregular, hyaline-looking tissue which stains diffusely blue with hematoxylin. The intima is thickened by the formation of a dense hyaline tissue containing few cells. The greatest thickening corresponds to the most marked degeneration of the media. On one of the sections an interesting condition is seen. At a point corresponding to a marked elevation of the intima there is a distinct line of fracture in the media. One end of the fractured media is turned up and distinct, the other end is obscured by the presence of granular necrotic tissue which extends from the intima into the space between the separated portion of the media. At this point the media is infiltrated with polynuclear leucocytes.

The sections of the innominate artery (Fig. 5) show an extreme degree of endarteritis. The adventitia is thickened, cicatricial and infiltrated with cells. There is cellular infiltration of the media with well marked degeneration of the muscular and elastic tissue. The intima is greatly thickened. On the distal side of the spur (Fig. 5, a) there is a mass of refractive, hyaline-looking tissue containing much nuclear detritus. In places there is much hyaline fibrin, and remains of blood-vessels can be seen. In a few places the mass is covered by the cells of the intima. At the beginning of the projecting spur both of the muscular coats in contact with each other can be made out. Toward the extremity of the spur both coats pass into hyaline necrotic tissue. At the lower side at the beginning of the spur the muscular layer is broken across, one end is continuous with the spur, the other is adherent to the bend of the upper portion. All around this area there is dense cellular infiltration which extends from the adventitia into the

projection and between the two muscular layers. At this point all this tissue is fused into a necrotic hyaline mass.

This case is one of arterio-sclerosis affecting the aorta and the large arteries. There is everywhere marked degeneration of the media, which has been followed by dilatation of the arteries and thickening of the intima. There is a general dilatation, and in places a more circumscribed fusiform dilatation. One of the sections shows, in addition to the degeneration of the media, a fracture of this, with separation of the ends. The most interesting feature of the case from the pathological point of view is the condition found at the proximal ligature of the innominate. The point where the ligature was applied corresponds to the apex of the projecting spur and to the line of cicatrix in the intima continuous with this. The ligature did not bring the artery together equally, but the anterior portion, which was probably thinner, was drawn in toward the posterior. There is a fracture of the media which does not correspond to the line of ligature and which probably resulted from injury at the operation. This ligature gradually cut its way through the artery and cicatricial tissue formed behind it. It is most remarkable that the cutting of the artery by the ligature should have been so even that the entire ligature with its knot should lie in the lumen of

following the operation, the complete relief of all the patient's symptoms and his almost uneventful recovery are remarkable.

(4) That the secondary hemorrhages which have occurred in almost all of the recorded cases were undoubtedly due to local sepsis, and that the recovery of this case was due to the accuracy with which it was possible to place the ligatures and to the asepsis.

(5) That if the innominate is ligated at all, two ligatures are necessary, one to act as a breakwater by obstructing the constantly recurring waves of blood coming from the aorta.

(6) That the collateral circulation was principally established in this case by a downward stream of blood from the right carotid and vertebral arteries into the right subclavian artery. That while the fusiform aneurism had shrunk, there was very little fibrinous clot above the second ligature (*vide plate*).

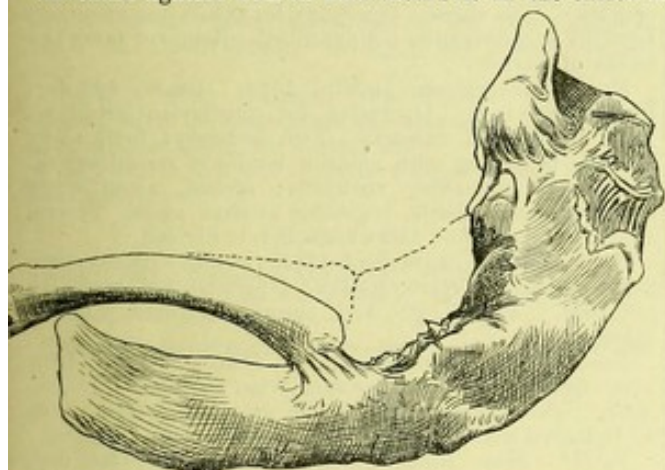


FIG. 4.

Sterno-clavicular articulation, showing loss of substance of sternum and end of clavicle on right side.

the artery. It is not possible that it could have cut through the artery at the time of its application or shortly afterwards. This ligature was of great importance in taking the strain of the aortic pressure from the distal ligature until it was included in the firm cicatricial tissue. The cutting through of the ligature was probably materially assisted by the pressure of the blood in the dilated artery. It is curious that no fibrin should have been found about the ligature. It was not examined microscopically, but it had probably become organized and covered with a smooth layer of the intima.

The diagnosis of syphilis was made from the interstitial orchitis.

The case which is here reported seems to teach some very important lessons, and they are:

(1) That a patient with general arterio-sclerosis and an enlarged and dilated heart may be kept under ether an hour and a half, subjected to a severe operation and recover with but little shock.

(2) That while the ligation of the innominate artery is not of necessity fatal, yet it will always be an extraordinary operation, fraught with danger from the cutting off of an extensive area of circulation. The removal of the sterno-clavicular articulation and such a portion of the sternum as may be necessary, makes the performance of the operation more practical and one of relative simplicity and safety.

(3) That the absence of pain or marked discomfort

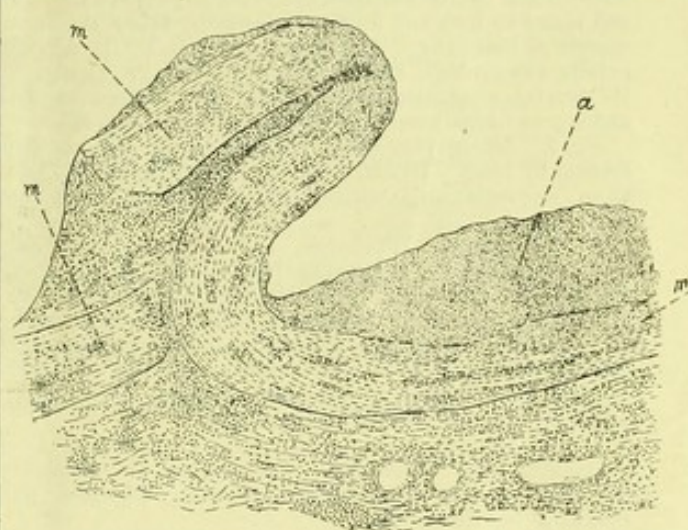


FIG. 5.

Section of innominate artery, through *b*, Fig. 2. *a*, Thickening of intima in artery at *d*, Fig. 2. *m, m, m*, Media. Further explanation in text.

This would lead me in another case of fusiform aneurism in this situation to ligature the carotid, if possible the subclavian in its first part, and, if practical, the vertebral.

(7) That the unique behavior of the first ligature that was applied to the innominate is perhaps the most interesting fact which we learn from this case. When the innominate artery was tied something in the wall was felt to give way. The ligature gradually cut its way through the coats of the vessel, followed by an inflammation with organization which prevented a secondary hemorrhage, and finally rested, organized and probably covered with a smooth layer of the intima, inside the innominate artery. This places a new fact at our disposal as regards final disposition of the ligature.

OPERATIONS.

No. 1. Valentine Mott, New York, 1818. Death, 26th day, by hemorrhage. Silk ligature. Operation: A transverse incision just above the clavicle, and carried to the upper part of the sternum, terminating immediately over the trachea, to the extent of three inches. A second incision, about the same length, extending from the termination of the first, along the inner edge of the sterno-mastoid muscle. The triangular flap was dissected back; cautious division of sternal part of mastoid, and as much of the clavicular portion as the size of the wound permitted, and

the flap reflected up. Aneurism of innominate, carotid and subclavian.

No. 2. Graefe, Berlin, 1822. Death, 68th day, from hemorrhage. Operation for subclavian aneurism. Longitudinal incision along anterior edge of sterno-mastoid down to sternum. Ligature not described.

No. 3. Norman, Bath, 1824. Death, 3d day, from hemorrhage. Operation for subclavian aneurism. Ligature and operation not described.

No. 4. Arendt, St. Petersburg, 1827. Death, 8th day, from sepsis. Operation for subclavian aneurism. Ligature not described. Operation: Incision three and a half inches long, on inner border of sterno-cleido-mastoid to half an inch below border of sternum.

No. 5. Hall, Baltimore, 1830. Death, 6th day, from hemorrhage. Operation for subclavian aneurism. Ligature and operation not described. Up and walking about 5th day.

No. 6. Bland, Sidney, 1832. Death, 18th day, from hemorrhage. Operation for subclavian aneurism. Ligature, thread. Operation: Incision made, extending upwards about two inches from the inner edge of the sternum, and about an inch and a half downwards, below the inner margin of that bone. The sternal insertion of the mastoid muscle was divided, and dissection further prosecuted by the careful separation of the fibres of the sterno-thyroid and sterno-hyoid muscles in their longitudinal direction.

No. 7. Dupuytren, Paris, 1834 (reported, but not performed by him). Death, 3d day, from hemorrhage. Operation for subclavian aneurism. Operation and ligature not described.

No. 8. Lizars, Edinburgh, 1837. Death, 21st day, from hemorrhage. Operation for subclavian aneurism. Ligature not described. Operation: Incision made, beginning at about one inch over the sternum, and extending four inches along the inner margin of the sterno-mastoid muscle. The sterno-hyoid muscle was then carefully divided, bringing into view the sterno-thyroid muscle, which was cut across in a similar manner.

No. 9. Hutin, Paris, 1842. Death, 12 hours after operation, from hemorrhage. Operation for secondary hemorrhage after a penetrating wound. Ligature and operation not described.

No. 10. Gore, Bath, 1856. Death, 17th day, from hemorrhage. Operation for subclavian aneurism. Hemp ligature. Operation: Usual longitudinal incision, and sternal attachment of sterno-mastoid were divided.

No. 11. Pirogoff, St. Petersburg, 1856. Death, 48 hours, from probable septicemia. Operation for subclavian aneurism. Ligature and operation not noted.

No. 12. Cooper, San Francisco, 1859. Death, 9th day, probably from sepsis. Operation for subclavian aneurism. After 5th day became restless, had dyspnea, retention, etc., till death. Ligature not described. Operation: Incision made, four inches long, in a line parallel, and half an inch above the upper margin of the clavicle, commencing internal to the sterno-clavicular articulation, and terminating near the anterior margin of the trapezius muscle. A transverse incision was then made, commencing a little to the inner side of the centre of the first, and extending upwards, external to the sterno-cleido-mastoid muscle, terminated two and a half inches above. The summit of the sternum and the sternal extremity of the clavicle were removed. This barely made room sufficient to enable one to reach the arteria innominata, owing to the large size of the aneurismal tumor at that point.

No. 13. Cooper, San Francisco, 1860. Death, 34th day, from hemorrhage. Operation for subclavian aneurism. Ligature not noted. Same operation as before, a portion of the sternum and clavicle being removed.

No. 14. Smyth, New Orleans, 1864. Recovery. Operation for subclavian aneurism. Carotid and innominate ligated, and 54 days later the vertebral also ligated. Ligature not noted.

No. 15. Lynch, 1867. Death, 12th day, from hemorrhage. Operation for secondary hemorrhage after gunshot wound. Ligature and operation not described.

No. 16. Porter, Dublin, 1867. Died of hemorrhage six weeks after. Operation for subclavian aneurism. Ligature not described. Clamp applied to innominate for three days and then removed. Mott's operation, V-shaped incision.

No. 17. Bickersteth, Liverpool, 1868. Death, 9th day, from hemorrhage. Operation for subclavian aneurism. Silk ligature. Operation: The usual triangular incision was made, dividing the sterno-mastoid, the sterno-hyoid and the sterno-thyroid muscles. Passed a lead wire around the innominate and held it by a clamp. Two days after, the wire separating, a silk ligature was applied to the artery in two places.

No. 18. A. B. Mott, New York, 1868. Death, 23d day, from hemorrhage. Aneurism burst into pleural cavity. Operation for subclavian aneurism. Mott's operation. Innominate and carotid tied.

No. 19. Partridge, Calcutta, 1870. Death, 1½ hours after, from hemorrhage. Operation for secondary hemorrhage. Previous operation, ligature for aneurism of carotid 13 days before. Operation and ligature not described.

No. 20. Buchanan. Death in a few minutes from shock. Operation for subclavian aneurism.

No. 21. O'Grady, Dublin, 1873. Death, 20 hours after operation, from shock. Operation for subclavian aneurism. Ligature and operation not described. Removed inner two inches of clavicle.

No. 22. Thompson, Dublin, 1882. Death, 42d day, from hemorrhage. Operation for subclavian aneurism. Tape ligature of ox-aorta. Two incisions: first, along clavicle, beginning with anterior border of sterno-mastoid muscle and extending outwards; second, along inner border of same muscle, beginning at same place. Sterno-mastoid, sterno-hyoid and sterno-thyroid divided.

No. 23. Banks, Liverpool, 1883. Death, 37th day, from hemorrhage. Kangaroo tendon. Operation for subclavian aneurism. Innominate and carotid ligatured. Mott's operation.

No. 24. Bull, New York, 1884. Death, 33d day, from hemorrhage. Operation for subclavian aneurism. Innominate, right common carotid and vertebral arteries were all ligatured simultaneously with a double catgut ligature.

No. 25. May, Birmingham, 1886. Death, 19th day, from hemorrhage. Catgut ligature. Operation for subclavian aneurism. Incision along inner third of clavicle and a second down line of common carotid, two meeting in episternal notch. Flap dissected back, and sterno-mastoid, sterno-hyoid and sterno-thyroid muscles divided.

No. 26. Durante, Rome, 1887. Death, 16th day, from hemorrhage and hemiplegia. Operation for subclavian aneurism. Mott's operation. Innominate, carotid and vertebral ligatured.

No. 27. Lewtas, India, 1889 (Mendon Hospital Punjab). Recovery at report, 43 days after. Catgut ligature. Operation for hemorrhage following traumatic aneurism of subclavian. Ligated carotid and innominate. Incision along inner border of lower end of sterno-mastoid. Partially cut sterno-hyoid and sterno-thyroid.

No. 28. Coppinger, Dublin, 1893. Recovery when exhibited at end of 42 days. Operation for subclavian aneurism. Innominate and carotid both ligated. Operation and ligature not described.

No. 29. Burrell, Boston, 1895. Recovery, all symptoms relieved and patient out and about. Two silk ligatures on innominate. Operation for fusiform aneurism of carotid, subclavian and innominate arteries. Death from arteriosclerosis and an enlarged and dilated heart on the 104th day.

Bardenheuer has a number of times exposed the innominate artery and the contiguous parts by resection of a portion of the manubrium sterni and the sterno-clavicular articulation, while removing tumors which involve the root of the neck. He is convinced from his experience that the ligature of the innominate can only intelligently be carried out by resection of a portion of the sternum and sterno-clavicular articulation.

Bujalski, of St. Petersburg, is said to have ligatured the

innominate artery twice. No published reports of the cases can be found, and they are considered by most authors not sufficiently authentic to be classed among the others. Not given by Thompson, because he said he could not verify them. Given by Le Fort, also by Velpeau.

UNFINISHED OPERATIONS.

No. 1. Porter, W. H., Dublin, December, 1831. Patient up and about when last reported on the 61st day. Operation for subclavian aneurism.² Innominate exposed, which was greatly dilated. Impossible to put ligature around. Wound dressed and healed.

No. 2. Hoffmann, New York, 1839. Operation for subclavian aneurism. Exposed the innominate, intending to ligature. Finding the vessel so large, he considered it inexpedient to proceed and abandoned the operation.

No. 3. Key, London, 1844. Patient died 23d day after operation. Attempted to ligature innominate for aneurism of the innominate, but had to desist on account of size of tumor.

No. 4. Peixoto, Rio Janeiro, 1851. Silk ligature. Common carotid had been ligatured previously for a tumor of the ear, and several hemorrhages resulting, an "expectant" ligature was passed around innominate in case of further hemorrhage, but it was not tightened. No further hemorrhage occurring, it was removed in five days.

No. 5. Charity Hospital, New Orleans, 1894. In a personal letter Dr. Edmond Souchon speaks of a case where a colleague exposed the innominate by removal of a part of the sternum, but not ligatured because it was found so greatly enlarged.

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² Operation described on p. 99, vol. xvii, Guy's Hospital Reports.

