A manual of military surgery - Chapter III: On the arteries

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CHAPTER III.

ON THE ARTERIES.

HEMORRHAGE.

The arteries are interesting to the military surgeon chiefly on account of the danger and frequent occurrence of hemorrhage in wounds and surgical operations. "Three-fourths of those who die on the field of battle," says Morand, "perish from hemorrhage." Hemorrhage, then, as first in importance among the accidents of battle, takes precedence of them all, in its claims upon the surgeon. The means of arresting the flow of blood from wounded arteries, is an object of the highest moment. With it are connected some of the surgeon's most responsible duties, often under circumstances in which time is not allowed for either study or preparation of any kind. No class of operations demands a more accurate knowledge of anatomy than those upon the arteries; no class, in which perfect equanimity is so important to the surgeon; and no class, the attendants of which are more calculated to alarm, disconcert and confuse him. A familiar and exact knowledge of the parts to be operated on, a thorough understanding of conditions in each instance, and a clear idea of the course to be pursued, are his only, but sure safeguards against mortification and well-merited blame. The well established results of experience, therefore, from whatever source they may be gathered, should be in the hands of every one having charge of the wounded soldier, with rules to guide, and principles to govern, in this most frequent and frightful emergency of both the field and the hospital.

Every lesion of the soft parts is attended with more or less effusion of blood, which occurs generally at the moment of injury; at other times, it appears at a period more or less remote from the accident. This difference in time has given rise to the division of hemorrhage into primary and secondary
or consecutive. A large number of cases have been grouped, by some, into classes termed retarded and intermediary, which terms also have reference to the time at which the effusion takes place, and which distinctions we shall retain with certain definite restrictions to be indicated hereafter.

**Primary Hemorrhage.**—Primary hemorrhage is more frequent in injuries from edged weapons than from gun-shot wounds, which are more apt to be followed by consecutive bleeding. It may be capillary, venous or arterial; infiltrated through the meshes of the cellular tissue or collected into a mass or clot.

**Capillary Hemorrhage.**—The loss of blood arising from the division of capillary vessels hardly deserves the name of hemorrhage, and seldom engages the attention of the surgeon except in cases of that peculiar condition of the system known as the "hemorrhagic diathesis," where there is always a troublesome tendency to sanguineous extravasations, and may often be observed in those whose constitutions have been impoverished by privations and fatigues. M. Legouest, whose valuable work we have freely used in these preliminary observations, justly remarks that this form of effusion "shows itself more frequently among soldiers towards the end, than at the beginning, of a campaign." We have observed also during the present war, that certain diseases seem capable of establishing the hemorrhagic constitution—especially has this been observed after the epidemic of measles, so wide-spread in our army during 1861 and 1862. The blood oozing from the general surface of the wound in these cases, re-appears as rapidly as it is wiped away, and we are unable to detect any precise point from which it comes. The blood itself is generally thin and resembles that of a chlorotic female—cherry juice—the clot, if any, is soft and of feeble tenacity. These cases, of course, are more suitable to the hospital than to the treatment of the camp, and come more properly under the supervision of the medical man than the surgeon, though, when the hemorrhage is from the gums or nostrils, we are tempted into operative measures, which, indeed, seldom accomplish anything.

**Venous Hemorrhage** is apt to occur in all wounds of the soft parts, but only requires attention when the lesion involves large vessels or veins whose calibre is kept open by their attachment to aponeuroses or the fibrous tissues they traverse,
the blood flows generally from the end of the vessel communicating with the capillaries. It is poured out by a continuous jet of more or less force, increased by pressure above, and diminished by pressure below, the point of lesion. The blood is black and slowly forms into friable and diffusible clots.

Arterial Hemorrhage.—The history of arterial hemorrhage is inseparable from that of wounds of the arteries. It is this form which has deserved and received most attention from the profession, both because it is more dangerous to the patient and more frequently demands operative measures for its relief.

When an artery of an appreciable size has been opened, the blood issues by the cardiac end of the divided vessel, in interrupted oscillatory jets of a bright vermillion color, synchronous with the pulsations. Pressure made between the heart and the wound generally arrests the hemorrhage.

Arteries may be incised, punctured, contused or lacerated. Each of these forms of injury is attended with results peculiar to itself, which, though they necessarily modify the history of the case, influence but little the principles which govern the treatment. Incised and punctured wounds of arteries give rise to primary hemorrhage; lacerated, more frequently to retarded or intermediary, when they bleed at all; while contused wounds of the vessel, either result in secondary hemorrhage or in traumatic aneurism.

The form and seat of the wound, and the extent and character of the division, cause also important modifications in the flow of blood. In clean and open wounds, both ends of the divided vessel are said to furnish a stream of blood; that from the superior end being of a bright vermillion color, while the recurrent stream from the lower end partakes, it is said, somewhat of the appearance and characters of venous blood; the jets being also less decided. The surgeon seldom has opportunity to observe this distinction, as in deep wounds, the two streams become mixed and the force of the respective pulsations is broken by the streams coming in contact with the walls of the wound in the soft parts leading to the orifice.

The location of the arterial lesion modifies the symptoms in other respects: thus, when a considerable vessel or the principal trunk of a limb happens to be wounded, if very high up and near the body, there will be no pulsation in the limb below, and the manner and character of the blood discharged
will indicate that only the cardiac end is bleeding; if lower down, where the collateral communications are abundant, pulsations will be perceptible, and the bleeding will probably arise from both the cardiac and distal end, or even altogether from the distal end.

This observation of M. Legouest's, relating to the influence which the locality of the lesion exercises on the symptoms, a little reflection will show to be of great practical importance. It has a bearing on that valuable doctrine of Mr. Guthrie, so generally applicable that it is now rapidly becoming the invariable and imperative rule of the profession, viz: That scarcely under any circumstances is it allowable to ligate a bleeding artery in its continuity above the wound, or elsewhere than at the point of lesion, and that, when this rule is departed from, the occasional success is "only a matter of accident." From the foregoing it will be seen that what has been considered accidental is the result of conditions and anatomical relations, which can be estimated previous to each operation, viz: the position of the wound, and the paucity or abundance of the collateral communications with the trunk to be operated on. The circumstances in which it may be desirable to depart from this important rule laid down by Mr. Guthrie, though but few, are yet of very frequent occurrence during every active campaign, where even the most unusual peculiarities repeat themselves so often and in such rapid succession. The advantage, therefore, of being able to recognize the cases in which we may safely depart from any given rule, when circumstances and the good of the patient seem to demand it, is worthy of some consideration. These cases will be referred to more fully when the surgical treatment of hemorrhage is in discussion.

The section of the walls of an artery may be complete or incomplete, transverse or longitudinal:

The complete transverse section of an artery of large calibre is apt to be immediately fatal; for it gives rise to a gush of blood which ceases only with life. In the most fortunate cases of this class, syncope and the other natural processes by which hemorrhage is arrested spontaneously, may even permanently close the wound. Most frequently, however, these barriers giving way, the effusion of blood re-appears after a longer or shorter interval, when it is known under the name of secondary or, more properly, consecutive hemorrhage.
The incomplete transverse section of an artery gives rise to phenomena of different kinds, according as it involves a fourth, a half, or three-fourths, of its calibre; the blood issues in part from the wound, and continues in part its course along the inferior portion of the vessel. The quantity of the blood which escapes being less than in the preceding case, the arterial pulsations are observed below the wound, and, though weakened in proportion to the extent of the orifice, still preserves somewhat of their normal characters. Pressure made above the wound arrests the flow, while it is augmented by pressure below, which last causes the entire contents of the artery to be thrown upon the orifice.

Ordinarily, the hemorrhage is more difficult to arrest when a vessel has been divided in part, than when completely severed. When the fourth only of the vessel has been cut, the wound is enlarged by the elasticity of the arterial tunics and by the flow of the blood; but, as its stream is not very large, nor very violent, it may, especially in the case of the smaller arteries, be stopped by the formation of a clot or by the effusion of plastic lymph. When half the circumference of the vessel is involved, the effusion is still more increased, and a loss of blood is sustained which is almost uniformly fatal. Death, of course, is still more certain when three-fourths of a large trunk is divided, unless, perchance, the remaining part should break under the efforts at retraction made by the arterial tunics, when the case will enjoy the scarcely more hopeful chances occasionally found in complete transverse section. Incomplete transverse sections are, therefore, more serious than the complete, because the obstacle to retraction and contraction of the vessel, which the undivided portion presents, keeps the wound permanently open.

Longitudinal sections of arteries, when not very extensive, are much less serious than any of the transverse, and spontaneous cures are by no means uncommon in this form of lesion.

It is always important to distinguish the kind of hemorrhage we have to deal with. The characters which have been assigned above are not so well defined, nor can they always be, as to leave no doubt on the mind of the surgeon when the wounds are deep and ragged, or when the bleeding, instead of occurring externally, takes place in the cavities. True, it is well known that blood coming from an artery
escapes with more force and in much greater quantity than when flowing from a vein; again, that arterial blood is much redder than venous, and that the first issues per saltum, while the latter escapes in a continuous stream; but still each of these guides is liable to its own peculiar fallacy. Thus, the bleeding may be arterial, and yet internal, most of the blood being retained in some cavity, or infiltrated among the meshes of the cellular tissue, while but a small quantity escapes to meet the eye of the surgeon. As examples of this kind of obscurity, it is not uncommon to observe, after the removal of large tumors, as the mamma, that hemorrhage comes on, after the dressing has been completed, from some small artery neglected at the bottom of the wound; on the removal of the bandage, a small opening is made somewhere along the line of recent union, and the blood issues in a jet upwards, sometimes five or six inches, the column being sustained by the elasticity of the skin, made tense by the accumulation of fluid blood; again, several times during the present war, have we seen, in the Georgia hospitals at this post, arterial hemorrhage some hours after amputation, or, as in one instance, many days after, when union had become pretty firm and the bleeding was secondary. In this instance, as in the one just stated, the blood, accumulated in the pocket formed by the flaps, was forced out of the small opening in a continuous jet, the elastic force of the skin overcoming the interrupted force with which the artery replenished the contents of the sac. Here the supply was arterial, the color red, but the manner of the flow was venous. Again, venous hemorrhage may simulate the interrupted jet of an arterial bleeding by the proximity of a large artery communicating its pulsations to a wounded vein. This is sometimes observed when the median-basilic is the vessel selected for venesection; the pulsations of the brachial artery beneath may cause the blood to issue per saltum. Secondly, if we depend on the quantity discharged for our criterion, we may still be deceived, as it is well-known that pressure on the vein between the wound and the heart will increase the abundance of the venous flow. Thirdly, the color is not a safe criterion for other reasons than those just given; the rapidity of the circulation may cause the blood to course with such celerity through the capillaries that, though it issue from a wounded vein, the change of hue not having been effected, it may be mistaken for arterial blood.
And, finally; we should remember that, in the hemorrhage which occurs during operations under chloroform and immediately after, the arterial blood is almost invariably of a dark venous color—sometimes nearly black—owing to the fact of the chloroform vapor having replaced the atmospheric air; and, though this seems to sustain respiration, it does not change the color of the venous blood in the lungs. This fact is, we suppose, pretty generally known; yet, on several occasions during the present war, we have seen patients lose an exhausting amount of blood after amputations, from the operator mistaking dark arterial blood, under these circumstances, for venous, and waiting for the spontaneous cessation of the flow, as he would be justified generally in doing were the hemorrhage really venous. For the same reason as given above—absence of oxygen—do we find the arterial blood of patients laboring under impeded respiration, as in extreme compression of the brain or apoplexy, dark enough to be taken for venous blood:

A soldier was brought to the Fourth Georgia Hospital with a wound in the temporal region. At first, there was only confusion of intellect, with partial hemiplegia—symptoms certainly not warranting the use of the trephine. After some days, the paralysis began to increase. He soon became comatose, the case now declaring itself one of compression from effusion—probably purulent. The symptoms increased so rapidly after trephining was determined on, that his respiration sank to six in the minute, and during the operation, as will be seen, ceased several times altogether; his face was turgid and very dark, lips and tongue blue. A deep incision, to the bone, was made in the temporal region in order to raise the fascia and muscle for the trephine. Of course, the temporal artery was cut; the blood was poured out abundantly per saltum, and it was black like venous blood. At this time respiration ceased entirely, and we supposed him to be dead. The heart being found still to beat, though feebly, "artificial respiration in the sitting posture," was applied. The vigor of the pulse was at once restored, and the color of the blood changed from that of venous to bright vermillion. The countenance also became natural during artificial respiration. With the finger on the pulse, the operation was rapidly proceeded with, but had to be interrupted frequently to apply the artificial respiration
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whenever the pulse was becoming extinct. The effort was always the same during the whole period—more than an hour—occupied by the operation, viz.: improvement in the heart’s action, and complete restoration of the arterial color of the blood, as shewn whenever there was any bleeding. On the removal of the bone the dura mater was found greatly distended, and a puncture gave exit to a large quantity—ounces—of pus. Contrary to our hopes, and, indeed, expectations, spontaneous respiration never returned, though he was sustained, and his face kept of the natural color for hours after the pus was evacuated. The heart’s action began to flag soon, even under the artificial respiration, and he must have died after a while, but his death was probably completed, we have suspected, by the fumes of ammonia, injudiciously and irregularly applied to excite natural respiration. The whole time, during and after the operation, he did not perform a single spontaneous act of respiration. The case is related somewhat in full because of its many points of interest, but our present use for it ends with the illustration of one single point—the coloration of the blood resulting from a gun-shot wound.

When hemorrhages, instead of being external, take place in the substance of the tissues or in the cavities, they give rise, on the one hand, to infiltration, and, on the other, to effusions of blood. The diffusion of blood among the tissues is seldom observed in arterial lesions. It is evidenced by rapid augmentation of the volume of the parts in which it occurs, by an unpleasant feeling of tension and weight, by the marbled and black coloration of the skin which covers the effusion, and by the more or less deep and wide-spread pulsations in the neighborhood of the wound. Sometimes the hemorrhage appears on the surface; at others, it is completely enclosed when the extravasation constitutes what is known as diffused traumatic aneurism.

If the effusion takes place in some cavity, the appearance, more or less promptly, of the signs of internal hemorrhage and the patient’s own sensations indicate clearly the means of diagnosis. These symptoms and sensations vary in accordance with the character of the special organ disturbed or impressed by the collection. Thus: if in the cranium, symptoms of cerebral compression become manifest; if in the cavity of the pleura, dyspnoea is observed; while, for collections in the
cavity of the peritoneum, the patient is apt to experience an unusual and ineffectual desire to evacuate either the rectum or bladder, caused by external pressure of the accumulating blood on the parieties of these organs. In connection with these special symptoms, however, the rapidly progressive or complete collapse seldom fails to declare positively, to the experienced observer, the existence of internal hemorrhage.

Consecutive Hemorrhages.—If there is any one accident of gun-shot wounds more alarming than primary hemorrhage, that accident is secondary hemorrhage; for, to all the frightful phenomena that assemble in the first, we have most frequently added in this last, the disconcerting element of surprise. Whenever the soft parts are wounded, a free discharge of blood, even to a dangerous amount, is not an unlooked for occurrence; but secondary hemorrhage often gushes out, under circumstances least calculated to forewarn. In gun-shot wounds, this is especially the case; the projectile is often devious in its course, and it is well known that the line, between entrance and exit, does not always represent the true track of the ball. Cases have not been wanting to illustrate this among our own troops. The situation of the wound, and the apparent course of the ball, may have suggested no suspicion that any important vessel had been approached, and yet an outburst of secondary hemorrhage in some cases, or the sudden formation of traumatic aneurism in others, even when the wound had nearly healed, may unexpectedly reveal the fact, that an artery of the largest size is involved. To the patient, the danger is always imminent; to the surgeon, the position is often perplexing. Few of us will deny the assertion of Legouest, that "secondary hemorrhages are the terror of the surgeon, as well as of the patient."

Even at the present day, much confusion seems to exist as to the terms used to indicate the varieties of consecutive hemorrhage. An exact nomenclature and a determinate classification are greatly needed for the methodical study of the subject. With the exception of the term primary hemorrhage, all the words used to indicate the differences in the time of the bleeding, which is the basis of classification adopted, are of the most indefinite and uncertain signification. Thus, the term "retarded hemorrhages" has long been in dispute; Dupuytren classes them with the primary, whilst others, before and since his time, place them among the consecutive
effusions. The term "intermediary" is not more fixed in its meaning, while those of "secondary" and "consecutive" are most unsettled of all; because mutually convertible, and because both of them are constantly applied to a wide range of cases illustrating great varieties of conditions. In the mind of no one do they establish any very definite time for the bleeding. When the terms which are intended to distinguish things are so loosely applied, confusion must necessarily follow.

We understand by Consecutive Hemorrhages the entire class of sanguineous effusions which appear at a period more or less remote from the moment of injury, and which are capable of placing in imminent danger the life of the patient. Using the term, then, in a general sense, it will embrace all hemorrhages which occur after the period of the primary, and, among these, secondary hemorrhage will be comprised as the most prominent and important variety. We shall recognize three others, viz: the retarded, or delayed, the intermediary and the indeterminate. The classification when arranged, in brief tabular form, will appear thus:

Consecutive Hemorrhages.


We have arranged the above classification for the convenience of the Confederate army, preferring it to the unsettled and indefinite application of terms now in use—and for the following reasons: first, because of its exposition of the actual facts of the history of hemorrhage; second, because such a classification will admit of the clear and accurate record of cases, and can be soon generally understood throughout the army; and, thirdly, because we confidently believe that the observation of those who have enjoyed the largest experience in the surgery of this war, will accord with our own, and gain for it an unhesitating assent. All have felt the inconvenience of a deficient classification.

Retarded Hemorrhages.—When the soft parts have sustained a severe gun-shot or other contused wound, if a large artery has been opened, death, as we have seen, is apt rapidly to follow; but when vessels of less considerable size have been wounded, especially in gun-shot wounds, the primary
hemorrhage soon begins gradually to lessen, and finally ceases altogether; or there may have been only a sudden spurt of blood at the moment of injury, succeeded by no further effusion. Sometimes, this sudden check constitutes the permanent arrest of the hemorrhage, but most frequently otherwise—the effusion, in the case of the larger vessels, almost certainly returns in the period of from six to ten hours—and it is to this effusion, which cannot properly be called either primary or secondary, whether it had been preceded by bleeding at the time of wound or not, that the name of "retarded or delayed" hemorrhage has been given. In many cases, the wound from which the bleeding proceeds had not bled at all at the moment of injury.

The conditions which give rise to delay in hemorrhages are: crumpling of the vessels; contusion; fraying of the soft parts; fright, syncope and concussion; exposure or contact with the air, and consequent rapid formation of clot. All these causes of delay are of a nature liable to be overcome by that restoration of the nervous system, and of the circulation, known under the name of "re-action," when the vessels bleed with great vigor, and call for the immediate attention of the surgeon. These hemorrhages seldom occur till after the patient has been removed from the field, and has been placed in the hospital or infirmary. During the engagements around Richmond, from the several battle-fields of Seven Pines, Mechanicsville, Gaines' Farm and Malvern Hill, large numbers of wounded crowded our hospitals. Some of the wounds had been carefully dressed by the surgeons at the field infirmaries; others came in to be attended to, for the first time, in the general hospital here, often less than five miles from the scene of action. The surgeons could not have failed to observe the very large number, comparatively, whose wounds began to bleed freely after arriving at the hospital. Such was the case, at least, to a remarkable extent, at the four Georgia hospitals, crowded at that time with the wounded from those bloody fields. These were all cases of retarded hemorrhage, taking place from eight to ten hours after the receipt of the injury. The bleeding in these cases was most probably due to the excitement and disturbance of transportation, and to the removal from the open air of the field to the closed walls of the hospital. Reckoning together the trivial and the serious effusions of this class, retarded hemorrhages may be
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considered as by far the most numerous of all the consecutive bleedings which attend upon gun-shot wounds.

Intermediary Hemorrhages.—We cannot say to whom the profession is indebted for the term "intermediary hemorrhage." It is of rather recent date in surgical language, and as yet, seems to have acquired no very determinate significance; thus Legouest (Traité de Chirurgie d'Armée, 1863,) defines intermediary hemorrhages as "those appearing suddenly tolerably long (assez long temps) after the injury, without being preceded by any other hemorrhage," and is disposed to agree with Dupuytren and class them with the primary hemorrhages. Mr. Ferguson, referring to them as they occur in civil practice, defines them as "those bleedings which take place in the period between the first dressing of the wound at the conclusion of an operation and the coming on of inflammatory action, and which occur in the first eight hours afterwards," thus confounding them with retarded hemorrhages. Our purposes of classification require us to give the term a more certain and exact meaning, which shall connect this class of bleedings with a definite time, and with a set of circumstances and conditions, if not peculiar to them, at least very generally attendant upon them.

In order to comprehend these circumstances and conditions, it is only necessary to recount a few of the facts which make up the history of the first four or five days of the inflammatory consequent upon a gun-shot wound in which an artery of considerable size is involved. At first, there is bleeding; then the formation of a clot, under the influence of retraction and contraction of the vessel and other tissues, aided by syncope; shortly after, the processes of congestion and inflammation begin; and finally, as these progress to the point when the swelling has attained its height, which is generally about from the third to the fifth day, the pressure exerted upon the vessel, and the accelerated condition and turgescence of the circulation, cause disturbance of the clot located in the mouth of the vessel;—it is forced away—when a sudden, and sometimes dangerous, hemorrhage takes place. This occurs just in the midst of that period of the inflammatory process in which the tissues are most sensitive and least favorable for any operative procedure—a fact which renders these hemorrhages more embarrassing to the surgeon than either the primary, the retarded, or even the secondary cases.
Secondary Hemorrhages.—Secondary hemorrhage is a bleeding not only occurring at a particular period and in a particular order, as the name justly implies, but it is one attended by a peculiar set of circumstances, conditions and causes which even more fully distinguish it from all other forms than either of these, and which, when properly considered, must be seen to exert a most important and instructive influence over the history, the treatment and the prognosis of the accident; over its history, as shown in the nearly uniform period at which the bleeding occurs, and also the much greater liability to dangerous complications in this form than in the others; over its treatment, because the feeble condition of the patient and the often tumid and inflamed state of the parts to be operated on introduce important considerations of practice, both operative and medical; and lastly, these attendants of secondary hemorrhage exert an important influence over the prognosis, either for or against the patient, because, as will be seen, the observation and experience of the present war have shown that though on the one hand there are often fever, inflammation and great turgescence to contend with, yet the very existence of these conditions, for so considerable a time, may be regarded as promotive of a favorable issue in the case of ligation, by the previous gradual establishment of the collateral circulation so necessary to success. In this place it may be stated that the operation itself has been found, under the above circumstances, a valuable means of relief, by moderating and controlling this inflammation, effectually restricting it within the bounds of a safe and healthy activity. Marked illustrations of these results may be adduced in the proper connection.

Although doubtless sometimes it may happen, in accordance with the statement of M. Legouest, that secondary hemorrhage is the result of a subsidence of the tumefaction surrounding the arterial lesion, the disturbance of parts removing the clot, this is by no means the rule applicable to the gun-shot wounds of large arteries, as observed in our own military hospitals. Indeed, a decidedly contrary condition of the tissues seemed to prevail, in most of the cases requiring ligation. The inflammation, so far from receding—“the parts shrinking and recovering themselves”—was, in nearly all instances, rapidly advancing, and, in some, had reached what appeared to be the utmost limit of intensity, consistent with
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structural organization, at the time the hemorrhage took place. How far this difference, in the stages and character of the inflammation, may be due to the difference in climate and circumstances, and the latter-day ingenuity displayed in the projectiles, producing many of our wounds, it would be difficult to estimate, but doubtless all these combine to render many features in the surgery of the present prolonged, gigantic and unprecedented struggle, widely aberrant from any rules deducible from the brief campaigns of European wars. Our men have been now, over two years under the privations and exposure of the field, and though veterans in morale, and heroes in valor and endurance, still that peculiar trait of the soldier's physique, which, for want of a better name, we hope to be understood in calling "the scorbatic constitution," has been deeply impressed upon them. For however stalwart and active the soldier may appear, the inflammation from the Minnie-ball wound defies all comparison with familiar precedents, shows little or no tendency to resolution, and a strong proclivity, to septic termination—the entire course of its sad history being painfully diversified by strange episodes of irregular and unexpected occurrences.

Indeterminate Hemorrhages.—In the foregoing paragraphs it has been seen, how and at what period the various forms of consecutive hemorrhages are occasioned; thus retarded hemorrhage more frequently comes in within from five to twelve hours after the receipt of the wound, and simultaneous with reaction or recovery from the general or local shock;—intermediary, within from three to five days, with the dislodgment of the ocluding clot and the increased circulation, consequent upon advancing inflammation and tumefaction;—while secondary takes place from the eighth to the fifteenth day, according to the artery wounded, and is occasioned, either by the separation of a slough opening into the calibre of a vessel previously injured, or by softening of the fibrinous adhesion in the mouth, or by the giving way of the walls of a traumatic aneurism. But there are still other cases of hemorrhage which admit of classification with none of these, and which are aberrant, both from the uncertainty attending the periods at which the bleeding occurs, and the variety of causes giving rise to it. These can only be classed under a common head, "indeterminate hemorrhages," by their one common feature, their irregularity, both as to the time of their occurrence and the
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<th>Age</th>
<th>Battle</th>
<th>Date of Wound</th>
<th>Artery Involved</th>
<th>Date of Consecutive Hemorrhage</th>
<th>Time elapsed</th>
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<td>Hyoid</td>
<td>May 12th, 1863</td>
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<td>&quot;</td>
<td>Femoral,</td>
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<td>Jan. 29th, &quot;</td>
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<td>J. W. Jones,</td>
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<td>19</td>
<td>H. R. Polk,</td>
<td>21</td>
<td>Gettysburg,</td>
<td>July 2d, &quot;</td>
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<tr>
<td>No.</td>
<td>Name</td>
<td>Place</td>
<td>Date</td>
<td>Injury</td>
<td>Place of Amputation</td>
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<td>20</td>
<td>John F. Endy</td>
<td>Gettysburg</td>
<td>July 3d, 1863</td>
<td>Sub-clavian</td>
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<td>July 17th, &quot;</td>
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<td>&quot;</td>
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<td>Lower jaw</td>
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<td>W. McBeth</td>
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<td>Amputation thigh</td>
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<td>30</td>
<td>J. M. Orr</td>
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<td>June 27th, &quot;</td>
<td>Anterior tibial</td>
<td>July 11th, &quot;</td>
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<td>31</td>
<td>C. A. Ried</td>
<td>Seven Pines</td>
<td>May 31st, &quot;</td>
<td>Aneurism of femoral</td>
<td>June 2d, &quot;</td>
<td>3 &quot;</td>
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<td>12 &quot;</td>
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<td>33</td>
<td>Drury B. Early</td>
<td>Seven Pines</td>
<td>June 1st, &quot;</td>
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<td>June 10th, &quot;</td>
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<td>T. Roach</td>
<td>&quot;</td>
<td>June 7th, &quot;</td>
<td>Radial</td>
<td>July 11th, &quot;</td>
<td>3 &quot;</td>
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ON THE ARTERIES.

manner of their production. The bleeding usually takes place, in gun-shot wounds, at a late period, when the danger of consecutive hemorrhage is supposed to have passed—in twenty, thirty or forty days, or indeed at any time during the advanced stages of a severe wound. The causes, as has been said, are various. Most frequently from attrition of the artery by contract with spiculae of bone, or from ulceration of the arterial tunics, or even from the advancement of mortification; though this last seldom gives rise to hemorrhage. Cases of undeterminate hemorrhage seldom admit of ligation at the seat of lesion, as their occurrence always involves such a condition of the surrounding parts, as to preclude operative procedure, unless at a considerable distance above.

In concluding this portion of the subject, we deem it of sufficient practical interest to present the experience of our own surgeons, as exemplified in the hospital reports sent to the Surgeon-General. The preceding tabular view of cases of consecutive hemorrhage, we have arranged out of the valuable materials found in the office of the Inspector of Hospitals.

The foregoing cases resulted principally from the fields of Chancellorsville and Gettysburg, the record being begun after the removal of the patients to the General Hospital. Hence no cases of retarded hemorrhage appear among them. These occur, as has been seen, more frequently either on the battle-field, or at the field infirmaries, and within a certain number of hours after the injury. The periods in the above table range, as will be seen, from three to thirty-five days, and among the cases will be found examples of each of the other varieties of consecutive hemorrhage. The largest proportion may be classed as secondary; some few intermediary; while cases 6, 7, 12, 14, 19, 23 and 29 all more properly come under the head of indeterminate hemorrhage, as the long period elapsed, between the receipt of the wound and the effusion, indicates plainly that other causes, besides those which occasion secondary bleeding, were at work in its production.

Treatment of Hemorrhage.—We have several times referred to the natural processes by which hemorrhage is arrested. These are syncope, general and local shock, the retraction and contraction of the arterial tunics, the gradual formation of a clot, and the final union of the edges of the wound as in the lesion of other parts. By one or other of these means, or by several combined, arteries of considerable size
sometimes heal permanently. Such occurrences, however, serve rather as rare accidents for the consideration of the student; but are seldom to be depended on by the surgeon; certainly never unless under the strictest watching and completest preparedness, in case it should be required to adopt more efficient haemostatic measures.

The means of arresting hemorrhage are of two kinds: the temporary or provisional, and the permanent or operative. The **provisional means** consist in all those agents and appliances which the surgeon may command on his first introduction to the case, and are intended to prevent the exhaustion of the patient during the time necessary either, to remove him from the field or to prepare for an operation. These means are few and simple in the hands of a good surgeon. **Pressure** on the main arterial trunk of the limb, under some form or other, is the principal, most reliable, and, when practicable, the **first to be applied**, of all these means. Position or the elevation of the wounded part (in case of one of the extremities), local styptics, the application of cold, by ice or cold water, making access for cold air to the part, and the administration of sedatives, are all valuable adjuncts in certain cases, never forgotten by the thoughtful practitioner.

**Pressure** is made either by the hand or by the application of the tourniquet, over the course of the main artery at some convenient point above the wound. The object is to flatten the vessel, and, for the time, to obliterate its calibre. If possible, such a direction should be given to the force as to compress the vessel between the fingers and the bone—as in the upper extremity; the brachial artery, (see Plate 1, Fig. 1, Arteries,) the point selected, is where the vessel is in close relation with the humerus. A moderate degree of pressure with the fingers and thumb will, if judiciously applied, effectually arrest the circulation for the time. When the seat of the wound will not admit of pressure being made against the humerus, the subclavian artery may be compressed with the thumb, just within the clavicle as it passes, rather deeply, over the first rib. The ring of a large key, wrapped with a piece of roller, is often conveniently used for this purpose.

In hemorrhages from the lower extremity, the pressure may be applied to the femoral artery at the brim of the pelvis where that vessel passes over the public bone. In wounds below the knee, if the patient is not too fleshy, it may be
applied in the popliteal region. Pressure with the hand can be applied to all the superficial vessels, as the facial, where it ascends over the inferior maxilla, the temporal and occipital upon the cranium, the primitive carotid upon the transverse processes of the cervical vertibre, and recently even the abdominal aorta has been effectually flattened against the bodies of the lumbar vertebre, to delay the fatal issue in a wound of one of the iliac arteries.

A very effectual mode of applying pressure with the fingers is often apparently forgotten or omitted by the surgeon, perhaps from a species of timidity, viz: pressure directly upon the bleeding orifice, by passing the finger into the wound, down to the artery. When applied in this way, very little force is required; it causes little or no fatigue to the surgeon, and, of all methods, is the one most certain to control the bleeding.

Pressure with the tourniquet is less fatiguing and more trustworthy than with the fingers. A good many modifications of the instrument have been suggested, some of them admirably adapted to certain specific purposes for which they were devised; we prefer, however, for the temporary arrest of hemorrhage, from wounds of the extremities, the ordinary tourniquet of Petit, (Plate 1, Fig. 2, Arteries,) with perhaps a somewhat larger pad than that in ordinary use. Though one of the oldest forms of the instrument, it is more readily applied, occupies less space, maintains its place on the vessel better, and is more reliable than any of its more modern competitors. As in pressure with the fingers, the pad of the tourniquet should be adjusted, if possible, so as to compress the trunk of the main vessel against the bone (Plate 1, Fig. 3, Arteries,) but, with a pad of sufficient size, it may be effectually applied at any portion of the limb which can be encircled by the band of the instrument. Care should be taken to have no greater constriction than necessary to arrest the circulation in the main trunk, and to keep up the application no longer than actually necessary, for fear of increasing the tendency to gangrene thereby, after the ligation of the artery. As a substitute for the regular tourniquet, every one is familiar with the use of the handkerchief, either smooth or with a knot, and made tight by twisting with a stick, bayonet or ramrod passed between it and the limb. This is a valuable extemporaneous means of compression.
Local Styptics.—These, though here classed among the temporary means of arresting hemorrhage, often serve the purpose of permanent measures, and obviate the necessity of an operation. They act both by changing the condition of the blood in the mouth of the arterial wound, and by stimulating retraction and contraction of the vessel when completely divided. The most powerful agents of this class are found among the preparations of iron, especially the persulphate and perchloride. They contract all the tissues about the surface of the wound, close the mouths of all the small vessels, and change the fluid blood into a firm, dense clot, which often plugs up completely an opening of considerable size in vessels of even large calibre. The persulphate of iron may be applied in solution, of a strength varying from ten to sixty grains to the ounce of water. Pledgets of lint, saturated with the fluid, may be stuffed into a deep wound; or laid upon the surface, when the source of the effusion is superficial. An objection made to its application, in certain cases, is that it prevents union by first intention. The sulphates of zinc and alumina are older remedies, which possess much inferior power to the above, but are similar in their mode of operation. Ice, creosote, tannin, and a variety of valuable agents of secondary power, so often applied in civil practice, and attainable in the hospitals, cannot be relied on for field practice, and are, therefore, out of the question, except under rare circumstances.

Admission of Air.—Too little value, ordinarily, is attached to the admission of air into the wound in a bleeding vessel. Vessels of a moderate size, as the anterior tibial, the radial, or the ulnar, often bleed most obstinately, till the wound in the soft parts has been widely opened, the clots turned out, and the cold air admitted—when the hemorrhage is apt to cease immediately. In wounds of the mouth, the hemorrhage is often alarming—sometimes the extraction of a tooth produces exhausting discharges of blood. In these cases, the removal of the clot, and the direction, to keep the mouth open, often arrests the hemorrhage without further efforts from the surgeon.

In penetrating wounds of the chest, where the lung is wounded and bleeding, the patulous condition of the external wound may be considered favorable to the arrest of the hemorrhage; it affords exit to the confined blood, and at each
effort at inspiration air enters the cavity of the pleura; on its first introduction the air is cold and acts as a local styptic, but, as with each inspiration the quantity increases, and also expands from the warmth of the cavity, the wounded lung is subjected to an equal and powerful compression, as by a tight and evenly applied bandage, is made to retire up to its bronchial and vesicular attachments near the spinal column—it can no longer dilate to receive the laryngeal current, its circulation is consequently greatly diminished, it obtains, or is compelled into, that "rest" which "is the condition of recovery." The hemorrhage ceases, the external wound closes, and by a gradual process, whether of absorption or otherwise, the pleural enphysema is removed. But, in the meantime, the wound in the lung has firmly cicatrized, and, in gradually resuming its functions, all danger of hemorrhage has passed away. Such has been the result of our observation of chest-wounds of the kind referred to above during the present war. Men are frequently brought to the hospitals with these penetrating wounds of the chest. They are suffering from dyspnoea; percussion shows extensive pleural emphysema; auscultation detects no respiratory murmur anywhere on that side—the lung is evidently compressed. Many of these cases have been left on the field all night without the attention of any surgeon, and most of them recover under treatment in the hospitals. Reflection, in such cases, would lead to the precept: to leave the chest-wound open for a considerable time, and so far from dreading and preventing the entrance of air into the pleura, to favor it on account of its hemostatic effect. Compression of one lung produced in a gradual manner, seldom destroys life; hemorrhage often does.

Constitutional Hemostatics.—Reputed remedies of this class are quite numerous; many of them are supposed to have considerable power, but have gained their reputation in arresting sanguineous discharges of a very different nature from the hemorrhages resulting from lesion of large vessels, with which the military surgeon has to deal. They are applicable rather to the accidents of the hemorrhagic diathesis than to traumatic effusions. The largest class of them therefore are tonics and astringents; as the preparations of iron, zinc and lead. Ergot is supposed to be possessed of some virtue, though its action is not at present well understood. The class of sedatives are much more answerable to the purposes of the surgeon. It is
but rarely that the sedation produced by nauseants such as antimony and ipecac, can be of judicious application in a case of profuse traumatic hemorrhage threatening a fatal termination. Such remedies depress the vital powers too decidedly, and yet often fail to arrest the sanguineous flow. Antimonial preparations are often injurious, if long continued, by their disorganizing effects upon the blood.

Venesection.—Equally unphilosophical and more injurious, in our opinion, than even the use of the last class of sedatives, is the time-honored absurdity of venesection. It comes to us embalmed in the dicta of "the highest authority," and consecrated by the owlish wisdom of "the ancients," and, until recently, the precept has met with submissive and unquestioning acquiescence. We are gratified to find that, in all the cases of arterial hemorrhage collected in the office of the inspector, not one is reported wherein the expedient was practised by a surgeon of the Confederate States. The measure is one which has doubtless been transferred from civil practice, where it has been found of the greatest value, but in a very different kind of hemorrhage from that to which some military surgeons have sought to apply it. It is the great reliance—the sheet-anchor—in the spontaneous hemorrhages resulting from general plethora or local visceral engorgements. For these, too much cannot be said in its praise. But for traumatic pulmonary hemorrhage, the measure appears to us, not only hazardous, but actually injurious. All the circumstances are different—the cause of the bleeding entirely dissimilar—and hence the result of the remedy is, doubtless, often fatally adverse to the ill-founded expectation on which it was applied. Exotics, however vigorous, seldom continue to thrive. So have we found that the traditions of civil practice, however reliable, will not always answer as principles of military surgery.

Opium.—So far, we have seen that all the constitutional haemostatics are either unattainable to the field surgeon, or, if applicable, of feeble power and totally unreliable in cases of serious hemorrhage. Most happily, there is a single blessed exception. Opium is the one indispensable drug on the battle-field—important to the surgeon, as gunpowder to the ordnance officer—for besides the ages of pain for which it is the reprieve as an anodyne, it saves rivers of blood as a haemostatic. The value of the remedy may depend somewhat on the pre-
paration used. The tincture or the gum itself seems preferable to any of its salts. The preparations of morphia relieve pain more quickly, but are more certainly and more rapidly succeeded by the stage of depression incident to some constitutions. They, also, seem to possess less power than laudanum in quieting the arterial excitement in the manner that arrests hemorrhage. For the object under consideration, the mode of administration most convenient is in doses of from twenty to sixty drops, repeated at intervals of from two to six hours, having reference always to the urgency of the symptoms and the constitutional peculiarities and habits of the patient. At the field infirmaries, where many wounded are crowding upon the medical officers, a decided dose of opium, or one of its preparations, may be safely administered to all the more severely wounded. All of these require the remedy for the relief of pain; in some of them, with undetected arterial lesions, impending hemorrhages will be delayed, till time shall be allowed for thorough examination of each particular case. We have found the remedy valuable in cases of diffused traumatic aneurism, whether bleeding had yet occurred or not. These cases arrive at the General Hospital often in the night; the administration of a full dose of laudanum lessens greatly the risk of that tempting, and indeed warrantable, delay till morning, which all good surgeons practice whenever admissible.*

Quinine.—To some, the suggestion of quinine, as one of the adjuncts in the treatment of hemorrhage, will appear a most extraordinary proposition. Not so to those who have carefully noted the progress of many cases. Consecutive hemorrhage does not always—indeed seldom—bursts out in such a manner as to destroy the life of the patient at the first or at any single bleeding. There is generally a premonitory period marked by interrupted discharges, of more or less profuseness, which forebode the serious or fatal bleeding. The prudent surgeon, of course, in case the artery involved is a large one, needs no further warning, but promptly performs

* Veratrum Viride.—We have been surprised at not finding, among the reports in the office of the Surgeon-General, some experience in the use of this valuable sedative, as applied to arterial hemorrhage. Careful experiments with this powerful agent may prove fruitful of good practical results.
ligation to prevent unnecessary exhaustion. It is in the case of smaller vessels, in which the danger is not imminent, and where there is hope of avoiding an operation, that it is important to consider the value of every remedy and the grounds for its application.

The febrile excitement, which attends upon the early stages of a gun-shot wound, is generally of the paroxysmal form, and it is during these paroxysms of arterial agitation that the bleeding is most apt to take place. In the cases above described, the use of quinine, in antiperiodic doses, during the intermissions, is a valuable adjunct to more specific treatment.

**Operative Treatment of Hemorrhage.**—"The great principles of surgery to be observed," says Mr. Guthrie, "in cases of wounded arteries, and which ought never to be absent from the mind of the surgeon, are two in number:

"1st. That no operation ought to be performed on a wounded artery unless it bleed.

"2d. That no operation is to be done for a wounded artery, in the first instance, but at the spot injured, unless such operation not only appears to be, but is, impracticable."

I. The propriety of a rigid adherence, in nearly every case, to the first of these rules is obvious. We have seen that the natural processes for the arrest of hemorrhage are so often reliable that, they may be depended on until the bleeding actually occurs. The nature of the arterial lesion in gun-shot wounds is such as greatly to favor the occurrence of a spontaneous arrest. The wound is often both contused and lacerated, the general and local shock deters re-action, and the formation of a firm clot, with subsequent adhesion of the arterial tunics, where the division is complete, is by no means an unreasonable hope, even in case of the largest trunks, as the axillary and the femoral. No case of even suspected arterial lesion, notwithstanding all this, should ever pass from under the immediate care of the surgeon, without the most particular instructions to intelligent attendants, as to the momentary danger of hemorrhage and the most efficient method of applying the means for its temporary suppression. The patient himself should also be calmly informed of his danger, in order that he may avoid unnecessary muscular efforts and be prompt in calling assistance at the first moment of the bleeding. It must be remembered that, to produce hemorrhage, it is not always necessary that the artery shall be opened; and also
that the necessity for close watching does not cease with the expiration of a few hours, or a few days; for the slightest brush by a passing ball against an arterial trunk is apt to lay the foundation of consecutive hemorrhage, by the subsequent falling away of a slough from the wall of the vessel. Experience has shown that the period of bleedings from this cause is generally from ten to fifteen days, though care may be recommended for a much longer time.

II. The principle upon which the successful ligation of arteries is based depends upon the existence of collateral vessels, capable of sufficient enlargement to sustain the nutrition of the parts beyond the point at which the ligature is applied. The arteries and their branches seem to enter into combinations with each other at every possible opportunity; every artery of the trunk, except some in the viscera, anastomoses with its fellow; every artery anastomoses with the vessel immediately above and below it, and every artery anastomoses with itself by a chain of communications established between its branches. It is this intercommunication of arteries, more abundant in some situations than in others, that is known under the name of the collateral circulation.

While this free communication of arterial branches is the very foundation of ultimate success in all operations interrupting the blood-currents in the main trunk, it has yet been found, when too direct or too abundant, seriously to interfere with the attainment of the proposed end, in ligations for the arrest of hemorrhage. This failure to arrest the hemorrhage by ligation, between the wound and the heart, is caused by what is known as the recurrent circulation—the blood passing through the capillaries of the collateral vessels into the lower portion of the main trunk, and being poured out at the wound from the lower end of the divided artery. Indeed so constantly does this abundance of collateral circulation exist, and so frequently has it been found to give rise to the refluent hemorrhage just referred to, that Mr. Guthrie's second proposition, that "no operation is to be done for a wounded artery but at the spot injured," has become the acknowledged rule of action, in all cases of traumatic hemorrhage. Nonetheless, and more particularly Mr. Hunter, had practised ligation in the continuity of the vessel above, successfully for the cure of aneurism, and surgeons, up to the time of Mr. Guthrie, had practised the same method, with a varying and uncertain suc-
cess, in cases of hemorrhage. Since the publication of Mr. Guthrie's views, it has been seen that the Hunterian operation, so successful in the treatment of aneurism, is, in the majority of instances, unsafe and inapplicable to traumatic hemorrhage, on account of the great liability that exists, especially in the upper extremity, to the recurrence of hemorrhage from the wound by the lower end of the divided artery. His views are thus stated:

"Whenever the collateral vessels are not capable of carrying on the circulation of the limb, mortification or death of the part ensues; and whenever this collateral circulation is sufficient to maintain the life of the limb, blood must pass into the artery below the wound, and must, as a general rule, pass up and out through the lower end of the divided artery, unless prevented by the application of a ligature, or by some accidental circumstance forcing an exception to the rule, but not the rule itself.

"The cause of difference in the success of the Hunterian operation in aneurism and in the case of arterial lesion is, that in the one case, the sac receives and retains the blood brought into it by the collateral circulation, while, in the other, there is no aneurismal sac to receive and retain it, and the patient bleeds, perhaps, to death, unless surgery comes to his assistance.

"The absence, then, of the aneurismal sac renders the application of two ligatures absolutely necessary; one on each end of the divided artery, or one above and one below the wound, if the artery should not be divided. This is the principal point to be attended to in the treatment of wounded arteries."

Such, briefly stated, are Mr. Guthrie's views on the most important points of interest connected with arterial hemorrhage. They are worthy to command from all, unlimited confidence, and have, indeed, already become, as has been said, the cardinal principles of practice for military surgeons, everywhere. It has been seen, however, that the occasional success of the Hunterian operation for hemorrhage, which he regards as due to "some accidental circumstance," is rather the result of well-ascertained anatomical facts, viz: the greater or less abundance of the collateral circulation, and to the situation of the wound along the course of the arterial trunk. This is a circumstance worthy to be taken into account in de-
termining upon the course to be pursued in cases either of unusual difficulty, or where, for some important object independent of such embarrassment, the surgeon may desire to adopt the plan of Hunter in preference to this. One of the most desirable, and, at the same time, most difficult, of these objects is to save a limb, as the superior or inferior extremity, in case of fracture of the bone, complicated with consecutive hemorrhage.

We have already intimated that, singular combinations of circumstances repeat themselves often, in every battle. This, however, can scarcely be considered a singular one. A ball cannot well fracture the femur, for instance, in certain portions of its diaphysis without endangering the femoral artery. How often do we see our hopes of a promising case of fracture of the thigh, dashed by the sudden occurrence of either a secondary or indeterminate hemorrhage. In such a case, no necessity more to be regretted could arise, than that of being compelled to make the deep incisions, and enter into the tedious search among the inflamed and tender soft parts necessary to find and secure the bleeding vessel at the seat of injury; converting our comparatively simple case into one of additional, and most serious complications—all pertaining to the immediate seat of the fracture. Here we remember that, according to rule, and not by accident, large arteries, when wounded high up, are not quite so subject to recurrent hemorrhage as when wounded near the extremity of the vessel; because the collateral communications, though sufficient for the purposes of nutrition, are not in such abundance as to produce hemorrhage by the recurrent circulation. The Hunterian operation then may be legitimately performed somewhere below the profunda, and the patient saved the greater evil of being operated on in the tissues about the fracture, or what, in our opinion, would be less objectionable, amputation.

Hunterian Ligation to Prevent Destructive Inflammation.—After the battle of Seven Pines, May 31st, 1862, many of the wounded in the General Hospital at this place suffered from the most violent and uncontrollable inflammation. The inflammation from gun-shot wounds for sufficient causes, viz: the shock or jar to all the tissues, especially the nerves and blood vessels of the part, is apt to be more intense than in other wounds of the same parts. Wounds of both the
upper and lower extremities resisted all ordinary measures of treatment. Suppuration in many had ceased, and, in its place, a bloody water was discharged from the openings and abrasions. The swelling in these cases was immense.

Six of the above cases* under our observation, were the subjects of arterial lesion. The arteries wounded in the lower extremity of three of these cases were, severally: in one, the peroneal, close to its origin; in the other two, the anterior tibial, near the middle of the leg. Profuse secondary hemorrhage occurred in all these cases, (see table, page 91, cases 30, 32 and 33,) respectively, on the 14th, 12th and 10th day. Ligation was determined on. The extreme swelling and inflammation of the limb, extending even above the knee in all, and in one, No. 30, marked by large patches of incipient gangrene on the foot, presented great embarrassments to the operation at the seat of lesion. It was not the difficulties, however, which caused Mr. Hunter's operation to be preferred in all of these cases to Mr. Guthrie's, notwithstanding the risk of recurrent hemorrhage. There was a desirable incidental benefit hoped to be attained, which was of even deeper interest, if possible, than the arrest of the hemorrhage. The idea pursued in departing from the rule was no less than the experimental effort to cure the inflammation in the limb by cutting off its arterial supply, by ligation of the main trunk which supported that inflammation. The femoral artery was tied in each case near the apex of Scarpa's triangle. The hemorrhage ceased immediately in all three of the cases, the swelling began to decline within twelve hours, and, in three or four days, the limbs were reduced to very nearly their natural size, the discharge having changed from the bloody water, to healthy pus.

Results.—Case 30 recovered slowly, on account of the sloughing out of the patches of gangrene, which had shown themselves previous to the ligation. These surfaces granulated healthily and cicatrized firmly. The suppuration was profuse and long continued.

In case 33, the result was most satisfactory and complete; the swelling had disappeared in three days—the appearance of the wound wonderfully improved—the discharge became

* See reports of 1st, 2d and 4th Georgia Hospitals in office of the Surgeon General—Ligation of arteries.
healthy, and the subsequent progress of the case rapid and favorable, ending in entire recovery.

In case 32 it was discovered, after the complete subsidence of the swelling, that the fibula was broken. Still the case progressed well. The inflammation was entirely subdued. On the tenth day after the ligation, recurrent hemorrhage supervened, causing great infiltration below the knee and in the popliteal space and rupture of the nearly cicatrized gun-shot wounds. This patient was greatly exhausted and was not thought to be able to bear the ligation of the peroneal artery. Amputation above the knee was determined on. Only one artery, superficial and of small size, required tying in the stump. It is worthy of remark, that the stump healed by the first intention—a most unusual result of a secondary amputation. It is not unfair to presume that the previous ligation favored this rapid recovery of the stump.

In the three cases of arterial lesion in the superior extremity, in which ligation of the main trunk in its continuity was preferred, in order to subdue inflammation, the arteries wounded, respectively, were the brachial, near elbow, in one, and the radial, in both the others. The inflammation was greatly modified, though not in so marked a manner—except in one of them—as in those of the lower extremities. The patients all recovered; and in two of them, recurrent hemorrhage took place, but was controlled without resorting to further ligation. In the exception mentioned, no recurrent hemorrhage occurred, and the inflammation seemed to be completely strangulated throughout the hand and forearm by the ligation of the brachial artery.*

* As the subject has only a relative bearing on the main object of the present paper, attention is called, only in a note, to the above practice of ligation to subdue or control inflammatory action. We believe that the cases of Privates C. A. Reid and Drury B. Early, (see table, page 91, cases 31 and 33,) ligation in the one, June 5th, in the other, June 11th, 1862, are the first cases on record in which this measure was adopted with reference to the proposed result. In all of the six cases, the Hunterian operation was chosen with the distinct end in view of combating and checking, if possible, the destructive progress and, in some, the septic tendency of the inflammation. In all of these, the pain, the swelling and turgescence were almost immediately relieved, and the most remarkable change was soon presented, as seen in the character of the discharges.

Surgeon A. C. Thom, of the Confederate States Army, has kindly
It will be observed that, in the above six cases, in which the rule of Mr. Guthrie was departed from, recurrent hemorrhage took place in three of them, but only in one, in such degree as to require an operation. The advantages gained in departing from the established rule would be more apparent from a detail of the cases than in the above very condensed notes. The cases are referred to more in illustration of the circumstances in which departure from the rule may be considered justifiable, than with any view of advocating the Hunterian practice in opposition to the more reliable one of Mr. Guthrie.

And lastly; though there are doubtless many other considerations which may justify the ligation of an artery in its continuity in the treatment of hemorrhage, we will refer to but one more: For instance, suppose a patient in a state of extreme exhaustion, whether from hemorrhage or other causes:—Consecutive hemorrhage in some inaccessible artery, for instance, as the peroneal or posterior tibial high up, occurring in a patient of this kind, especially if complicated with great tumefaction and consequent change in the histology of the parts, would present a case, even for the most practised operator, of unavoidable delay. A prolonged and trying—we had almost said a blind—search among clots and fibrinous masses and condensed infiltrated tissues, every one who has tried it knows full well, is sometimes the only route to the open mouth of the bleeding vessel in such cases. This greatly exhausts the strength of the patient, and lessens—indeed destroys—his chance of life. Under such circumstances, the Hunterian operation would be preferable, especially in a wound of the lower extremity. In the first

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furnished us notes of a case, in which he subsequently practised Hunterian ligation of the femoral, and in which the same beneficial results were exhibited in the most marked degree—"the inflammation relieved, as by magic."

The application of the ligature, in cases of elephantiasis and for malignant diseases of the face, does not, it appears to us, interfere with any originality which the principle here practised may possess. The present operations, besides being applied with an entirely different object, fully answered the proposed end, while the others did not. We feel confident, that this practice will become one of frequent application in the treatment of otherwise unmanageable inflammation, under a variety of circumstances authorizing its adoption.

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place, it arrests the hemorrhage for the time being at least, and affords a chance of even permanent arrest; and secondly, by cutting off the main stream from the support of the inflammation and general turgescence, the condition of the limb may be so improved that, in case the recurrent hemorrhage should return, a less embarrassing state of things will attend this more desirable operation. The adoption of the one operation gives a chance for life; we think we have seen the adoption of the other, under just such circumstances, take it away.

The Ligation of Arteries.—Under this head, we shall consider those operations necessary to the exposing of an artery in its continuity, its isolation from surrounding parts, and the arrest of the circulation through it by the application of a ligature. We shall also describe the application of ligatures to arteries in gun-shot wounds and aneurism, presenting such guides as are at present recognized in this more difficult surgical procedure. That whole class of ligations which are necessary during the course of amputations, resections, and other operations, together with those required to arrest consecutive hemorrhage, sometimes attendant upon them, have received no particular attention anywhere in the present chapter, as their consideration comes more properly under the head of those several operations, or of the accidents incident to them. All that is necessary on these subjects will be found under Amputations, Resections, and the Diseases of Stumps.

No class of operations have received more particular attention, or have the advantage of more definite rules for every step in their procedure, than those required in the ligation of arteries. They are thought more to resemble the lessons of the dissecting-room, than any other class of operations on the living subject; and certain it is, that their previous rehearsal on the dead will often save much mangling and pain to the living.

General Rules for Ligation of Arteries.—Lisfranc, Malgaigne, and a variety of French writers, furnish valuable definite rules for operations upon the arteries, which, in one form or another, constitute the basis of the directions to be found in all works on operative surgery. Though the arterial walls have been more elaborately studied by the histologist, for all the practical purposes of the surgeon, it is only necessary to recollect that, they consist of three coats; the internal, known as the serous, the middle or musculo-elastic, and the
outer or areolo-fibrous; that each artery is surrounded by a special cellular sheath, that it is accompanied by one or more veins and nerves, and is under the enveloping aponeurosis.

1st. In determining the position of an artery, its known anatomical relations are greatly assisted, often in the living body, by the pulsations of the vessel, though the tumefaction and the natural depth of the artery, in many instances, deprive the operator of this great advantage.

2d. **The Incisions.**—These are properly but two, viz: through the skin and through the aponeurosis, though supplementary cuts are frequently necessary. In making the first, the fingers and thumb of the left hand should be placed perpendicularly and firmly upon the surface to be operated on, care being taken not to draw the skin away from the seat of the artery, or to slide it, so as to alter its relations in the attempt to make it tense. If the artery is superficial, the direction of the incision may be parallel with its course and its extent, moderate; but, if the vessel is large and deeply seated, it is more convenient and safe to make an ample incision, and that its course traverse that of the artery obliquely, in order to avoid the accident of falling too much to one or the other side. The skin and superficial fascia having been divided, the aponeurosis presents itself, and is of a whitish and sometimes glistening appearance. This may be pinched up with the forceps, and a small opening made into it, the knife being held flatwise to the artery. The director is then introduced first upwards and then downwards along the course of the artery, and the bistoury, with the back of its point in the groove, run along so as to divide this membrane in both directions, to the full extent of the opening in the integuments.

Malgaigne directs that, when the artery lies immediately under the aponeurosis, the incision be made to one side, in order to avoid wounding the vessel; but when the groove director is used, and it should be in all cases, this precaution is unnecessary.

3d. **Separation of the Muscles, &c.**—The muscles now present themselves, and generally their interstices are sufficiently apparent; but, if not, such movements may be produced in the limb as will contract them, especially the satellites, when the depression will be recognized. Having now arrived almost in the very presence of the sheath enclosing the artery, its accompanying vein, and perhaps an important nerve, the
blade of the bistoury will not be used, but the separation will be made with the fingers, or with the groove director, or the handle of the knife. If necessary, the muscles should be drawn aside from the course of the artery, either with the hand or with bent spatulas, so as to bring the enveloping sheath into full view; or it may be necessary even to cut the muscle. It is better to avoid this; but the measure is preferable to that of allowing it to obscure the position of the vessels and embarrass the further proceedings.

At this stage of the operation, we may sometimes find that we have been at fault in our incision, the appearance of the parts presented, after dividing the fascia, seeming unfamiliar and different from that which was anticipated. Under such circumstances, the operator should not enter into a blind search after the vessel, into first one and then another inter-muscular space, but should pause and carefully study the parts as they are found in the incision he has made. By producing contractions of the several muscles traversing the wound, he will soon comprehend the exact relation of the parts presented to the point he desires to attain. Each step in the operation should have its own definite end in view, and the surgeon should not occupy himself in attempting to find the artery on making the first incision, as this cannot be attained till the last has been completed.

4th. Isolation of the Artery.—The sheath of the artery should be opened by raising a fold of it with the dissecting forceps and nicking it carefully with the bistoury, held parallel to the artery and never turned towards it. Now laying aside the bistoury, but retaining his hold on the fold of the sheath held by the forceps, the surgeon should introduce into the opening the point of the groove director. With this, he should endeavor to loosen the connections between the artery and the sheath, taking care not to extend the separation more than a few lines, and also to introduce the instrument between the artery and the vein, so that the latter shall not be exposed to injury from the point of the director as it passes beneath the artery. Should the artery be deep, it may be found necessary to curve the director in order to pass it beneath it. Sometimes, in arteries of large size, the vessel will flatten before the point of the director or blunt-curved needle, in which case it may be punctured. To avoid this, the forefinger and thumb of the left hand should be applied above and below
the point where the pressure is made, so as to facilitate the rolling of the vessel over the point of the instrument.

If the director has raised any important structure with the vessel, a second director or probe may be used to complete the isolation before withdrawing the first. The artery having been thus placed upon the director, we feel for the pulsations, in order to assure ourselves, to the last degree, that there is no mistake as to its identity. We cannot mistake the artery for a vein, as the color of the latter alone will prevent such an error. The accompanying nerve is sometimes nearly as large as the artery, as in the case of the median, in ligation of the brachial, but can always be easily distinguished by its color and cord-like solidity.

Application of the Ligature.—The thread for the ligature should be a small round cord, of silk or hemp, from twelve to fifteen inches long, so as to admit of secure holding, and possessed of sufficient strength to allow of considerable force being used in drawing a compact noose and forming a firm knot. It should be carefully waxed to prevent slipping. The ligatures used by the surgeons of the Confederate States army are of the material known as saddler's silk, of such medium fineness as will serve single, for the small branches and, when twisted double, answer for the larger trunks. We have used strands of cotton-thread twisted to the proper size, but prefer the saddler's silk.

Having ascertained, by careful examination, that the artery alone has been raised on the director, a common eyed-probe, slightly curved and armed with the ligature, may be used in case the aneurism needle is not at hand. This may be passed along the groove of the director and under the artery, till the armed eye is presented on the opposite side. The ligature should then be extricated from the eye with a hook or the forceps, and both the probe and director withdrawn. Most surgeons, however, use the common aneurism needle (plate I. fig. 4, Arteries) when the director will not be required in the introduction of the thread. Others use the needle, both to isolate the vessel and to pass the ligature, to which no particular objection is seen—indeed, we most frequently practise it.

Various forms of aneurism needles are at present in use. A short blunt-curved needle, held firmly in the artery forceps, was used by Dr. Physic; or the same, attached by a screw to
a staff, known as the American needle, (plate I. figs. 5 and 6,) attributed to Dr. Mott. This latter instrument is managed as the ordinary aneurism needle, till the ligature has been introduced; then the blunt hook of figure 6 is introduced into the eye—this holding it steadily, while the staff is unscrewed. The needle is then drawn through by the hook and removed, leaving the thread in position. For arteries still more deeply seated, as the anterior or posterior tibial, or especially for the internal iliac—which operation would have failed on one occasion except for its use—is the very admirable needle figured in plate I. figure 7, which has been delineated, for this work, from the instrument in our possession. It is somewhat on the plan of Belloeq's tube. The principle, it is said, being first applied to ligation by Professor Gibson, the father of Surgeon Gibson of our army. In application, the curved tube (a) is passed under the vessel, as the ordinary aneurism needle; the slide (c) is then pushed down with the index finger, causing the delicate hooked watch-spring (b) to be projected, and to rise from the bottom of the wound, in most cases, above the tegumentary surface and within easy reach of the operator. The ligature is then looped into the hook and the spring drawn within the tube, carrying the ligature securely against its edges, holding it fast. The whole instrument is now withdrawn and removed, leaving the thread in proper position under the artery.

Having raised the artery, by drawing gently on the ligature, to be sure that the circulation is arrested and that we have not included a nerve or a tendon, as has been done, the ligature is firmly secured with a double knot. It should be tied directly across the vessel, as an oblique loop, by slipping on one side, might fail to make sufficient compression. When the vessel is deep, each fold of the knot must be firmly tightened, and so held as to avoid slipping, till the entire knot is completed. One end of the ligature is then removed, and the other brought to the surface by the most direct route.

The ligature, when properly applied, as is well known, divides the two inner coats of the vessel, and, subsequently also, the remaining coat by ulcerative absorption. A clot, extending to the first collateral branch above, having formed, the vessel is completely plugged; but it is now understood that the adhesion of the coats of the vessel is fully as effectual as the clot, in preventing the recurrence of hemorrhage. The
enlargement of the collateral branches secures the nutrition of the limb beyond the ligature.

**Dressing and After Treatment.**—The dressing of the wound should be simple, having for its object, as far as practicable, union by the first intention. The lips should be brought together with adhesive straps, and lightly secured with a compress and roller. If the loss of temperature is persistent under the use of woollen wrappings, stimulating liniments may be used till the time is afforded for the establishment of the collateral circulation. This is apt to be very deficient in ligations for primary hemorrhages, better in those for the consecutive forms, and quite abundant whenever an aneurism has existed for a considerable time. The wound should not be disturbed by frequent dressings. The ligature should be left untouched for eight or ten days, in case of the smaller arteries, and for two or three weeks in that of larger ones; at which time it may be tried by gentle traction. It frequently separates and begins to protrude spontaneously, as will be shown by the projection of a half-inch or more of the clean white thread beyond the surface of the skin. Throughout the treatment, the limb should be placed in such a position as will moderately relax the muscles and favor the escape of the discharges from the wound.

**The Ligation of Arteries at the Seat of Lesion.**—The lessons of the amphitheatre, the study of anatomical details, the descriptions by authors and the stress laid on the surgical relations of arteries, as well as, in most instances, the rules enunciated for their ligation, have, until a very recent period, contemplated tying, *only in the continuity of the vessel*; consequently, the whole science of the subject, so to speak, has been adjusted and is more applicable to the treatment of aneurism, than to that of traumatic hemorrhage. It has been plainly shown that, for the treatment of hemorrhage, the operation of Hunter is unsafe and entirely inapplicable, however often we may be forced to use it as a temporary means, or adopt it for the control of concomitant inflammation threatening the life or limb of the patient.

As the doctrine of ligation, by two ligatures at the point of injury, is here acknowledged in its fullest acceptation, an embarrassing incongruity would be avoided could we furnish reliable directions for operating on the principle so strongly urged. It must be acknowledged, however that, as compared
with the ligation in the continuity of the vessel, the operation at the wound, while in itself it is far more difficult and embarrassing, is yet less clearly treated in the works of authors, and sadly needs that clearness of description and systematized programme of procedure which has rendered the other so easy—we had almost added—positively attractive. In consequence of the comparatively recent and sudden change wrought in the practice by the convincing and brilliant experience of Mr. Guthrie, time has scarcely been allowed for that thorough study and well-considered teaching which a new, and certainly more difficult method requires; nor for the enunciation of such rules as will safely guide, and above all, give confidence to, the inexperienced. Nevertheless, the facts are overwhelming, the necessity imperative, our duty unmistakeable. We must cast about for principles, or, in their default, even operate without them. Otherwise, condemnation awaits us from without, and worse still—self-accusings from within.

The records of surgery, however, are not wholly without very useful hints in this mode of operating. It must be recollected that, previous to the time of Anel and Hunter, this, or something very similar to it, which we now call the new method, was then the old and only one at command of operating surgeons whenever they were heroic enough to attempt the surgical treatment of aneurism; and there may be found, scattered up and down along the annals of medicine, both before their time and since, occasional cases wherein ligation at the seat of lesion was successfully accomplished.

In the consideration of this particular aspect of the subject the cases presented may be divided into two classes: 1st. Cases of hemorrhage with simple arterial lesion; and 2d. Arterial lesion complicated with diffused aneurism.

1. Ligation in Simple Arterial Lesion.—The nature of this injury has been already fully described. The time, above all others, at which we may hope to find the opening in the artery entirely uncomplicated with clots or matted fibrine is immediately after the receipt of the wound and when the vessel is to be ligated for primary hemorrhage. In these cases, the wound is apt to be still patent at the time of the bleeding, and as little or no barrier is presented to the easy outflow of the blood no infiltration occurs, and the clots formed, if any, are confined entirely within the walls of the fleshy tube punched
HEMORRHAGE.

by the projectile in its progress through the structures towards the artery. Even in retarded hemorrhage, the same clean condition of the tissues about the arterial lesion may sometimes be found, unless the movements of the patient have so disturbed the relation of the superimposed muscular layers as to interrupt the exit of the blood. Unless the situation of the wound is a very unusual one, the immediate anatomical relations of the artery and the descriptions for the Hunterian operations can be made easily available in reaching the vessel in simple arterial lesion.

External Wounds and Tracks of Projectiles.—A consideration of these is important, as they have reference to, and, in a measure, determine the line and position of the incisions. It will be understood that any classification of wounds or the course of balls here found, is made specially and purely in reference to, and on the one principle of, their connection with the arterial lesion, and is not intended to be considered as an arrangement of gun-shot wounds in any other relation whatever. We would ask to be allowed, for a moment, to conceive the track of the ball as the tunnelled highway through a solid mass, crossed, at some portion of its course, by a tubular stream—a culvert, which, when entire, conducts a living tide, to a glowing region beyond, but now, breached and interrupted, the stream is diverted—and, wasted at one or other end of the tunnel, leaving pools and sediment, here and there, throughout its course. All along this highway, the anatomist has his beacons, his finger-posts, and his mile-stones, by which he shapes his course and measures his distances, in seeking any particular point. There is but one point of absorbing interest—the wound in the artery—all pointers and measurements tend onward to this centre.

Balls producing arterial lesions approach the vessels in every conceivable direction: Directly, obliquely, sometimes longitudinally from above, sometimes, from below; they pass through the body or limb in a straight line, or they diverge in an angle or by a curve; or, again, they may enter on the outer side, distant from the vessels, traversing the limb towards the inner aspect, wounding some large trunk—as the femoral or brachial, or axillary as from the shoulder, coming to the vessel thus from the rear, but making no wound of exit, are incomplete. We cannot consider all of these; we select but three for description, which we shall take the liberty of
naming respectively: 1st, the direct; 2d, the oblique; and 3d, the posterior incomplete track.

The two first of these are selected because they are very frequent; and the third—not much less frequent—because its bleeding is apt to be obscure, and because it requires careful consideration always, whenever it gives rise to hemorrhage.

It doubtless for a moment occurs to the mind of some one, that this classification might be extended. We agree that it might, but with little or no advantage to our subject, and we cannot see that such a basis of classification could be made to elucidate any other connected with gun-shot wounds. It may be asked are there not posterior complete tracks, and anterior incomplete; and, if so, why are they not considered? Without doubt, there are both of these varieties, for balls do often pass entirely through limbs from behind, and they sometimes pass partly through from the front, but we only recognize their tracks, for our purposes, when they happen to wound an artery, and then we view them altogether, and only from the antero-internal or vascular aspect of the limb; therefore, they both become either direct or oblique tracks, so far as we are concerned, and are so considered in our operations. We have no interest in these tracks except, either as a route from the surface of the vascular aspect* of the wounded man, to the bleeding vessel, or as a line in reference to which we make a route to the bleeding vessel from that portion of the surface least removed from it. Briefly, here is our object, and method of attaining it: We wish to reach the bleeding artery—we know that the track has crossed it somewhere, and at the very place which is bleeding, for in the making of the track, the wound was made; we know, also, the general course and position of the artery. Now, if either end of this track happens to be the shortest route leading directly to the opening in the artery, we enlarge it to reach the vessel—but if there is any much

* We mean by "vascular aspect," that surface in relation to which the artery is most superficial. It is generally, as is known, for the primary trunks, on either, the anterior or internal aspect of the body, as in the neck the carotids; in the superior and inferior extremities, the axillary, brachial, radial and ulnar; femoral and anterior tibial, &c. But in the case of those arteries that approach nearer to the posterior plane of the body, the vascular aspect is reversed, as in the case of the posterior tibial, peroneal, gluteal, and ischiatic arteries, and also some arteries of the shoulder.
HEMORRHAGE.

more direct route through the sound skin and muscle, we cut down and bi-sect the track, as nearly parallel with the course of the wound as we can, the track greatly assisting us in finding the arterial wound. Thus far, the track is our great rallying point, and has the most important value in the operation—beyond that, none at all.

Operation.—We shall have reference to these tracks in connection with the incision and search for the arterial lesion. We prefer completing the description of the operation in connection with the incision of the oblique track, because that one, we conceive, to be of the most frequent occurrence, and the one which seems to present more clearly, a type of ligation at seat of lesion than either of the others.

1st. Instruments.—A tourniquet, a straight, a convex and probe-pointed bistoury, a female catheter or straight sound, probes, forceps, bent spatulas, needles, sponges, and the dressings, complete the preparations.

2nd. Digital or Instrumental Compression.—In case the tourniquet or other means of compression is not already applied, the surgeon having prepared for the operation, should see that the main trunk leading to the wound about to be disturbed, is securely compressed, either by that instrument or by the fingers of a perfectly reliable assistant. Never begin the operation without some form of compression.

3d. The Incision.—The circulation being controlled, time is now allowed to consider well the circumstances of the wound, the relations peculiar to the particular and perhaps unusual portion of the vessel he has to reach, and also by which wound, if there are two, he should attempt to approach it, or whether the incision should traverse the wound in the skin at all, in order to reach the arterial wound.

Direct Track.—When the course of the ball is direct, the entrance being near the line of the artery, the incision should traverse that wound, whether of entrance or exit, which is nearest to the general course of the artery and most accessible to it. The catheter may be used to follow the course of the ball during its search for the artery, as it is certain that the wounded vessel will be found somewhere in its track. We should at no time lose sight of the anatomical guides of the particular region in which we operate.

Oblique Track.—The ball may have penetrated the artery very obliquely in such a manner that, both its wound of en-
trance and exit may be far removed from the known course of the vessel which it has traversed, in this case, the incision should be made perpendicularly to the course of the ball, bisecting it near its middle and parallel with the known course of the artery. Here the introduction of the female catheter or sound through the wound, from one opening to the other, will be found of great assistance as indicating the level or plane of the wounded artery.

Under these circumstances, make an ample incision in the skin, especially if the vessel is deep. Divide the aponeurosis as heretofore described on the director, and proceed cautiously, directing the assistant to make such movements with the sound—pressing it upwards, &c.—as will indicate the approach of the operator to it; or he may feel for it through the tissues in the bottom of the incision. As the seat of the wound is approached, the stained appearance of the tissues, together with the prominence of the sound will guide to the track of the ball. The particular satellite muscle must be recognized, and the relation of the artery to it, considered. Having arrived at the level of the instrument, the sheath of the vessels should be carefully searched for—in this, the clots about the wound will materially assist. Sometimes the sheath may be protruded, which will indicate the vicinity of the cut in the artery. Having approached thus near to the vessel or to the wound itself, if there is any difficulty, scraping with the handle of the knife or raking with the point of the director or probe, and picking in the suspicious places with the forceps, will be apt to plough up the vessel. If not now found, or even before this stage, the surgeon should direct the tourniquet to be relaxed, when the beating of the vessel will indicate its course and the flow of blood, divulge perhaps the very point of the opening. When one end has been found—most frequently the upper on account of its pulsations, the lower or distal end should be looked for. In vessels of considerable size, where the sound or catheter is used, the cardiac end of the artery is on one side and the distal end on the other, the instrument occupying the space between them, caused by retraction. If the vessel is not completely divided, the search may be somewhat shortened.

Application of the Ligature.—This requires no very particular description. If the vessel is only partially divided, the common aneurism needle (plate I. fig. 4, Arteries,) may be used,
as in ligation in the continuity of the artery. When completely severed, the cardiac end will be found to have contracted for some lines from its mouth, resembling, as described by some, the neck of a claret bottle. It will also be found to have retracted within its sheath. The mouth of the distal portion of the artery will probably be found less, and perhaps not at all contracted, and also less drawn within its sheath. This end is much more apt to bleed afterwards, if neglected, than the upper end. Either the forceps or tenaculum may be used. The forceps are supposed to be more suitable for the trunks and the tenaculum for the branches. If the forceps are used, seize the upper end of the vessel in such a way as to flatten its calibre, and not introducing one branch into its mouth, as recommended by Dessault. If the tenaculum is used, it is better to traverse the vessel, and not introduce the point into its calibre—this, we think, often gives rise to imperfect ligation in amputations. The vessel, thus seized, is pulled a little out of its sheath, an assistant passes a thread beneath the forceps or tenaculum, surrounds it, and makes a knot, taking care, before tying, to push it over the vessel and as close to the surface from which it emerges as possible. Then, in the same manner, apply another ligature to the lower end. Both ends being ligated, the instrument is withdrawn from the vessel, and the pressure on the main trunk is relaxed, in order to ascertain whether the ligation is effective. The pulsations of the vessel will be observed moving the ligature. Sometimes small branches in a wound bleed so as to give trouble, and yet are difficult to isolate—a sharp-pointed aneurism needle, (see plate I. figure 5, Arteries,) armed with a thread, may be passed into the structures under it, including a little muscular fibre, &c., with it, in a common ligature.

Dressing.—Sponge out the wound to remove all clots, and dress and place in position as heretofore described, adjusting the parts for union by the first intention.

In posterior-incomplete tracks, it will be recollected, that the ball enters at some point distant from the artery, penetrates to it, or a little beyond, and wounds the vessel, but makes no exit.

This form of track is seldom found in connection with simple arterial lesion and free external bleeding, but is the one which is more apt to be characterized by diffused aneurism. Partly, for this reason, have we deferred its consideration till we ap-
ach that more complex portion of our subject. Still, inasmuch as cases do occur in which the more simple operation is required, we describe here some of the details of the procedure, especially as these details easily lead on, as by gradual approach, to the perplexities of that uninviting operation.

Suppose, for instance, the ball to have entered the middle of the thigh posteriorly, as before described, wounding the artery and lodging in the limb—an alarming hemorrhage from the wound results, and ligation is determined on. Here, as in the oblique wound, we wish to use the track to assist in finding the arterial lesion. The general precept, to "enlarge the wound and tie both ends of the bleeding vessel," of course, cannot here be carried out, and it would be simply absurd to follow that track in reaching the artery. Yet the track may be made very useful as a guide, though not as a route. Effectual compression being made, and the limb being placed in such a position as will make all parts of the track coincide, the sound is introduced and pushed to the bottom of that canal. If it has approached near to the surface, the point can be made prominent through the skin in front. Knowing the course of the vessel, the incision may now be made by the side of the point, if the prominence does not exactly correspond with it, or directly upon the end of it, if it does: We may then follow the sound downwards to the plane of the vessel, and we will probably find the gap in the artery, either very near the side of the sound, on the same vertical plane, or perhaps traversed by it. The lesion being thus arrived at, the operation does not differ in general principles, nor even in its details, from the one just described.

Although it may happen that there exist no aneurism with wide-spread pulsations and an ampullated space, still an arterial wound, so circumstanced, cannot fail to present complications approaching to aneurismatic characteristics; there are apt to be more or less infiltration, and a large number of clots, while the confusion of tissue simulates the matted and stiffened condition of the parts—unless the bleeding is primary—observed in diffused aneurism. The simplest of them belong to that indefinite order known as "transition cases," embarrassing every classification, and which here bridge over the chasm between the uncomplicated and the complex, overlapping the boundaries of one grand division with the confusing outskirts of another.
LIGATION IN TRAUMATIC ANEURISM.—The Hunterian operation of ligation in the continuity of the vessel, facilitated as it is by the normal condition of the structures and guided by undisturbed anatomical relations, is seldom, in itself, a difficult procedure. Even ligation at the wound, in simple arterial lesion, though the tissues are altered more or less by the extravasation, always in some degree present, is still an operation, the performance of which the surgeon may contemplate with complacency, and which he may hope to accomplish successfully in most instances, without meeting serious embarrassment at any stage of the procedure. His anatomical guides and the course of the artery itself being well considered, he avails himself of the track and finds that he has, crossing each other at angles, varying in different cases, two lines, one longitudinal, the other oblique or transverse—the intersection of which must rest at a point, not very distant from the arterial wound. The transverse or oblique line is the track, a straight, narrow tube, undilated in any portion of its extent, which offers easy and certain transit to his sound, from the wound of entrance to that of exit, or the reverse indifferently—that when this is accomplished, he knows that the vessel rests somewhere against the side of the instrument, crossing it. He considers the superimposed layers of muscles, if there be any, their number, their thickness, and thus he arrives at the depth at which the arterial wound rests from the cutaneous surface; and with his mind and his eye familiar with every object he is to encounter, he starts out, not on a voyage of discovery, but with a clear conception of his end, guided, at every step of his course, by pointers and beacons, which illumine every portion of his way.

If, then, such are the guides—in the one case, rendering the wound in the artery easily attainable—what, it will be asked, is the new condition which so alters the situation as to make traumatic aneurism, perhaps in the very same region, the dread of the surgeon and its surgical treatment, the most difficult and embarrassing of all the operations of modern practice—the whole field of surgery not presenting a more difficult operation, nor one requiring greater judgment, nerve and dexterity?* A consideration of the circumstances and condition of parts involved in diffused traumatic aneurism

* Druitt.
will enlighten us as to the reason why these operations are generally considered so difficult.

This form of aneurism, if we may so term it, resulting either from the obstruction presented by the partial agglutination of the wound or sinuous course of its track, consists of an effusion of blood poured out by, and communicating with, a wounded artery. It has no distinct sac and is only limited in its extent by the pressure of the surrounding parts. Even these do not form for it a distinct wall, but, as long as the accumulation continues, they are themselves subjected to infiltration, till each organ surrounding the accumulation becomes soaked and stiffened by the fibrine and discolored by the red particles of the blood. The accumulation, beginning at the arterial wound, sometimes dilates and presses before it the sheath of the vessel; at others, passing through a free opening in the sheath, it makes for itself outside of it, in the intermuscular space immediately overlying the vessel, a dilating cavity—of which the distended track also forms a part—of constantly increasing dimensions, imperfectly and irregularly lined with layers of clotted blood and fibrine. In the centre, or more frequently lying against one wall of this irregular cavity, is the wounded artery; the blood from which is being constantly poured into the sac, so that the entire space is filled with fluid blood, momentarily increasing with each pulsation of the vessel. The pulsations are accompanied by dilatations of this pseudo-sac. The accumulation continuing, some portion of the wall of clotted blood and fibrine gives way; if the rupture is opposite the partially healed external wound, profuse hemorrhage follows, relieving the distension for a time, to be repeated again and again, till the vessel is secured; but if at some other portion of the wall, the blood is still farther extravasated among the muscles, under the aponeurosis, and in the meshes of the cellular tissue, till, for an indefinite distance around the wounded vessel, all the structures are distended, compacted, matted and consolidated, and the tissue of each particular organ infiltrated and stained with blood as just described. In certain portions of the body, where the distensibility of the parts is great, the artery being large, the accumulation is sometimes so abundant as to produce syncope by the sudden diversion of so large an amount of blood from the current of the circulation.

From the above statement of the facts, connected with
traumatic aneurism, as briefly presented as clearness will permit, it will be seen that the great advantage afforded by the anatomical relations of the region, so valuable to us in the other two operations, is, in a great measure, withdrawn in this. On laying open the cavity to reach the vessel, the mass of clotted blood and of fibrine—partly effused from the tissues and partly deposited from the blood—obscures the view of all the parts familiar to us in our dissections; and the altered appearance of everything throughout the entire region, does not fail to embarrass the operator, and to make each step uncertain and hesitating. A wilderness of matted, confused and unfamiliar structures bounds all the cavity from which he has removed the blood, and he looks in vain for something he has ever seen before, to direct him to the place where the artery, at least, ought to be located. Again; to add to the difficulties which present themselves, we know by experience, that, however well our pressure may be applied to the main trunk, we cannot always be secure against a certain oozing of blood from the turgid vessels of the parts, which, though it does not damage the patient always, will continue still farther to confuse and embarrass the operation.

For the condition of things above described—and in many systematic works, the difficulties are more graphically amplified than in the above brief sketch—it is surprising, how little detail of directions is given for the operation. Some writers simply recommend "the old operation for aneurism," and, with a few additional directions, pass on to some other subject. Others complacently and tritely advise to "lay open the sac, turn out the clots, and secure both ends of the artery"—these teachers had certainly never operated—while John Bell, whose evident experience determined him to recommend baldness as better than caution, thus dashingly describes his operation—which seems to have been performed without a tourniquet—and which, in cases where pressure cannot be made, is perhaps the best that can be recommended:

"Run your bistoury upwards and downwards, so as to slit up the tumor quickly; plunge your hand suddenly down towards the bottom; turn out the great clots of blood with your fingers till, having reached the bottom entirely, you begin to feel the warm jet of blood; and, directed by that, clap your finger upon the wounded point of the artery; as
it has but a point, your finger will cover it fairly, and your
feeling of the artery assures you that all is now safe."

The objections to the above mode of procedure, in cases
where a more careful and deliberate operation can be per-
formed, are many. Most operators could not safely trust
themselves, especially in a first operation, to remove the pro-
tection which the pseudo-sac affords against the frightful he-
morrhage which would follow, and which would continue to
gush out while they pursued the search for the artery, if com-
pression is neglected, the finding of which, many occurrences
may present to interfere with.

In diffused aneurisms, situated in parts in which pressure is
impracticable or in such as are fed by small arteries, the bold
measure of John Bell, may be the best that can be adopted,
but those who have operated on these effusions know full well
that sometimes, even where pressure is used and no hemorrhage
embarrasses the surgeon, there is often an unavoidable amount
of delay in finding and securing the vessel which is apt to
disconcert the surgeon and materially deprecate the strength
of the patient and lessen his chances of ultimate recovery. It
must be recollected, that many patients who require the opera-
tion have suffered at least one, and perhaps several, exhausting
bleedings, and they can ill bear the additional loss of blood
as a part of the operation.

Others, however, and among them Vidal, Nelaton and
Frichsen, describe their several procedures with more par-
ticularity, recommending, very properly, as the first step in
the operation, either the careful application of the tourniquet,
or that efficient compression of some kind be exerted on the
main trunk leading to the vessel to be operated on.

Both Vidal* and Nelaton† recommend the female catheter
to be used in the operation; not, however, to re-establish the
track, and to make it available to the operator throughout the
whole process, but to be introduced into the mouth of the
upper and lower end of the severed vessel, for the purpose of
elevating them and separating them from the accompanying
vein and nerve. The ligature is passed over the vessel en-
circling the instrument, which is slipped out as the thread is

* Traite de Pathologie Externe et de Medicine Operatoire.
† Elemens de Pathologie Chirurgicale. Paris, 1844.
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tightened. Erichsen* recommends the use of a probe, to be used as a centre, on which to make the incisions. Too much minuteness, in our opinion, cannot be observed in the detail of description for every portion of this, sometimes, tedious operation; for no duty the surgeon has to perform requires more careful reflection, a closer study of each particular step, more forethought to anticipate accidents, or promptness in meeting them, than this one of ligation in diffused aneurism.

The Operation in Diffused Aneurism.—For the control of the circulation in the ligation of any large artery supplying a diffused aneurism, the fingers of an assistant should not be relied on whenever the tourniquet can be applied. This instrument should be applied with great care, and in cases where it is impracticable, two assistants should be assigned the care of the main trunk, that they may relieve each other in case of a prolonged operation. The surgeon having assured himself that all circulation has ceased in the limb, proceeds deliberately with the further steps of the operation.

Re-establishing the Track.—As we have shown in the ligation in simple arterial wounds, so, for a still greater reason, is it important to re-establish the original track of the ball in diffused aneurism. For this purpose, an ordinary probe is recommended by some—we prefer a female catheter; but in many instances it will be found too short to traverse the diameter of the thigh. A better instrument than either would be a straight steel sound, \( \frac{1}{2} \) of an inch in thickness and eight or ten inches in length. If the track is direct, the ball having penetrated the limb, the surgeon should pass the sound into that wound which is nearest the vessel, continuing it on till it emerges from the opposite wound, in its course breaking up the partial adhesion of the soft parts.

If the track is oblique or indirect the instrument should, in the same manner, be passed through its entire course, from one opening to the other. In case there is but one wound, traverse the course of the vessel as nearly as possible in the track of the ball.

In case the track is of the posterior-incomplete kind, having no opening anywhere in the neighborhood of the course of the vessel, the instrument should be passed as directed in case of the same track in simple arterial lesion, viz: through the full

extent of the wound, its point being pushed towards, or past the normal position of the vessel, and it being made to become prominent on the surface near the line of its course. If the ball has not approached near enough to the surface for this, the instrument must be pushed *towards* the line described.

The original track of the ball having been thus re-established by the introduction of the sound, which now represents it, the operator may consider the normal course and position of the vessel, which is the *other bearing* by which he is to arrive at the exact site of the arterial wound. He will recollect that if the sound has been properly introduced, and especially if there be two wounds, notwithstanding the ampullated area into which the track has been distended and the vast accumulation of both clotted and fluid blood which surrounds it in that cavity, his sound still coincides with at least one *plane of the vessel*, and, whether he cuts down *by the side of it*, as in both the direct and posterior-incomplete tracks, or *crosses it* with his incision, as in the transverse or oblique track, he must reach the plane of the vessel, and the close vicinity of the arterial wound, by arriving at the point where these two lines intersect—where the course of the vessel crosses the track of the ball.

*The Incisions.*—An assistant must see that the sound remains in the track, holding it if necessary. The normal position of the vessel being borne in mind, the incisions must coincide with the usual direction of the vessel, no matter what may be the amount of swelling produced by the accumulation. They should equal, if not exceed the limits of the tumor, in order to give free discharge to the clots and fluid blood, but more particularly to allow ample room for the operator to make the movements necessary to search for, expose and separate the wounded vessel. At the first cut, the skin and fascia overlying the tumor, should be divided; the second divides the aponeurosis, under which, generally, is found lying the clotted mass of blood and fibrine, irregularly moulded to the elevations and depressions of the surrounding organs. This forms the pseudo-sac of the aneurism. The external appearance of this mass varies somewhat in accordance with the length of time during which the sac has been forming; if but recent, the color of the outside is dark, like the clot of venous blood, but if the tumor has existed for some time, from two to five weeks, the color is changed by the accumulation of lymph.
upon its surface, effused from the surrounding structures with which the clot had been in contact.

Search for the Arterial Wound.—The sides of the wound must now be held widely apart with bent spatulas, so as to afford ample room for the operator. The mass of clotted blood should be broken into and the cavity reached. A large quantity of fluid blood will be discharged, notwithstanding the pressure on the main trunk. If the flow is rapid, showing that it is from the artery supplying the sac, an endeavor should be made to reach the orifice within the sac, so as to cover it with the finger, till the compression can be made effectual, the jet of warm blood will indicate its position. The clots should be removed, and the fluid blood sponged out by an assistant. The operator should, in direct tracks, follow the sound to the bottom of the cavity, and search there for the vessel, or somewhere along the length of that instrument. In transverse or oblique tracks he should seek the sound where it traverses the cavity, or on the floor of it, looking for the gapped or divided vessel running in a line across it. In most aneurisms, after the interior soft clots are removed, the more external portion of the tumor will be found laminated, increasing in density as we approach their periphery from within, which is apt to be formed, as before stated, by a layer more fibrinous than the internal ones. This laminated feature, like the fibrinous character, depends much upon the length of time the aneurism had been forming at the time of the operation. The last layer appears to be closely agglutinated to the surrounding tissues, so that when removed, there yet appears to be a quantity of the fibrinous clot still adhering, and the surfaces of muscles are covered with it, and the muscular tissue itself, deeply infiltrated and stiffened, and densified with the same agglutinating material.

The fibrine must be cleared away from the surface of the muscles with the handle of the knife—the inter-muscular spaces will thus be defined, and the edges of the satellite recognized. This must be raised, and the sheath containing the artery vein and nerve will be found either under it, or lying along its edge. The search will be made more particularly and with more confidence, in the immediate vicinity of the sound representing the track than elsewhere. Should neither the artery nor its wound present, the tourniquet should be relaxed for a moment; the pulsations will indicate the course
of the vessel within its sheath, and the bleeding will soon begin, revealing the opening in it. The sheath being recognized, the opening made by the projectile must be sought for, and the director introduced so as to open it both up and down for a few lines, when the ligature may be applied as in simple arterial lesion. The lower end is generally more difficult to secure, and its importance is such, that it is recommended by some, that rather than close the wound without tying it, even the actual cautery should be applied. It appears to us, however, that if we approach near enough to apply the cautery, we might continue our efforts and secure the vessel. The lower mouth is generally found open. The spots of greenish yellow fibrine, described by some excellent authorities as being found accumulated around the open ends of the severed vessel, serving to indicate their situation, we have never particularly observed in cases operated on by us, and cannot, therefore, undertake to estimate their value. Doubtless they will be found to assist those who have learned to distinguish them among the masses of clot and fibrine which are apt to be found, in all directions, about the wound and track, in even simple arterial lesion—and more abundantly in diffused aneurism.

Recapitulation.—Apply compression; introduce the sound; make an ample incision; clear the wound of clots and fluid blood; dilate with bent spatulas; seek first the portion of sound in contact with the vessel; look next for the satellite muscle, if any; next, for the sheath; then search for the opening in the sheath; relax the pressure if necessary; introduce the director, and divide the sheath carefully; now look for the wound in the vessel, not before; seize each end, and apply the ligatures.

Dressing.—Cold water may be used in the often, extensive wound left by the above operation; but we prefer that it be applied in form of a wetted pad laid on the wound. Adhesive straps should be applied to bring the edges in apposition to prevent wide gaping, to which these wounds seem much disposed. A roller is valuable for the compression it exercises; thus favoring the discharge of the extensive infiltrated clot, dissolving from among the tissues, and which discharge we have known to continue for more than a week, producing the impression that the hemorrhage had returned. After this, pure pus makes it appearance, and the wound
LIGATION OF PARTICULAR ARTERIES.

heals satisfactorily, but not by the first intention, or, at most, only in part.

Chloroform.—The administration of chloroform has not been referred to in any of the foregoing operations. Its value in all surgical operations is, with but few exceptions, so well established, that it was not deemed necessary to urge its applicability here. It may be suggested, however, that inasmuch as the subjects of hemorrhage are often more or less debilitated, and the operations, especially those at the seat of lesion, often prolonged and tedious, the administration of the anaesthetic should not be commenced till the surgeon is fully ready to begin; and if the search is unusually long and difficult, the application should be remitted at intervals, to allow a partial subsidence of its effects. We think that patients, in exsanguined and feeble conditions, are sometimes overwhelmed with the too free use of chloroform, which, under such circumstances, may seriously retard re-action after the arrest of the hemorrhage.*

THE LIGATION OF PARTICULAR ARTERIES.

In this second portion of the present chapter, we propose to describe, briefly, the ligation of the individual arteries wherever they have been found accessible to the efforts of the surgeon.

Any general system of descriptions must necessarily contemplate, as we have heretofore remarked, only ligation in the continuity of the vessel as the basis of the directions

* As, in the foregoing considerations, the deficiency of Data, on many unsettled points connected with hemorrhage, has been referred to, we may briefly suggest, the keeping of a SYNOPTICAL Record of all cases, in which shall be noted, among others, such as the following interesting particulars: Time elapsed between the receipt of the wound and the occurrence of consecutive hemorrhage; Condition of limb, or other part, at period of consecutive hemorrhage; Whether the ligation was performed at the wound, or in the continuity of the vessel; How the inflammation was affected, by reducing the supply of blood in the part, by ligation. The columns might be so extended as to include every fact in the history of each case worthy of registration, and Tables, similarly constructed, would be found to apply conveniently, to the statistical investigation of all other subjects in the domain of military practice. For the form of the SYNOPTICAL Record, see pages 90-91.
given. Ligation at point of lesion can only refer to special cases, either actual or supposed. We shall, however, keep constantly in view the more frequent accidents of the several vessels, adding such special descriptions as may be deemed useful.

The operations will be grouped in the following manner: Arteries of the Superior Extremity; Arteries of the Head and Neck; and Arteries of the Inferior Extremity.

**Arteries of the Superior Extremity.**

The artery which supplies the superior extremity continues as a single unbifurcated trunk from its origin, within the cavity of the thorax, to a point generally, a little below the elbow. The several portions of it have received different names, corresponding to the region through which it passes. That part of the vessel, which extends from its origin to the outer border of the first rib, is called the subclavian artery; beyond this point, to the lower border of the axilla, it is termed the axillary artery; and from the lower margin of the axilla, to the bend of the elbow, it is known as the brachial. The single trunk here terminates by dividing into the radial and ulnar, very similar in arrangement to that which is found to exist in the lower extremity.

**The Ulnar Artery.**—From the division of the Brachial, the ulnar artery runs downwards and inwards along the ulnar side of the fore-arm. Passing in front of the wrist between the two portions of the annular ligament, on the radial side of the pisiform bone, it enters the palm of the hand where it terminates in the palmar arch, anastomosing with the superficialis volae and radialis indicis of the radial. The line which the vessel describes is, first, a curve inwards from near the tubercle of the radius—marked in the living subject by the lower tendon of the biceps—to the junction of the upper and middle thirds of the ulnar, then directly downward to the pisiform bone.

**Relations.**—The artery is deep in the upper third of the fore-arm, being covered by the superficial layer of muscles, but in the lower two-thirds, it is superficial, being covered only by the integument and fascia, and by the tendon of its satellite muscle, the flexor carpi ulnaris, the muscle lying upon its inner or ulnar side. The ulnar nerve accompanies it,
on the inner side, for its lower two-thirds; at the wrist, it gets somewhat behind the artery. The venae comites, one on either side, accompany it throughout its whole course.

If wounded, the vessel should be ligated in any portion of its course. The three following portions are most frequently operated on:

I. AT THE WRIST.—The ligature is to be applied near the point at which the vessel terminates in the superficial palmar arch. (Plate II. Fig. 8.) This is not a desirable operation, unless the vessel is here wounded.

Operation.—The wrist being made prominent by extending the hand, a slightly curved incision of about two inches, concavity looking inwards, is made on the radial side of the pisiform bone, through the skin and superficial fascia. The strong tendinous arch thrown over the vessel from the pisiform bone should be divided on the groove director, and the artery isolated with the point of that instrument. The needle should be introduced from the ulnar side to avoid the nerve which lies somewhat behind the vessel.

Explanation.—Plate II. figure 8, Arteries: a, the artery; b, the ulnar veins; c, the ulnar nerve.

II. IN THE LOWER THIRD OF THE FORE-ARM.—The artery is here covered by the skin and the superficial and deep fasciae, and lies rather under the edge of the tendon of the flexor carpi ulnaris, with the nerve on its ulnar side and the flexor sublimis digitorum on its radial side.

Operation.—The arm is placed in the supine position, and the tendon of the flexor carpi ulnaris made prominent by extending the hand. An incision, about two inches in length, divides the skin and superficial fascia along the radial border of that muscle. The deep fascia being divided on a director, the tendon of the flexor carpi ulnaris will be seen and must be drawn to the inner side. The artery will be found between its accompanying veins in a common sheath and the nerve on its inner side. The needle may be introduced from the inner side, but it will be found more convenient to pass it from the radial side, as the vessel is overlaid by the muscle. Mr. Holmes* considers it a matter of indifference whether the venae comites are included in the ligatures or not. Flexing the hand upon the fore-arm, during the operation, will facili-

tate the isolation of the vessel and the introduction of the needle.

Explanation.—Plate II. figure 9, Arteries, represents the parts exposed in the operation: a, tendon of the flexor carpi ulnaris; b, the satellite veins; d, the artery between them; c, the skin; e, the cellular tissue.

III. IN THE UPPER THIRD OF THE FORE-ARM.—The tying of this artery in its upper third, where it is covered by the superficial layer of muscles of the fore-arm and the median nerve, is more difficult than either of the preceding operations. For a wound at this point, attended with serious hemorrhage, the operation should be performed without hesitation. Ligation of the brachial would fail, from its free anastomosis with the radial, in the hand, and also from that between its recurrent branches and the profunda arteries of the brachial. Both the upper and lower ends would be liable to bleed. This portion of the vessel makes a curve, with the convexity, towards the ulnar border, from near the tubercle of the radius to the border of the ulnar, at the junction of its upper and middle third; thence, it passes down on the ulnar side of the fore-arm. It is covered, near its origin, by the semilunar fascia of the biceps, and crossed, obliquely from within outwards, by one head of the pronator radii teres and the median nerve, and lower down, it is covered by the other muscles of the superficial layer. The veins accompany the artery, but the ulnar nerve is not in relation with this portion.

Operation.—Place the fore-arm in a state of forcible supination. A number of different incisions are advised in this operation; the one preferred is that which crosses the course of the artery at the region operated on and runs nearly parallel with the intermuscular spaces. This incision should be about three inches in length and situated about one-fourth the width of the fore-arm from its ulnar margin. This will fall very nearly upon the natural division which exists between the flexor carpi ulnaris and flexor sublimis digitorum, or, when the aponeurosis has been divided, the operator will easily find it. The incision should be extended low enough to reach the tendinous portion of these muscles, where the separation is distinct. The skin being drawn aside with hooks or bent spatulas, the surgeon continues the separation of the intermuscular space upwards, using the knife and director as he
approaches towards their origin, if necessary. Continuing
the separation outwards and working his way towards the
radial border of the fore-arm, he will find his finger beneath
the flexor sublimis and resting on the profundus. Upon this
last, the artery rests, about an inch and a-half from the ulnar
border of the fore-arm. The ulnar nerve will be first seen
near the border, running parallel with the bone; this will
assist in finding the artery. In searching for the vessel, the
operation will be greatly facilitated by flexing the fore-arm
moderately and the hand strongly, so as to relax the muscles
to be separated. When found, the artery should be, isolated
and the needle introduced from within outwards.

Explanation.—Plate II. figure 10, Arteries: a, shows the
flexor sublimis drawn outwards; b, the ulnar nerve, running
parallel with the bone at some distance from the portion of
the vessel operated on; c, the flexor carpi ulnaris drawn in-
wards, so as to expose the artery; d, the two vasa comites;
e, the ulnar artery.

In case of hemorrhage from a gun-shot wound, the incision
would, of course, be modified by the track of the ball. The
use of the sound, applied as directed in a former paragraph,
will be found to assist in reaching the opening in the vessel.

IV. Near its Origin.—"If the ulnar artery be wounded
near its origin, through the radial side of the pronator teres
muscle," says Mr. Guthrie,* "an incision should be made
through the integuments and the aponeurosis of the biceps
muscle; the pronator muscle, being then exposed, is to be
drawn inwards and downwards, or towards the ulnar, and the
dissection continued until the median nerve is brought into
view. The probe, introduced through the original wound,
will lead to the artery—the pulsation of which will be felt
and the bleeding seen. When the nerve crosses the artery,
the vessel will be found above, to the radial side of it and
to the ulnar side below. It may be tied above, without di-
viding a single muscular fibre; but at the point where the
nerve crosses, and below it, some fibres of the pronator teres
must be divided, and in some cases the whole of them, before
the artery can be properly secured by two ligatures; but this
division is of little or no consequence, as the muscular fibres
re-unite without difficulty."

The Radial Artery.—As has been seen, the brachial artery bifurcates near the coronoid process of the ulnar into the radial and ulnar arteries. The former of these, although the smaller of the two, runs more in the direction of the parent trunk. From its origin, the radial artery descends, along the radial side of the forearm to the wrist, nearly parallel with a line drawn, from the centre of the elbow to the base of the metacarpal bone of the thumb, immediately above which it winds round the outer surface of the carpus, descends a little beneath the extensors of the thumb, turns forwards, passes between the heads of the first and second metacarpal bones, and sinking deep into the hand, it becomes the deep palmar arch. The vessel is superficial throughout the greater portion of its course. In the upper third, it is overlapped by the convergence of the pronator radii teres and supinator longus, which latter muscle accompanies the vessel on its radial side, from the elbow to the wrist, and is considered its satellite. It has two venae comites; but the radial or musculo-spiral nerve is in relation with it on the outer side, only in its middle third. It can be reached anywhere in the forearm without the division of muscular fibres; ligation is usually described, however, in but three places.

I. At the Wrist.—At this point, the vessel winds round the outside of the carpus and crosses the external lateral ligament of the wrist; then passes under the tendons of the extensor metacarpi and primi internodii pollicis, between which and the tendon of the extensor secundi internodii it may be felt during life. The vessel may be tied at several points in this restricted region; near the styloid process of the radius, while between the extensor tendons of the thumb—“surgeon’s snuff-box”—or just before it dips into the palm between the two heads of the abductor indicis. None of the operations are advisable unless the vessel be wounded and bleeding at one of these points. As an expedient for arresting hemorrhage from the palmar arches, it is unreliable—first, on account of the large inosculatio between the radial and ulnar; and, secondly, because the superficialis volae—often a considerable branch—is given off above this region and would continue to supply the bleeding vessel after the ligation. We here describe one of these ligations—at the commencement of the palmar arch:

Operation.—Determine the position of the tendon of the
LIGATION OF RADIAL ARTERY.

*extensor secundi internodii* by producing forced extension of the thumb; make an incision, little over an inch in length, along its inner border and parallel to it. The centre of this incision should correspond with the proximal end of the first interosseous space; by dividing the deep fascia on a director, the artery will be exposed as it passes through the first interosseous space to reach the palm of the hand. Two veins accompany the artery. Isolate the artery with the needle or the director, and pass the ligature beneath it. Bringing the hand somewhat toward the radial side will facilitate the latter part of the operation.

Explanation.—Plate II. figure 11, Arteries: *a*, the extensor ossis metacarpi pollicis drawn inward to expose the vessel; *d*, the extensor secundi internodii drawn outwards; *c*, the artery exposed, with a ligature passed under it; *b*, venae comites.

II. IN THE LOWER THIRD OF THE FORE-ARM.—This is, perhaps, the ligation most easily performed in the whole body. The artery just above the wrist, and for some distance up the fore-arm, is superficial, covered only by the integument and the superficial and deep fasciae. It lies between the tendons of the supinator longus and the flexor carpi radialis, each of which is considered its satellite muscle. Its venae comites lie on either side of it; but the radial nerve is not in relation with it, having diverged from it, four inches above the wrist, and passed under the supinator, to reach the posterior aspect of this region. The pulsations are easily detected—it is "the pulse."

Anomalies.—One of the anomalies of the radial, pertaining to this region, is so frequent, that it deserves mention, as it might cause embarrassment if not remembered. This vessel not unfrequently deviates from its normal course down the lower third of the fore-arm and winds over the radius, two or three inches above, the original course of the artery being continued by the superficialis vole, a small branch comparatively. In case such an anomaly should exist, and the object was to ligate the radial for bleeding in the palm, the operation would, of course, fail, by the true vessel escaping ligation.

Operation.—The arm should be supinated. The line of the vessel may be traced along the inner margin of the tendon of the *supinator longus*, where the pulsation may be felt. In the groove between this tendon and that of the *flexor carpi*
radialis, the skin may be carefully divided for about two inches. The superficial veins and nerves crossing the wound should be drawn aside, and the fasciae divided on a groove director. The sheath of the vessel being exposed, it is carefully divided, the artery isolated, and the ligature passed from within outwards.

Explanation.—Plate II. figure 12, Arteries: a, the deep fascia divided and drawn aside; e, the artery with the ligature passed under it; b, the vena comites; d, intended for the nerve, is an error of the cut from which the present has been taken; there is no nerve in that place.

III. In the Upper Third of the Fore-Arm.—In the upper third of the fore-arm the radial artery is deeply seated, being overlapped by the belly of the supinator longus on the outer side, rather overhung by that of the pronator radii teres on the outer side. It can be reached, however, without the division of any muscular fibres. It is covered by the superficial and deep fasciae, and, with its vena comites, rests upon the supinator brevis and lower portion of the pronator radii teres. The radial nerve has not yet joined the artery, and is, therefore, not interested in the operation. In making the incision, the median vein, which passes over it, should be avoided if possible.

Operation.—To expose the vessel, make an incision along the inner border of the supinator longus, of three inches in extent, beginning near the middle of the bend of the arm. The line of incision may be made plain by putting the supinator in action in flexing the fore-arm. This will divide the skin and superficial fascia. It would be safer to divide the deep fascia on the groove director, and to pursue the isolation of the artery afterwards without the edge of the knife; ordinarily, the beating of the vessel will lead to its exact location. The supinator must be drawn slightly outward to expose the artery. The ligature is passed indifferently from without or from within.

Anomalies.—The radial, it will be remembered, is subject to anomalies of origin and course. In the observation of Professor Quain, the high division of the brachial occurs in one case out of five, the vessel dividing anywhere between the armpit and its normal point of bifurcation below the elbow. The radial is not always deep seated, as above described, but varies much in this respect; it is even sometimes found on
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the outside of the aponeurosis for a great portion of its course; fortunately, when this is the case, it can be detected. Much circumspection is necessary in operations upon this vessel on account of these various anomalies.

Explanation.—Plate III. figure 13, Arteries, is a greatly improved copy of the original which misrepresents the operation; a, intended to represent the supinator longus drawn aside; b, is the artery exposed, with the ligature under it.

The Palmar Arches.—It has been seen that, the ulnar artery, after passing the outer side of the pisiform bone, runs into the palm of the hand upon the tendons of the superficial flexor, and is covered by the palmaris brevis and palmar fascia; that it crosses the hand towards the radial side, to unite with a branch of the radial, forming the superficial palmar arch; and further, that the radial artery also dips between the first and second metacarpal bones, to form the deep palmar arch, which rests upon the metacarpal bones and interosseous muscles, being covered by the flexor tendons of the hand, and freely communicating with the ulnar artery by a large inosculating branch. Whenever either of these arches are wounded, ligation of either, the radial or ulnar, has been found inadequate to arrest the bleeding, on account of the perfect community of circulation, established through them, in all the vessels of the hand and forearm.

Operations in the palm, with a dread that seems to be traditional, are deprecated by most writers, on account of the large number of nerves and tendons and of the thick fascia of the part. Tying both, the radial and ulnar, has been resorted to, often without success, on account of the free supply by the interosseal artery; till finally, it is recommended, to ligate the brachial in case the bleeding cannot be suppressed by pressure. This is objected to by Mr. Guthrie, except after efforts have been made to reach the wounded artery in the palm. “When there is a large open wound, and the bleeding end or ends of the vessel can be seen, a ligature should be applied on each.” When the search has been made by incisions, such as the nerves and tendons will allow, and we fail to find the bleeding point, he directs, that pressure at the wrist, on first one and then the other artery, be made, in order to detect the point of lesion. All the coagula should then be removed, “when a piece of lint, rolled tight and hard, but of a size only sufficient to cover the bleeding point, should be
laid upon it. A second and a larger hard piece should then be placed over it, and so on, until the compresses rise so much above the level of the wound, as to allow pressure to be continued and retained on the proper spot, without including the neighboring parts."

Operation.—If the gradual compression above recommended, together with due pressure on the radial and ulnar arteries at the wrist, should fail to arrest the bleeding from the wound in the palm, the same author advises that, the two muscles, forming, what may be called the web, between the thumb and fore-finger, should be divided, until the wounded artery can be seen. "If a man in opening an oyster," says he, "were to divide these muscles, by an accidental thrust of his knife, it would not be considered a serious accident, and yet, some surgeons are dismayed if desired to divide them surgically, to expose this artery at the spot where it has been wounded."

The Brachial Artery.—This vessel, the continuation of the axillary, commences at the lower margin of the teres major and latissimus dorsi muscles, it passes downwards, forwards and outwards, lying first on the inner surface of the arm, then on its anterior surface; it descends below the elbow joint, where it sinks into a triangular fossa, bounded by the supinator longus and pronater radii teres, and terminates opposite the coronoid process of the ulna, by dividing into the radial and ulnar arteries. Throughout its entire course, the vessel is superficial, being covered only by the integuments and brachial aponeurosis. It rests successively on the triceps, coraco-brachialis, brachialis anticus and tendon of the biceps. To the inner side, is the internal cutaneous and ulnar nerve; to the outer side, the coraco-brachialis and biceps muscles. It is crossed very obliquely by the median nerve which rests upon it during most of its course, but gets to its ulnar side at the elbow. It has two venae comites in its sheath, and the basilic vein also corresponds with its course. Ligation at three points may be described:

I. At the Elbow.—In front of the elbow is a triangular space formed externally by the supinator longus and internally by the pronator radii teres. The brachial artery runs through the middle of this space, resting upon the brachialis anticus, having the median nerve half an inch to its inner side, and the tendon of the biceps on its outer side. It is covered by the skin and superficial fascia and is separated from the median
basilic vein by the semilunar aponeurosis of the biceps. The tendon of the biceps is our satellite at this point; the artery on its inner side.

Operation.—An incision, a little over two inches in length, will be made along the internal edge of the tendon of the biceps, inside the median basilic vein. This divides the skin; then carefully lay bare and put aside the vein which rests upon that aponeurotic expansion of the tendon of the biceps called its semilunar fascia. Make an opening into this carefully; introduce the groove director and divide the aponeurosis to the extent of the first incision. This exposes the tendon of the biceps, sinking deeply into the triangular space heretofore described; feel on its internal edge and the artery will certainly be perceived on the loosing of the tourniquet. It has a satellite vein on either side, and the median nerve is a quarter or half an inch towards the ulnar side. Now flex the fore-arm a little to facilitate the isolation and introduction of the needle, and then pass the ligature from within outwards, excluding the satellite veins. If the incision should be made about two inches higher up, it must be recollected that the median nerve is here in contact with the artery resting upon it, somewhat to its internal side.

Explanation.—Plate III, figure 14; c, the deep fascia; c, the tendon of the biceps; a, the artery at the inner side of the tendon, with the ligature passed under it; b, the median nerve; d, the skin.

II. IN THE MIDDLE OF THE ARM.—The vessel lies in the upper portion of its course to the inner side of the coraco brachialis; lower down, on the inner side of the biceps, being somewhat overlapped by it. The median nerve lies along the external and anterior side of the artery, and being exposed, is one of the best guides to the vessel after the aponeurosis is incised. The "directing line" given by Sabatier for the whole vessel is from the middle of the axilla to a point just within the middle of the elbow. The vessel is sufficiently superficial to feel its pulsations in the living subject, which is always a valuable guide.

Operation.—Place the patient in a recumbent posture with the arm abducted and rotated outwards, make an incision about three inches long, in a line with the inner edge of the biceps muscle, through the integuments and superficial fascia, taking care to avoid, as much as possible the superficial ves-
sels and nerves; cut through the aponeurosis on a director and separate the artery from the median nerve which will be found here, lying somewhat above and in front of it, and from the vena comites. The vessel is secured in the usual manner.

Explanation.—Plate III. figure 15; d, the biceps muscle drawn aside to expose the artery; b, the median nerve drawn up with a blunt hook; c, the artery; a, the vena comites.

III. IN THE UPPER THIRD OF THE ARM.—The vessel, as we have seen here, lies to the inner side of the coraco-brachialis muscle, and somewhat upon its brachial attachment. The median nerve is on its outer, and the ulnar nerve on its inner side. The other relations are not altered.

Operation.—The incisions, made as in the last operation, are carried along the inner border of the coraco-brachialis muscle for about two and a half or three inches. The vessel should be isolated with the needle or director and the ligature passed so as to exclude everything but the artery.

Anomalies.—As the brachial artery frequently divides high up in the arm, into the radial and ulnar arteries, it may happen that the operator, in performing any of the preceding operations, will meet with two vessels running parallel, or may possibly meet with but one, and that perhaps, the vessel which does not require the ligature. This will remind the surgeon of the necessity of ascertaining always, by compressing it between his fingers, previously to tightening his ligature, whether the vessel, he is about to tie, commands the bleeding or aneurismal pulsation, as the case may be. Should it do so, the artery may at once be secured. In this anomaly it may be necessary to tie both vessels as they frequently communicate by a transverse branch in their course down the arm, which would render the tying of one, perfectly useless.

In the arm, much more even than in the lower extremity, does the necessity always exist of tying the wounded vessel at the seat of lesion with two ligatures, one to the upper and one to the lower end of the open artery. The anastomosis in the upper extremity is so abundant that there is scarcely ever any danger that the nutrition of the limb will not be kept up, but on the other hand, in case of a bleeding wound, or even in true aneurism, ligation in the continuity of the vessel, is apt to fail on account of the too abundant collateral circulation, establishing a refluent stream, which in the case of the wound,
flows out of the lower end, and in the case of aneurism prevents the changes necessary for its cure. In several cases of secondary hemorrhage, in which the Hunterian operation was chosen with the view of controlling the inflammation in the fore-arm and hand, all but one of the operations was followed by recurrent hemorrhage. In primary hemorrhage the brachial artery should never be tied except at the seat of lesion.

The Axillary Artery.—The axillary artery, the continuation of the subclavian, commences at the lower margin of the first rib, from which it passes downwards, outwards and backwards, across the axilla and along the inner and upper part of the arm, until it arrives at the lower margin of the tendons of the teres major and latissimus dorsi muscles, where it becomes the brachial. In this course, it forms a curve, the convexity of which is turned upwards and outwards. It is closely accompanied by the axillary or brachial plexus of nerves, and by the axillary vein, which last lies, at first to the inner side, and then in front of the artery, obscuring it from view. Near the middle of the axilla, it is embraced by the two heads of the median nerve. The vessel is crossed in its course by the narrow portion of the pectoralis minor muscle, passing to its coracoid attachment. This has resulted in its division, for the purposes of description, into three portions, viz: 1st, that above the lesser pectoral muscle, and just below the clavicle; 2d, that under or behind the muscle; and 3d, that below the lesser pectoral muscle. This vessel may be tied in its first and third stages only, either for the cure of aneurisms, or in cases of wounds in these situations.

I. Below the Pectoralis Minor.—In this portion of its course the axillary artery extends from the lower edge of the pectoralis minor to the inferior edge of the latissimus dorsi and teres major tendons. It here rests on the insertion of the subscapularis muscle; and below this, on the tendons of the latissimus dorsi and teres major; a plexus of veins covers it, as in the second stage, the axillary vein lying in front of the artery, and the branches of the brachial plexus of nerves are related to it as follows: to its outer side are the median and external cutaneous; to its inner, the internal cutaneous and ulnar; and behind it are the musculo-spiral and circumflex nerves. It is covered by the integuments and pectoralis major
muscle, and may be exposed from the axilla, by cutting through the integuments and axillary fascia only.

Operation.—Place the patient in the recumbent position, with the arm rotated outwards, raising it from the side; make an incision in the line of the artery, about three inches in length, through the integuments and fascia, and opposite the head of the humerus, between the folds of the axilla, but a little nearer to the posterior one; tear cautiously through a quantity of loose cellular tissue, and the axillary vein or veins, with the branches of the brachial plexus of nerves, will be exposed, concealing the artery. Great caution must be used now in isolating the vessel, to avoid wounding the vein which lies before it, and is the first object which meets our view. The vein must be pushed backwards with the brachial plexus. The median nerve must then be sought for, and on the inner side or beneath it, the artery is found. The pulsations of the vessel are valuable in guiding to its position. In order to isolate the artery, the elbow must be bent so as to relax the nerves, and permit their more easy separation from the vessel. The needle must be passed from behind forwards. In case any small arterial branches are cut in the first incision, they should be tied, or torsion applied, to prevent embarrassment to the surgeon.

Explanation.—Plate III. figure 16, Arteries: g, the coracobrachialis muscle; b, the skin divided; a, the axillary vein; c, the median nerve; e, the internal cutaneous nerve; d, the ulnar nerve; f, the artery.

II. Below the Clavicle.—This operation is frequently improperly referred to as ligation of the subclavian below the clavicle. It is properly ligation of the axillary in its first stage. As the number of gun-shot wounds of the shoulder has been found to be great, the necessity for ligations of the axillary is therefore frequent. The present operation requires deep cutting, but when the vessel is wounded in this portion of its course, ligation of the subclavian above the clavicle, though an operation so much easier, will not answer the purpose of restraining the hemorrhage. In its first stage, the artery lies above the pectoralis minor muscle, and is covered by the great pectoral and a dense fascia, the costo-coracoid membrane from which the vessel emerges, as it passes from under the clavicle. It is separated from the pectoralis major by a layer of adipose tissue containing numerous small veins
and arteries. The axillary vein is situated in front and to the inner side of the artery, but is not in immediate contact with it in this portion of its course. More superficially the cephalic vein passes upward in the intermuscular space between the deltoid and pectoralis major, crossing the axillary artery just above the superior border of the pectoralis minor, and empties into the axillary vein. The nerves of the brachial plexus lie behind and somewhat above the artery; the superficial thoracic nerve crosses the course of the artery, sometimes in front and sometimes behind, to be distributed to the pectoralis major muscle.

Explanation.—Plate IV. figure 17, Arteries, is a representation of the surgical anatomy of the region above described, taken from the work of MM. Bernard and Huette. A portion of the clavicle has been sawn through, and the upper part of the pectoralis major cut away to expose the vessel and its relations; j, the pectoralis minor muscle; i, the pectoralis major cut away with a portion of the clavicle; a, the suprascapular artery, a small branch of the subclavian, crossing the base of the neck and brachial nerves just above the clavicle; b, the brachial nerves; c, the brachial plexus; h, the axillary vein on the inner side of the artery, with the cephalic vein emptying into it; g, the axillary artery, as it emerges from under the clavicle, with the vein in front and the nerves behind it; f, the sterno-mastoid muscle, with the external jugular vein passing down over its surface; d, the omo-hyoid muscle.

Operations.—Four methods of performing this operation have been in practice. 1st, the ordinary method of cutting through the pectoralis major, by a nearly transverse incision; 2d, Desault's method; 3d, Lisfranc's method; and 4th, Chamberlayne's method.

1st. The Ordinary Method.—The muscles of the shoulder being perfectly at rest, the elbow slightly separated from the trunk, and the head inclined to the opposite side, an incision, three inches in length, is made about three-quarters of an inch below the clavicle, and parallel with it. This incision divides the skin, platysma and subcutaneous cellular tissue, and extends from the septum, between the deltoid and pectoralis major, to within two inches of the sterno-clavicular articulation. The muscular fibres of the pectoralis major are successively divided and pushed aside, till the posterior fascial
investment of this muscle is brought into view. The shoulder should now be depressed to favor the separation of the edges of the wound, and the fascia torn through with the point of the director. When the finger is now introduced into the wound, to press downwards and outwards the pectoralis minor, by feeling carefully, the following parts will be recognized: 1st, the axillary vein distended with blood; 2d, the axillary artery pulsating, farther on the outside and behind the vein; the nerves of the brachial plexus, still higher up and farther behind; the needle is introduced between the vein and the artery, and it is important that the vein should be pressed to the inner side with the finger, in order that it may be protected from injury from the point of the director or needle.

Malgaigne thinks this is one of the most difficult of all ligations. Dupuytren was obliged to tie, on one occasion, twelve or thirteen small vessels before he reached the axillary artery. Many of these small vessels, however, though they spirt freely when first cut, cease bleeding if compressed, for a little while, between the finger and thumb. In extirpation of the mamma they seldom require ligation.

2d. Desault's Method.—This has been modified by Delpech in which form we here present it. Lay the patient on his back, with his arm separated from his body, at an angle of about 45 degrees; make an incision through the integuments two inches and half long, commencing beneath the clavicle, at theunion of the external and middle third, and descending obliquely towards the humerus in the direction of the intersticementioned in the last operation. Separate and strongly draw apart, the deltoid and pectoralis major, and the pectoralis minor will be exposed, divide it completely near its insertion into the coracoid process. Then carry the index finger to the bottom of the wound and follow the surface of the serratus magnus until stopped by the seapula; then bring back the finger bent, pressing it between the subscapularis and the entire mass of nerves and vessels and raise them on it to the surface of the wound. The artery is seen at once, exposed just before it passes between the roots of the median nerve, having the vein on its internal side and almost all the plexus on its outer side. It is now easy to press the director or needle under it. In this operation, we must look for the superior thoracic artery, the first branch of the axillary, which passes in front of the pectoralis minor, to the walls of the
chast, and secure it either before or after its division, as its bleeding would embarrass the operation.

3d. Lisfranc's Method consists in giving an oblique direction to the incision downwards and outwards, following the interstice between the sternal and clavicular portions of the pectoralis major, the arm being strongly abducted to make the depression more apparent. This plan has the advantage of not dividing any of the fibres of either muscle, but it is said not to expose the artery high enough up, which renders the operation difficult. It is also suggested by Malgaigne that the contraction of the pectoralis major would prevent the free discharge of pus, and favor the formation of abscesses and sinuses.

4th. Chamberlayne's Method.—Make an incision three inches in length below the clavicle, and join it by another of the same extent, corresponding with the intermuscular space between the deltoïd and pectoralis major. It will be seen that this method unites the incision of the ordinary method, viz: make the first incision three-quarters of an inch below the clavicle, beginning two inches from its sternal end and terminating at the muscular interspace between the deltoïd and pectoralis major—make the second incision three inches in length along the muscular interspace between the deltoïd and pectorals major. The result of these two incisions is a triangular flap which is turned downwards in proceeding with the operation. The clavicular portion of the pectoralis major being detached in this flap, and the cellular tissue overlying the vessels torn through, the search should be made first for the vein which is most anterior—this is the infallible landmark—drawing the vein gently inwards we find the artery pulsating to the outer side and a little behind it. The nerves are seen still further outwardly and further still, behind the artery. The needle, of course, is introduced between the vein and artery, avoiding the nerves lying behind the latter.

Explanation.—Plate IV, figure 18, arteries, is intended to represent Chamberlayne's operation. The line of incision, however, does not correspond with our description, $g$ and $b$; the clavicular portion of the pectoralis major cut through and detached and turned down; the cellular tissue being torn through $c$; the pectoralis minor is exposed also; $d$, the margin of the deltoïd muscle; $e$, the axillary artery, with $a$, the vein, lying in front, and $f$, the brachial nerves, lying outwardly and behind.
As Applied to Wounded Arteries.—Of the four methods described, Chamberlayne’s will be found most frequently the preferable operation. The double incision exposes the vessel better and affords room for the movements necessary to introduce the ligature. In any of the methods, the operator will find great advantage in the use of bent spatulas to draw the lips of the wound apart, and that changing the position of the limb in the several stages of the operation, will relax the muscles and facilitate the isolation of the vessel and the introduction of the needle. In gun-shot wounds it is well to consider in each case, before the operation begins, the possible necessity, as the procedure advances, of having to modify its method, on account of the development of the individual character of the wound. Thus, an operation, begun on Desault’s method, with the incision along the intermuscular space, may be changed to Chamberlayne’s by adding the horizontal incision of the ordinary method; and so, the ordinary method, after being begun, may be also changed to Chamberlayne’s by adding Desault’s incision along the line above mentioned. Again, we may find, after removal of the clots form a diffused aneurism in this region, that the wound is below the pectoralis minor; in that case the division of the muscle, as described in Delpech’s modification of Desault, may be found necessary to get at the wound. It must be recollected, as we have said in the first portion of this chapter, that all these descriptions refer to ligations for true aneurism, somewhere below the point of ligation; when they come to be applied, in the case of arterial lesion, or still worse, in the cure of diffused aneurism, the altered circumstances may embarrass and disconcert the operator, unless he has maturely deliberated on all the possibilities of the operation he has gone into. Balls which wound the axillary artery most frequently pass through the shoulder, making a complete track. When this is the case, the surgeon can have the advantage of the introduction of the sound, as recommended on page 123, to re-establish the track in the same manner as though the missile had passed through the limb lower down, or through the thigh or leg. In case of wounds, there will be found large quantities of clot and matted tissues about the vessel, which will obscure and confuse the parts, to an embarrassing degree. The surgeon should secure the most intelligent and reliable one of his assistants, to compress the subclavian artery.
as it passes over the first rib, and in case the compression cannot be made effectual without it, it has been recommended by some to make an incision above the clavicle, as if to expose that vessel so as to allow the finger to come in contact with it. This certainly cannot often be necessary.

The Subclavian Artery.—The subclavian artery arises on the right side, from the arteria innominata, opposite the sterno-clavicular articulation; and, on the left, from the arch of the aorta; these two vessels, therefore, necessarily differ, in the first part of their course, in their length, their direction, and their relation to surrounding parts. These differences will be considered, when necessary, in connection with the description of the several operations. The vessels ascend from their respective origins, pass between the scaleni muscles, and curving in the form of an arch, cross the first rib, at the lower border of which, they take the name of the axillary arteries. This short trunk has been divided, for the purposes of description, into three stages: the first or ascending, extends from the origin of the vessel to the inner border of the scalenus anticus muscle; the second or transverse, or middle stage, is the portion of the vessel which lies between the scaleni muscles; while the third or descending stage, extends from the outer border of the scalenus anticus muscle to the lower margin of the first rib, when the vessel terminates in the axillary artery. It has been ligated in each one of these three stages.

I. Outside the Scaleni Muscles.—In its third stage, the subclavian artery lies in the posterior inferior triangle of the neck, bounded by the omo-hyoid muscle externally, the sterno-mastoid and scalenus anticus muscles internally, and the clavicle inferiorly; it is covered only by the integuments, platysma and a quantity of cellular membrane, which contains several branches of the cervical and brachial plexus, the subclavian, external jugular, and other veins, and the transversalis colli and humeris arteries; it rests on the first rib, which separates it from the pleura; the brachial plexus lies above and posterior to it; the subclavian vein lies anterior and inferior to it.

Operation.—This portion of the artery is the most favorable for the application of the ligature. To secure it in this situation, place the patient in the horizontal position, with the
head and neck turned towards the opposite side, and the
shoulder depressed as much as possible; the skin over the
parts being drawn down upon the clavicle, so as to have a
firm surface to cut upon, make an incision along the clavicle,
commencing at the outer edge of the sternomastoid muscle,
or a little internal to the centre of the bone, and terminating
near its acromial end at the anterior border of the trapezius
muscle; in this, the integuments, platysma, and a few of the
supra-clavicular branches of the cervical plexus will be divided.
A quantity of loose cellular tissue is now exposed, filling the
posterior inferior triangle of the neck; in this are contained
some branches of the cervical and brachial plexuses, lymphatic
glands and a number of small veins, crossing from the poste-
rior part of the neck, to terminate in the external jugular
vein, which lies close to the outer margin of the sternomastoid
muscle. Tear through the cellular tissue, taking care to
avoid, if possible, the several parts just mentioned, especially
the external jugular vein. In some subjects, the clavicular
portions of the sternomastoid muscle encroaches on the space,
and will require partial division.

On continuing the dissection more deeply, the omohyoid
muscle will be brought into view, crossing the upper part of
the space; this being drawn upwards, the subclavian vein
and transversalis humeri artery will be exposed in the base
of the triangle, and the transversalis colli artery in its apex;
separate these parts, and expose the outer edge of the scalenus
anticus muscle; pass the finger downwards along this, and it
will thus be conducted to the subclavian artery, where it rests
on the upper surface of the first rib. As the brachial plexus
lies in close contact with the artery, it is possible that one of
its branches, and most likely the central one, from its running
a long course before it joins the plexus and from its proximity
to the artery, may be mistaken for the subclavian artery.
Detach the artery from its surrounding connections, and pass
the aneurism needle from below upwards and a little from
within outwards. Sometimes it is difficult to pass the needle
in this direction from the position of the clavicle; it may then
be passed in the contrary direction. Throughout the opera-
tion, the subclavian vein must be remembered and carefully
avoided, both in making the incisions and in introducing the
ligature. After the first incision, the knife should be aban-
LIGATION OF SUBCLAVIAN ARTERY.

Doned, and the operation continued with the handle or the director as much as possible; if the knife is required at all, it should be used only on the groove director.

If the external jugular is cut, it must be pressed by the fingers of an assistant at both ends for a while, till the bleeding is arrested, or ligatures may be applied, to be removed after the operation is completed. The upper end is apt to bleed profusely, and a greater danger attends the lower end, which being open, air is sometimes drawn through it into the heart, when the patient dies instantly.* Should the transversalis humeri or colli artery be wounded, they should be sought for and tied at once, for their bleeding would not only embarrass the operation, but weaken the patient—they are of considerable size.

Explanation.—Plate IV. figure 19, Arteries: a, the brachial plexus, above and behind the artery; b, the artery; c, the subclavian vein, in front and somewhat below the artery; d, the border of the scalenus muscle, with the artery emerging from behind it—the vein should have been represented in front of the muscle; e, the external border of the sterno-mastoid muscle. Figure 17, on the same plate, represents a dissection of the parts, together with a portion of the axillary artery, the clavicle being sawn away.

Different Methods.—The operation we have described is very nearly that recommended by Lisfranc. He recommended the division of the external portion of the sterno-mastoid, and advises that the external jugular should be drawn inwards, with a blunt hook, to keep it from being injured. The tubercle of the first rib is his "rallying point" in finding the artery—we prefer the scalenus anticus, which conducts us to it—the elevation on the rib is occupied by the insertion of the muscle, and cannot always be felt. Roux has proposed an incision perpendicular to the clavicle, Marjolin, a \( L \) incision with the base inferior, and Physic a \( V \) incision. The operation described above, besides the great advantage of simplicity, we

*We witnessed the death of a valuable horse, some years ago, from this cause. The ordinary phleane not being at hand, a thumb lancet was used, which, in passing out, opened the orifice, or elevated one edge of it—a peculiar gurgling was heard for a moment, when he fell down and died instantly, from the air being sucked into the right auricle of the heart.
have found it to expose the vessel sufficiently to answer all useful purposes.

II. BETWEEN THE SCALENI.—In the second or middle stage, the subclavian artery rests on the scalenus medius muscle and the cone of the pleura; the brachial plexus lies above and posterior to it; in front of it are the integuments, platysma, sterno-mastoid and scalenus anticus muscles; on the anterior surface of this last are the subclavian vein, the transversalis colli and humeri arteries, and the phrenic nerve, which runs parallel with and in front of the scalenus anticus muscle.

Operation.—The patient must be placed as in the preceding operation. Make an incision about three inches long and a little above the clavicle, commencing at a short distance from its sternal end; divide the integuments, the platysma, the fascia, and the clavicular portion of the sterno-mastoid muscle, the last on the director; the subclavian vein, transversalis colli and humeri arteries are exposed; and the phrenic nerve on the anterior surface of the scalenus anticus muscle. These several parts having been drawn out of the way, pass a director behind the scalenus anticus muscle and divide it; the subclavian artery will now be brought into view; pass the aneurism needle from below upwards, taking care to avoid the cone of the pleura, which lies behind the artery, and the brachial plexus of nerves.

III. WITHIN THE SCALENI.—The difference in origin, length and direction in the arteries of the two sides has given rise to a corresponding diversity in the relations of their first portion. The first portion on the right side is in relation in front with the internal jugular and vertebral vein, and is crossed by the pneumogastric nerve, phrenic nerve, and one or two branches of the sympathetic. Behind and beneath, it is invested by the pleura, is crossed by the right recurrent laryngeal nerve, and is in relation further back with the sympathetic nerve, longus colli muscle, and transverse process of the seventh cervical vertebra. The first portion on the left side is in relation in front with the pleura, internal jugular vein, vena innominata, and pneumogastric and phrenic nerves, which lie parallel to it. To its inner side is the left carotid artery, trachea, oesophagus and thoracic duct; to its outer side, the pleura; and behind, the oesophagus, thoracic duct, longus colli and vertebral column.
The chief points of difference may thus be summed up: the right arises from the arteria innominata, the left from the arch of the aorta; the right is larger but shorter than the left, is more superficial and takes a more transverse course, and differs in its relation to the par vagum and vena innominata; the left only is related to the thoracic duct and oesophagus and is more closely connected with the pleura.

This operation on both the right and left side has been almost abandoned by the profession, even for aneurism, on account of the small space allowed on the right side for the formation of the occluding clot, and the almost insurmountable difficulties presented on the left, in the isolation of the vessel. Brasdor's distal ligation is recommended in cases of aneurism when ligation in the first stage is debated, so difficult has the operation been found, and so uniformly fatal has been the result. In the case of gun-shot wounds, it is not probable that our surgeons would have the trying opportunity of ligating the first portion of either the right or the left subclavian, as any wound which would involve this portion of the artery would be so speedily fatal, generally, as to allow no time for such an operation; indeed, we know of but one contingency under which the military surgeon might have to consider the necessity of operating on the subclavian artery within the scaleni as a consequence of any of the casualties of battle; that is, in case a ball, in passing through this portion of the body, should brush or graze the artery somewhat beyond this place, so as to weaken its coats and give rise to the formation of a circumscribed traumatic aneurism. Even in this rare case, we would not advise the operation. Brasdor's plan to ligate beyond should be here applied to the third portion of the subclavian, or, if it should be on the right side, even ligation of the innominata, hopeless as it is, would be a preferable operation. Here, however, are the directions as we have condensed them from one or two systematic works, for the guidance of any one who may conceive it his duty to perform either of these operations:

Operation on the Right Side.—The patient is to be placed upon his back, with his chest moderately elevated, his head turned to the opposite side, and the shoulder carried downwards and backwards as much as practicable, in order to make tense the skin fascia and muscles. Make an incision about three inches in length along and a little above the clavicle,
commencing at its sternal end; from the inner extremity of this, carry another along the external margin of the sterno-
mastoid muscle to the extent of about two inches and a half; in these incisions, the integument platysma and fascia are di-
vided; raise a triangular flap so as to expose the lower part of the sterno-mastoid muscle, behind which pass a director and cut through it; the sterno-hyoid and sterno-thyroid are now exposed, with a few branches of the descendens noni nerve; they may be divided in like manner, and drawn in-
wards. By a little farther dissection, the right vena innomi-
nata, formed by the junction of the internal jugular and sub-
clavian veins, is exposed. Tear through some cellular sub-
stance found here and the artery will be brought into view. Now draw the par vagum, recurrent nerve and the sympa-
thetic filaments to the inner side, (if they are drawn to the outer side the recurrent nerve will certainly get under the ligature,) depress the vena innominata towards the thorax, and pass the aneurism needle from below upwards, taking care to avoid the parts which lie behind the vessel. It is seldom that the phrenic nerve is exposed in performing this operation, as it lies either on or close to the scalenus anticus muscle. There is only a space of about three quarters of an inch between the origin of the vessel and the place where it gives off its branches, where the vessel can be safely reached. The ligature should be applied about midway between these two points, or per-
haps a little nearer the first branch, so as to allow as much space as possible for the formation of the internal clot. It has been suggested by Mr. Hayden to ligate the common carotid at the same time, so as to secure, if possible, the obliteration of the arteria innominata by arresting the circulation in both its branches.

On the Left Side.—The operation on the left side does not differ so much from that on the right as to require a separate description. On this side it will be recollected, that this por-
tion of the vessel is more intimately connected with the pleura; has the subclavian vein in front of it and the thoracic duct behind it. The operation has been performed two or three times, and the nearest approach to success, so far as we re-
member, was the case of Mr. Colles, of Dublin, whose patient survived the operation about nine days. Sir Astley Cooper had to abandon the operation once on account of its great difficulty.
Ligations of the subclavian, even in the external third of its course, cannot be regarded as a very reliable means of arresting hemorrhage from gun-shot wounds of the axillary or its branches. Mr. Guthrie deprecates the operation in hemorrhage, except in cases where the artery is wounded at the point ligated, and one of his precepts is: "Never commit the error of ligating the subclavian above the clavicle, for a wound of the axillary below it." The circles of anastomosis are very abundant around the shoulder, and the communications large, amounting to inosculations. The re-establishment of the circulation may, therefore, be expected to be rapid, and bleeding is apt to follow quickly by the refluent current. The operation is of great value in axillary circumscribed aneurisms, but not to be trusted in axillary traumatic hemorrhage.

Branches.—Some of the branches of the subclavian are of sufficient size to require ligation when wounded and accessible to the surgeon. Operations on the internal mammary and the inferior thyroid are selected for description.

I. The Internal Mammary Artery.—This vessel, arising from the under surface of the subclavian, nearly opposite the point where the vertebral is given off, passes downwards and forwards behind the phrenic nerve, and enters the cavity of the thorax to its outer side. It has a long course in the thorax, descending along the outer margin of the anterior mediastinum, behind the sternal extremities of the costal cartilages; it is covered by the triangularis sterni muscle and the pleura till it arrives at the diaphragm. It here enters the sheath of the rectus and descends in it along the posterior surface of the muscle, and finally, arriving opposite the umbilicus, terminates by anastomosing with the epigastric, a branch of the external iliac. Dr. Harrison has remarked upon the number of the inosculations of this artery and the distant parts of the arterial system which they serve to connect. The two arteries anastomose with each other, and their inosculations with the aorta, completely encircle the body, and, besides other inosculations, they connect the main trunk of the superior with that of the inferior extremity.

Operation.—This vessel may require ligation in penetrating wounds of the chest, when the operation may be performed as follows: It may be tied best in the second, third or fourth intercostal space in case of a wound. Make an incision in either one of these spaces, beginning at the edge of the ster-
num, and carrying it outwards, for the distance of an inch and a half or two inches, along the middle of the space between the costal cartilages. Divide the intercostal muscle cautiously on a director; the artery will be found lying upon its aponeurosis, which is stretched between the ribs; it is easy to isolate it from the veins and to tie it without injuring the pleura. If the vessel is wounded higher up, it may be tied, as recommended by Scarpa, between the first and second ribs, in which case the pectoralis major will have to be divided, as well as the intercostal muscle. In this position, it lies very close to the edge of the sternum, which increases the difficulty of the operation.

II. THE INFERIOR THYROID ARTERY.—The thyroid axis, of which this vessel is a branch, arises close to the inner border of the scalenus anticus muscle. The inferior thyroid ascends obliquely, in rather a serpentine course, behind the sheath of the carotid vessels, and in front of the longus colli muscle, to the inferior and posterior part of the thyroid body, to which it is distributed.

Operation.—Sir Everard Home recommended the ligation of these vessels, together with the superior thyroids, branches of the external carotid, for the cure of bronchocele; the operation has long since been abandoned for this purpose, on account of its difficulties, and still more on account of the unsuccesful attending the practice.* Place the patient in the

* In these cases the cause of failure is, that the abundant anastomosis of the supplying arteries soon re-established the excess of nutrition, and the tumor continued to grow, because its feeder could not be permanently cut off. Indeed, so long as a part exists, we cannot permanently diminish its blood supply; and hence, whenever the case depends upon that, it fails—the collateral circulation in time certainly enlarges, so as to be adequate to even the morbid appetite of the hypertrophic parts. The measure of ligation, as applied to inflammation, is different; here the morbid demand for blood is evanescent, existing only so long as the causes of irritation at the wound remain—if its feeder, the main trunk, is cut off, the diminution in the supply, though not permanent, is not required to be—still it is sufficiently so to allow of the recovery of the parts, before the collateral circulation can be fully established. If inflammation was of a nature to demand for its cure the permanent diminution of the blood-supply, then ligation of the main trunk would be of no avail. It is most fortunate, in the general interest of humanity, that we cannot cure tumors and other morbid conditions dependant upon excessive nutrition, by cutting off their arterial supply. The
recumbent posture; then, turning the head towards the opposite side and moderately extending the neck, make the incision, about three inches in length, along the inner edge of the sterno-mastoid, commencing close to the sternum. All the steps in the operation are nearly the same as those necessary to reach the primitive carotid in its first stage, to be described presently. The sheath and its contained structures are drawn aside with a blunt hook or curved spatula, and the vessel will be found behind it, ascending by the side of the trachea to reach the thyroid body. The inferior or recurrent laryngeal nerve, lying behind it, must be avoided in the application of the ligature.

**The Arteria Innominata.**—Ligation of the arteria innominata, like that of the subclavian in its first stage, experience has so far shown to be a hopeless and useless operation. Nine failures in the one case and seven in the other have served to secure for them general condemnation, and convinced the profession of their inutility.

The arteria innominata is the first branch given off from the arch of the aorta, being the common trunk of the right carotid and subclavian arteries, into which it bifurcates. It is generally not more than an inch and a half in length, and ascends obliquely from the right side of the arch of the aorta, to the right sterno-clavicular articulation. It has, in front of it, the sternum, the sterno-hyoid and sterno-thyroid muscles and the left vena innominata or transverse vein, which crosses it. On the right side, the right vena innominata and the pleura; on the left, the left carotid and the remains of the thymus gland; behind, the trachea and right pneumogastric nerve.

**Operation.**—The patient is laid on his back, his head thrown backwards, with his face inclined a little to the left shoulder. The surgeon stands on the right side and makes a horizontal incision from the median line of the neck, directed outwards for two and a half inches, at about half an inch above the clavicle. Another incision of the same length traces the In possession of that power would involve a denial to us of one far more important, viz: that of ligating to cure aneurism and to arrest hemorrhage—for, in that case, wherever the main trunk of a limb was ligated, for any object whatever, its nutrition would be permanently destroyed, and the organ it supplied would consequently perish.
ternal border of the right sterno-mastoid, and falls on the exter-


nality of the first. In the same direction the sternal end of the muscle is cut, and most of the clavicular portion also, which is turned upward and outward. The sterno-hyoid and sterno-thyroid are cut on a director carefully passed under them. With the director and fingers, the veins and cellular tissue which cover the artery may be separated, and the vessel may be isolated and tied.

Of course the above operation could scarcely, in any event, be debated for the arrest of hemorrhage. The singular circumstance that in two cases wherein the operator, after exposing the vessel failed to apply the ligature, the pulsations in the tumor gradually diminished, and in one the patient recovered, suggests that this partial procedure may perhaps hereafter become the method for treating certain forms of aneurism, wherein the vessel was formerly ligated.

Explanation.—Plate IV. figure 20: d, the arteria innominata isolated and with the ligature passed under it; b, the pneumogastrosic nerve; c, the internal jugular vein; a, the phrenic nerve; e, the sterno-mastoid with the sterno-hyoid and sterno-thyroid muscles beneath it, all divided.

M. Sedillot makes an incision which he thinks is convenient for the ligation of both the primitive carotid and the subcla-


vian in the first stage. The patient is placed in the position described in the last operation. The incision is then made, three inches in length, in the depression, observable in the living subject, between the sternal and clavicular portions of the sterno-mastoid muscle. The head being now flexed, the two portions of the muscle are separated, the sterno-hyoid and thyroid muscles divided on a director, and the vessels exposed, as in the operations above described.

Explanation.—Plate V. figure 21a. Arteries: d, exhibits the parts as exposed in M. Sedillot's operation; a, internal portion of the sterno-mastoid muscle; b, the sterno-hyoid and thyroid muscles divided; h, the arteria innominata; c, the common carotid; d, the pneumogastic and recurrent laryn-


geal nerves; g, the origin of the subclavian; c, the vertebral artery and thyroid axis.
Arteries of the Head and Neck.

The arteries of the head and neck are derived principally from divisions of the primitive carotid. The branches of the respective sides anastomose freely with each other, and also with the corresponding branches of the opposite side, which results in a complete mesh-work of communications, both in the scalp and on the interior of the cranium.

The Primitive Carotid Arteries.—Like the subclavians, the two primitive carotid arteries differ in their origin on the two sides of the body. The right, as we have seen, arises from the arteria innominata opposite the right sternoclavicular articulation; the left from the arch of the aorta, between the origins of the arteria innominata and left subclavian. From these different origins, the vessels ascend backwards and outwards into the neck, being enclosed with the pneumogastric nerve and internal jugular vein in a common sheath. Arriving opposite the os hyoides or the upper edge of thyroid cartilage, each divides into the external and internal carotid arteries. Only in the first part of their course do the relations of the two vessels differ. Being derived from the aorta, the left carotid at first, lies within the thorax, and is covered by the sternum, the transverse vein and the remains of the thymus gland, resting on the trachea a little above its bifurcation. Escaping on the left side of the trachea, it rests on the thoracic duct and oesophagus, whence, ascending into the neck, it resembles the right carotid. It is longer than the right, lies deeper in the neck, and is generally somewhat smaller.

The course of the common carotid arteries in the neck is, divided into a superficial and deep stage, by the omo-hyoid muscle, which crosses the neck obliquely. In the deep stage, the artery, enveloped in its sheath, lies in the anterior inferior triangle of the neck, covered by the skin, platysma, fascia, sterno-mastoid, hyoid and thyroid muscles; to its inner side, lie the trachea and left recurrent nerve; on the left side the oesophagus; to its outer side, the par vagum and internal jugular vein; and behind it, and behind its sheath, are the inferior thyroid artery, the recurrent and sympathetic nerves, the longus colli and rectus anticus muscles. On the left side, the internal jugular vein overlaps the artery as it descends to
join the subclavian, which increases the difficulty in securing the carotid on this side.

In its superficial or upper stage, the common carotid lies in the anterior superior triangle of the neck; it is only covered by the skin, platysma and cervical fascia, and by its sheath, on the outer surface of which, are the filaments of the descendens noni nerve. Sometimes this nerve is within or behind the sheath. The larynx, pharynx, superior thyroid artery, and superior laryngeal nerve are to its inner side, the par vagum and internal jugular vein to its outer side, enclosed in its sheath; while behind it are the sympathetic nerve and longus colli, and rectus anticus major muscles. Numerous lymphatic glands accompany the artery which, when enlarged, may somewhat obscure its appearance. The vessel rests posteriorly on the cervical portion of the spinal column, and in cases of hemorrhage, may, for a short time, be compressed against it. The artery cannot be long compressed here, as the internal jugular is necessarily compressed with it, thus obstructing the return of blood from the brain.

The primitive carotid can be tied in any portion of its course; two operations are generally described.

I. At the Base of the Neck.—The vessel, as we have seen, is here covered by the skin and fascia, the platysma, sterno-hyoid and thyroid muscles, having the trachea and recurrent nerve to its inner side; its immediate relations being the same as before mentioned.

Operation.—The patient is placed in the recumbent posture, with the head turned towards the opposite side, and the neck moderately extended. An incision, about three inches in length, is then made along the inner edge of the sterno-mastoid muscle, beginning at the sternum, and cutting through the skin and platysma myoides muscle. The fascia is then cut through, avoiding any veins that may present. The inner edge of the sterno-mastoid, and also the sterno-hyoid and thyroid muscles are exposed with a few branches of the descendens noni nerve; draw the mastoid muscle to the outer side, the others to the inner or tracheal side; or, if necessary, cut across some of their fibres on a groove director. The sterno-thyroid, from its greater breadth, overlaps the artery, and is most likely to require division. The sheath will now be brought into view, having the omo-hyoid muscle crossing it at the upper part of this region. Pinch up a small portion
LIGATION OF PRIMITIVE CAROTID ARTERIES.

of the sheath to make an opening for the director, and divide the sheath on it, to the required extent. The carotid artery will be exposed with the vein and nerve. The artery must be gently detached from its connections within the sheath, and the needle passed under it from without, inwards; in doing so, the pneumogastric nerve and the vein on the outer side, the sympathetic nerve and inferior thyoid artery behind, and the recurrent nerve on the inner side, must be avoided. If the left carotid be the artery operated on, the thoracic duct and oesophagus must also be guarded against.

All the large veins at the root of the neck are emptied when inspiration takes place, and distended during the act of expiration; motion also is communicated to the blood by the regurgitation from the right auricle; these changes cause the internal jugular vein alternately to flap over, and recede from, the artery, causing more or less embarrassment to the surgeon. Should this become troublesome, the vein should be compressed both above and below.

Explanation.—Plate V. figure 21. Arteries, does not represent the operation as described, but that of Sedillot, as applied to the carotid in this region, the incision being made between the sternal and clavicular portions of the sterno-mastoid. We prefer the operation above described; c, the internal portion of the muscle drawn inwards; a, the external portion drawn outward, with bent spatulas or hooks; b, the internal jugular vein; e, the pneumogastric nerve, lying between the vein, and j, the carotid artery.

II. IN THE SUPERFICIAL STAGE.—Where the vessel is crossed obliquely by the omo-hyoid muscle, or just above that point, in the anterior superior triangle of the neck, is the point of election for tying the primitive carotid artery, as it is here most easily reached. Its immediate relations are nearly the same as those mentioned above, viz: the internal jugular on the outer side, the pneumogastric nerve between and somewhat behind both, enclosed in a common sheath. The vessel here bi-sects the triangle, passing under the edge of the sterno-mastoid, and being crossed by the omo-hyoid muscle. The descendens noni is upon its sheath, and covering it, are the fascia, platysma, and the skin.

Operation.—Place the patient in the recumbent posture, with the head turned to the sound side, slightly extending the neck; make the incision, about three inches in length,
along, and a little internal to, the anterior margin of the sterno-mastoid muscle, extending from a little below the angle of the jaw, to the side of the cricoid cartilage. In this, the integuments and platysma are divided, and the cervical fascia exposed. This must be cautiously divided on a director, care being taken to avoid the veins which cross this part of the neck, the facial or labial vein being one of them. The descendens noni nerve will soon appear lying on the surface of the sheath; open the sheath to one side of this nerve, introduce the director and divide carefully with the knife for a short distance; pass the needle from without inwards, leaving out the par vagum and internal jugular vein. If the lips of the wound are held well apart with bent spatulas, any parts outside of the sheath cannot be in much danger of being included in the ligature. The trunk of the sympathetic nerve is behind the sheath, and the superior laryngeal nerve and superior thyroid artery are on its inner side. The ligature should be applied some distance from the bifurcation of the vessel, to allow the better opportunity for the formation of the coagulum. Should the sterno-mastoid artery, a branch of the external carotid, be cut, and bleed much, it should be ligated, as it may obscure the further steps of the operation. It is a small muscular branch, crossing the sheath of the vessel and inner edge of the muscle, to be distributed to its posterior surface.

Explanation.—Plate V. figure 22: Arteries, exhibits the parts exposed by the operation. The incision as represented, does not extend high enough for the operation in the superior triangle; a, the omo-hyoid muscle; b, the carotid artery crossed by filaments of the descendens noni nerve, which, before the dissection, were on the outside of the sheath; c, the internal jugular vein, external to the artery; d, the pneumogastric nerve, drawn from its position a little forward, so as to appear between the vein and artery; e, the inner border of the sterno-mastoid muscle drawn backwards.

Anastomoses.—To the anastomosing communications of the primitive carotid artery, with surrounding vessels, attach surgical considerations of unusual importance. These relate, both to the success of ligation in the various cases in which it may be practised, and to the influence of that operation upon the important parts within the cranium. Especially do these considerations force themselves upon us in military practice, where the operation requires to be so frequently debated for
hemorrhage resulting from gun-shot wounds of this vessel, or some one of its branches. Even more abundant than the arterial communications of the superior extremity, those of the head and neck present almost an impossibility of permanently arresting the circulation through any of their trunks, and in ligation of the primitive carotid, pulsation readily re-appears beyond the point at which the vessel is tied. The vertebral, the internal carotid, the thyroid, the lingual, facial and temporal of the opposite sides, communicate freely, while the superior and inferior thyroid and the princeps cervicis, and the profunda cervicis, keep up the communication between the subclavian and external carotid on the side on which the vessel may be tied.

Results and Effects of Ligation.—On account of the abundant anastomosis above described, it has been found that whenever the common carotid has been tied for aneurism, the pulsation, as we have said, returns in the vessel above the ligation in a very short time, and if tied for hemorrhage, the sanguineous effusion takes place by the recurrent circulation. For this reason, ligation of the primitive carotid for anastomotic aneurism of the branches of the external carotid, a practice once quite popular, has been nearly abandoned at the present day, and, for a stronger reason, ligation of this vessel for hemorrhage from any of its divisions or for bleeding from the trunk itself, except at the seat of lesion, is peremptorily condemned by the highest authorities.* It is a vessel very liable to become the subject of frequent and ineffectual ligation, on account of its easy accessibility and its apparent availability for the trying emergency of alarming and persistent traumatic hemorrhage. We have tested, by repeated trials, how frequently this ligation is inefficient, both in the case of erectile tumor and in hemorrhage from its branches.

Considering the freedom of collateral communication between the circulation of the various regions of the head and neck, it is surprising how frequently ligation, of one common carotid artery, is attended with serious cerebral disturbance,

* Mr. Guthrie says, "No fact can be more satisfactorily shown, than that, in every case of wounded—not aneurismal—artery of the neck, one ligature should be applied above and another below the opening in the wounded vessel, and not, one alone on the common trunk, even if that should be the part injured."—Commentaries, page 252.
and how invariably the simultaneous arrest of circulation in both, has been followed by death. The experiments of Meyer, Jobert and others to throw light on this subject were inconclusive on account of the varying relative importance of the common carotid to the brain in the lower animals as compared with man. Observations on the human subject go to show that out of 149 cases, in which the vessel was tied for various objects, 33 proved fatal, and of these, 18 died of cerebral disease, showing that the most frequent cause of death after ligation of the common carotid is this cerebral disease induced by the operation. The successive ligation of both carotids, with a considerable interval between the operations, has been attended with no greater cerebral disturbance than that following the single operation. While the simultaneous ligation† of both has invariably ended fatally. Mr. Erichsen thus sums up his conclusions on this subject: 1. Ligature of one carotid artery is followed by cerebral disturbance in about one-fifth of the cases, more than one-half of which are fatal. 2. When both carotids are ligated simultaneously, death has hitherto always resulted, as in the two cases in which Mott and Langenbeck ligatured these vessels with an interval of but a few minutes between each operation. 3. When the two carotids are ligatured, with an interval of some days or weeks, the operation is not more frequently followed by cerebral disturbance than when only one is tied.

The symptoms arising from this cause are either immediate or remote. The first are syncope, trembling, giddiness, impairment of sight, and hemiplegia—then the remote symptoms appear, which are such as result from impairment of the nutrition of the brain and softening of that organ, ending generally in convulsions, paralysis and death.

The External Carotid Artery.—This vessel extends from the division of the primitive carotid, opposite the upper border of the thyroid cartilage, to the neck of the lower jaw, where it divides into its two terminal branches, the temporal and internal maxillary. In front of it, crosses the posterior belly of the digastric and the stylo-hyoid and platysma myoides muscles. The facial nerve passes over its upper part while in the parotid gland, and the hypoglossal nerve over its lower part near its origin. Behind it, is the internal carotid artery.

with the glosso-pharyngeal nerve, the stylo-glossus and stylo-pharyngeus muscles and part of the parotid gland intervening. It has been divided into three stages: 1st, below the digastric muscle; 2d, from this point to the parotid gland; and, 3d, where it is lodged in that gland. The vessel is seldom tied in its third stage, except during extirpation of the parotid, or in an open wound. In the first or second stage, it may be tied in the following manner:

Operation.—The patient must be placed in the position for ligating the primitive carotid. Make an incision, about three inches in length, through the skin, platysma and fascia, extending from beneath the lobe of the ear downwards towards the cornu of the os-hyoides. This is in the direction of, and overlying, the digastric muscle, and will expose it. The muscle guides the operator at once to the artery, which may by brought into view, either above or below it, by a little dissection. The hypoglossal nerve should be carefully avoided in every stage of the operation, and the needle introduced from without inwards. The external carotid should only be tied for a wound of that trunk itself; and then two ligatures should be applied. The operation is seldom performed, on account of the numerous branches of the vessel rendering it unfavorable for the formation of a clot.

The Superior Thyroid Artery.—This artery arises from the external carotid, a little below the cornu of the os-hyoides. It first passes upwards and inwards, then curves downwards and forwards, by the inner side of the common carotid artery, to the edge of the thyroid body, in which it is distributed. Besides the gland, the superior thyroid sends branches to supply the mucous membrane and muscles about the larynx. It is accompanied, for a short distance, by the superior laryngeal nerve, which lies posterior to it, and the hypoglossal above it.

Operation.—This operation was formerly practised by Sir Everard Home, Walther, Theden, Langenbeck, and others, for the cure of bronchocele, hoping to produce atrophy of the gland. It is now abandoned for this purpose, on account of its invariable failure. In case of wound, it may be performed as follows: The head is extended; make an incision, about two inches in length, along the internal border of the sternomastoid muscle, letting the centre of it correspond with the cornu of the thyroid cartilage. By this, the skin, platysma
and fascia are divided. The sterno-mastoid may be drawn outwards, exposing the omo-hyoid muscle, underlying which are the sheath, and its contents, of the primitive carotid artery. The artery we are seeking lies, in this situation, between the carotid sheath and the lobe of the thyroid gland. It should be carefully isolated with the point of the director and ligated in the usual manner.

**The Lingual Artery.**—The lingual artery has a very tortuous course from its origin, on the inner side of the external carotid, to the base of the tongue, when it becomes the ramine artery. It first ascends somewhat obliquely to reach the cornu of the os hyoides, along which it runs parallel for some distance under the hyo-glossus muscle, when it ascends to the base of the tongue. In this course, it is covered by the tendon of the digastric and the stylo-hyoid muscle; then by the hyo-glossus, which separates it from the hypo-glossal nerve; and in the third part of its course, it rests between the hyo-glossus and genio-hyo-glossus muscles.

**Operation.**—First find the position of the cornu of the os hyoides; make an incision, somewhat over an inch in length and about half an inch above it, through the skin, cellular tissue and platysma; this incision will expose the lower border of the submaxillary gland, under which the shining tendon of the digastric may be seen; less than a line below this, lies the hypoglossal nerve. Now look for the outer border of the *hypo-glossus* muscle, pass a director carefully under it, and make a transverse incision through its fibres, when the artery will be exposed in a situation in which it is unaccompanied by any nerve or vein. The needle may be passed under it from either side. The main point to be recollected in reaching the vessel is, that it is under the hypo-glossus muscle, parallel with and a little above the cornu of the os hyoides.

**Explanation.**—Plate V. figure 23, represents the operation above described. The hypoglossal nerve is seen running parallel with the artery, but superficially to it and to the hypo-glossus muscle, which has been divided; *a*, refers to the artery, with the ligature passed under it.

**The Facial Artery.**—The facial or external maxillary artery passes forwards from its origin, a little above the lingual, and becomes embedded in the submaxillary gland. It then curves around the body of the lower jaw, close to the anterior inferior angle of the masseter muscle, where it may be felt
beating during life or effectually compressed in hemorrhage; ascending to the angle of the mouth and thence to the cornu of the eye, it becomes the angular artery. The facial vein lies to its outer side.

Operation.—In case of wound, the artery may be ligated below the jaw, either before or after it enters the submaxillary gland, by enlargeing the opening and seeking for the vessel within the border of the inferior maxilla. It is more frequently tied, as it passes over the ramus, at the foot of the masseter muscle. Feel for the pulsation, and then make an incision a little over an inch in length obliquely over the course of the vessel, dividing the skin, fascia and platysma—using the director, if necessary, to divide the fibrous tissue surrounding the vessel. Pass the needle from without inwards.

Explanation.—Plate V. figure 24: a, the masseter muscle; b, the vein; c, the facial artery, with filaments of the portion dura passing over it and the ligature passed under it.

The Temporal Artery.—The temporal is one of the terminal branches of the external carotid. It arises opposite the neck of the lower jaw, in the substance of the parotid gland, passes over the zygoma, in front of the ear. It shortly divides into an anterior and posterior branch, anastomosing with the occipital and opposite temporal.

Operation.—Find the vessel by its pulsations just in front of the external ear, a little above the zygoma; make an incision, about an inch in length, through the skin, in the direction of the artery; divide the dense cellular tissue on the director, and introduce the needle from without inwards, avoiding the vein and neighboring nerve.

Explanation.—Plate V. figure 24: a, the temporal artery exposed, with ligature passed; b, the temporal vein.

The Occipital Artery.—This vessel arises from the back part of the external carotid, opposite the facial. The hypoglossal nerve hooks round it near its origin, about opposite the angle of the jaw. The artery passes behind the parotid gland, under the posterior belly of the digastric and trachelo-mastoid and sterno-mastoid, and ascends between the splenius and complexus, from under the posterior border of which it emerges, to perforate the trapezius and supply the back of the head. The vessel, like the temporal, can be easily compressed and
seldom requires ligation in the scalp. It is tied in two other places:

I. AT ITS ORIGIN.—It is in relation here with the hypo-
glossal nerve, and lies under the stylo-hyoid and digastric muscles.

Operation.—Make an incision, about two inches in length, along the upper portion of the inner border of the sternomastoid muscle. Divide the deep fascia carefully on a director, expose and isolate the artery carefully, avoiding the hypo-
glossal nerve.

II. BEHIND THE MASTOID PROCESS.—The artery is here covered by the sterno-mastoid and splenius muscles, and lies in the occipital groove of the mastoid portion of the temporal bone.

Operation.—Make an incision through the skin, full an inch and a-half long, half an inch behind and a little beneath the mastoid process, obliquely upwards and backwards; the aponeurosis, sterno-mastoid and splenius muscles are to be di-
vided, layer by layer, carefully on a director, till the artery is reached. The pulsations must be felt for, as the operation advances. The vessel must be carefully isolated from any branches of the great occipital nerve which may be lying near it.

Explanation.—Plate VI. figure 25: a, the occipital artery with the ligature passed under it; b, the obliqueus capitis su-
perior muscle exposed; c, the thin tendon of the sterno-mastoid cut through and drawn apart.

THE INTERNAL CAROTID ARTERY.—The internal carotid artery curves slightly from the bifurcation of the common carotid, and ascends, by the side of the pharynx, to the carotid foramen of the temporal bone. It has behind it, the rectus anticus major muscle, the superior cervical ganglion, and the pharyngeal and superior laryngeal nerves; internally, is the pharynx, tonsil, and ascending pharyngeal artery; externally, the internal jugular vein, the glosso-pharyngeal, pneumoga-
stric and hypoglossal nerves; and, in front, the stylo-glossus and stylo-pharyngeus muscles, the stylo-hyoid ligament, glosso-
pharyngeal nerve and parotid gland.

A vessel thus deeply situated, is ordinarily equally secure from injury, and out of the reach of the surgeon; its lesion, however, is not an uncommon occurrence, as one of the acci-
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dents of battle. Balls entering the mouth frequently divide or open the internal carotid, making their wound of exit near or above the angle of the lower jaw. Though, perhaps, the very most difficult ligation of the whole body, yet the vessel has been reached and secured on several occasions. Mr. Guthrie describes two processes by which the operation may be performed; one from without, by external incision, and the other from within the mouth, by division of the lower jaw. In regard to the first, his remarks are as follows: "The internal carotid, when wounded near the bifurcation of the common carotid, is to be secured by two ligatures, and the steps of the operation are the same as those for exposing the external carotid, the surgeon recollecting that the internal is more deeply-seated and to the outside of the external." In case the injury should encroach on the bifurcation, he recommends three ligatures, one to each division, and one to the common trunk, considering nothing less sufficient to secure the patient against recurrent hemorrhage.

In regard to the operation recommended below by Mr. Guthrie,* it may be said that, it is nearly equal to a resection of a portion of the inferior maxilla, yet we subject patients to this constantly, for dangers often much more remote than the fatal hemorrhage which must follow a wound of the internal carotid.

Operation from within the Mouth.—An incision is to be begun opposite to, and on the outside of, the extremity of the lobe of the ear, and carried downwards in a straight line, until it crosses a little below the angle of the jaw, at the distance of nearly half an inch, more or less, as may be found most convenient from the form of the neck. This incision exposes the parotid gland without injuring it. A second is then to be made from the extremity of the first, extending at a right angle forwards; under or along the base of the lower jaw, until the end of it is opposite the first molar tooth. This incision should divide the skin, superficial fascia, platysma myoides muscle, and the facial artery and vein. The second molar tooth should then be removed and the jaw sawn through at that part. Then cut through the deep fascia, the mylohyoideus muscle, and the mucous membrane of the floor of the mouth, exposing the insertion of the internal pterygoid muscle,

* Commentaries, page 256.
which is to be divided. The surgeon will next be able to raise and partially evert the angle of the jaw, and thus obtain room for the performance of the remaining part of the operation, which should be effected by the pointed but blunt edge of a scalpel, or other instrument, chosen for the purpose of separating but not cutting. The styloid process of the temporal bone may then be readily felt and exposed, by the separation of a little mucous membrane, and with it the stylohyoid muscle, which is to be carefully raised and divided. The external carotid artery will thus be brought into view, together with the stylo-pharyngeus muscle and glosso-pharyngeal nerve attached to it. These are to be drawn aside by a blunt hook, when, if care be taken to avoid the pneumogastric nerve, the internal carotid artery may be felt, seen, and secured by ligation, with comparative facility, outside the tonsil, there being between them, the superior constrictor of the pharynx, which, in case, of wound through the mouth, must have been divided. The pneumogastric nerve should be drawn outwards, and the external carotid artery also, if in the way. The division of the jaw will not lead to further inconvenience, as the bone always re-unites when divided, with little difficulty.

Arteries of the Inferior Extremity.

The main artery, supplying the inferior extremity, arises from the aorta, within the cavity of the abdomen, by a common trunk, the primitive iliac, which also supplies parts within, and external to, the pelvis. The crural division, like the main artery of the upper extremity, proceeds as a single vessel, through several successive surgical regions before it divides, receiving from each one a corresponding designation. That portion of the vessel which extends from its origin to the femoral arch, is called the external iliac artery; beyond this line, to the opening in the adductor magnus, it is termed the femoral artery; and from the termination of Hunter's canal, to the lower border of the popliteus muscle, it bears the name of the popliteal artery. The vessel here terminates by dividing into the anterior and posterior tibial arteries for the supply of the tissues of the leg and foot.

The Dorsalis Pedis Artery.—This vessel is the continuation of the anterior tibial upon the dorsum of the foot. It runs along the inner side of the dorsum, from the middle
of the ankle to the base of the metatarsal bone of the great toe. It here gives off the dorsalis hallucis and then dips into the first interosseous space to communicate with the deep plantar arch. In this course, it lies along the outer border of the tendon of the extensor proprior pollicis and has the innermost tendon of the extensor longus digitorum to its fibular side being crossed, near its termination, by one of the tendons of the extensor brevis. It is accompanied by venæ comites and has the continuation of the anterior tibial nerve to its outer side.

Operation.—Make an incision, about two inches in length, along the external border of the extensor proprior pollicis muscle, which line may be made prominent by directing the patient to extend his big toe. The deep fascia should be divided on a director. The artery will be found about a quarter of an inch or more from the outer border of the extensor proprior tendon, with a collateral vein on either side and the anterior tibial nerve on its fibular side. Isolate the artery and pass the needle from within outwards.

Explanation.—Plate VI. figure 26: c, the extensor proprior pollicis tendon; a, the extensor brevis digitorum drawn outwards; d, the dorsalis pedis artery, with the ligature passed under it; b, the venæ comites.

The Anterior Tibial Artery.—This artery passes directly forwards from the bifurcation of the popliteal, through the opening in the upper part of the interosseous membrane of the leg, close to the inner side of the neck of the fibula, thus gaining the anterior aspect of the leg. It then descends inwards in front of, and resting upon, the interosseous membrane, and passes over the ankle-joint, beneath the annular ligament. It here becomes the dorsalis pedis, which, as we have seen, crosses the dorsum of the foot near its inner edge and plunges between the first and second metatarsal bones. A line drawn from a little within the head of the fibula, to the base of the great toe, will run nearly parallel to the course of both the anterior tibial and dorsalis pedis artery. In its upper third, it is situated between the tibialis anticus and extensor longus digitorum: lower down, between the tibialis anticus and extensor proprior pollicis; and just before it reaches the ankle, it is crossed by the tendon of the extensor proprior pollicis, and is placed between that tendon and the tendons of the extensor longus digitorum. In its course down the leg,
it rests on the interosseous membrane and is bound down to it by a little tendinous arch thrown over it. Its immediate relations are its venæ comites and the anterior tibial nerve. The nerve lies, at first, to its outer side; about the middle of the leg, in front of it; and at the ankle is again on its outer side. This artery, though deeply situated in its upper two-thirds, can be reached in any portion of its course without the division of the muscular fibres—though, to isolate the vessel and introduce the ligature conveniently, it may be necessary to divide the muscles at the point ligated, by a crucial incision. Three operations are described:

I. At the Lower Third of the Leg.—The artery is here crossed by the tendon of the extensor proprius pollicis, and lies between the tendon of this muscle and that of the extensor longus digitorum. The anterior tibial nerve lies to its outer side. It is here superficial.

Operation.—The leg being placed with its anterior surface upwards, the foot is extended so as to make prominent the line of the tibialis anticus. An incision, three inches in length, extending not quite to the annular ligament, is made along the external border of that muscle; carefully divide the deep fascia on the director, find the space between the tibialis anticus and extensor proprius pollicis, flex the foot so as to separate the two muscles with the index finger. The artery, here resting on the anterior surface of the tibia, may be felt pulsating, isolated and secured. Draw the nerve inwards and pass the ligature from within outwards. This place should not be selected for the operation, on account of its proximity to the joint.

II. At the Middle Third.—Through its upper and middle thirds, the artery lies very deep in the intermuscular space upon the interosseous membrane, is covered by the skin and superficial fascia and the deep fascia, which is very thick and aponeurotic. On its inner side is the tibialis anticus, and externally, the extensor longus digitorum and the extensor proprius pollicis. The nerve is in front and the veins on either side.

Operation.—Make an incision, over three inches in length, over the intermuscular space between the tibialis anticus and extensor longus. This line is from an inch to an inch and a-half, varying with the subject and the position incised, from the spine of the tibia. The incision should be carried low
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enough to strike the distinct separation of the muscles, so that it may be traced up to the fusion, if necessary. In case it is made higher, the line of fusion of the muscles may be recognized by its whiteness as it runs upwards, uniting their heads. This must be carefully dissected apart down to the interosseous membrane, upon which, first the nerve, and then the artery and its two veins, will be found covered by the tendinous arch before described. The foot must be flexed to relax the muscles, and a crucial incision made across their bellies, if necessary, to give room for the isolation of the vessel. The instrument figured in plate I, figure 7, will be found convenient for a vessel so deeply seated and so overhung by muscles.

Explanation.—Plate VI, figure 27: a, the skin, deep fascia and muscles drawn outwards to dilate the wound; b, the tibialis anticus pressed inwards; c, the vein comites; d, the artery. The nerve should be represented smaller, running upon its surface.

III. IN ITS UPPER THIRD.—Here the artery is almost inaccessible, deeply situated between the tibialis anticus and extensor longus digitorum. The muscles are fused together, and the white line between them is the best guide to the artery when the deep fascia has been cut into. The nerve lies to the outer side of the artery and the vein comites on either side.

Operation.—Make an incision, about four inches long, through the integument and superficial fascia, about one inch from the spine of the tibia. Then divide the deep aponeurotic fascia, making a crucial incision in it to allow of its easier separation. Now seek for the white line of the intermuscular septum, which is the first from the tibia. The white line is better marked at the lower part of the incision. The foot should be flexed to relieve the tension of the muscles; these may be separated with the index-finger and held apart with blunt hooks or spatulas. The muscle may be cut across, if necessary, to reach the vessel, which will be found between its veins, with the nerve on the outer side. Pass the needle from without inwards.

In gun-shot wounds near the knee, it is difficult sometimes to determine whether the anterior tibial or upper part of the posterior tibial is injured. The anterior tibial, when severed
very high up, sometimes retracts through the opening in the interosseous membrane, in which case, the membrane should be divided or the artery sought from behind.

**The Posterior Tibial Artery.**—The posterior tibial is much larger than the anterior. Beginning at the lower border of the popliteus muscle, it passes obliquely downwards, along the tibial side of the leg, to the concavity of the os calcis, where it enters the sole of the foot, between the two heads of the abductor pollicis muscle, and divides into the internal and external plantar arteries. In this course, it is covered by the intermuscular fascia, which separates it, above, from the soleus muscle, and, below, from the deep fascia and the integument. It is accompanied by venæ comites and by the posterior tibial nerve, which lies to its inner side at first, and to its outer side for the rest of its course. In its upper two-thirds, the vessel is deeply situated, being covered by the gastrocnemius and soleus muscles and the intermuscular fascia above-mentioned. It rests successively on the tibialis posticus, on the flexor longus digitorum, and, below this, on some fat and cellular tissue, which separates it from the tibia and internal lateral ligament of the ankle-joint. Three operations on this artery are usually described:

I. **In Its Lower Third.**—The artery here descends at first parallel with the tendo-achillis, but soon diverges from it behind the internal malleolus, and occupies a position midway between the internal malleolus and the os calcis. In the fossa between these two eminences are the following: tibialis posticus tendon, flexor longus tendon, posterior tibial artery and venæ comites, posterior tibial nerve, flexor longus pollicis tendon, plantaris tendon, and tendo-achillis. The skin and a very dense process of the deep fascia covers all these parts. The artery is here comparatively superficial, and may be felt pulsating in the hollow of the heel.

*Operation.*—The limb must be everted and the foot flexed so as to make prominent the tendo-Achillis. Make a somewhat semilunar incision over the course of the artery, and nearly midway between the two bony prominences of the os calcis and internal malleolus, but a little nearer to the ankle. This divides the integument and superficial fascia for about two and a half inches. The deep fascia is then divided on a director, to the same extent. The artery can soon be
brought into view, with the end of the director, in company with its nerve and veins. Secure the vessel by passing the aneurism needle from behind forwards, to avoid the nerve.

Explaination.—Plate VI figure 28, Arteries: a, the deep fascia; b, the posterior tibial nerve; c, the venæ comites; d, the posterior tibial artery, with the ligature passed under it.

II. In its Middle Third.—This is considered quite a difficult operation, as the posterior tibial artery in its upper two-thirds lies very deeply situated between the superficial layer of muscles and in close proximity to the bone. The vessel is very frequently wounded in these situations as an accident of battle, and the hemorrhage is apt to be complicated with diffused aneurism on account of the depth at which the vessel lies and the dense fascia covering it. Re-establishing the track by the introduction of the sound—entering it at one wound and passing it out of the other—we have found, greatly facilitates the finding of the wound in the vessel. The artery here rests, with its two venæ comites, upon the tibialis posticus and flexor longus digitorum, and has the posterior tibial nerve to its outer side, covered by the deep fascia and the gastrocnemius and soleus muscles.

Operation.—In case of hemorrhage or traumatic aneurism* in the middle third of the posterior tibial artery, the vessel must be tied with two ligatures at the point of lesion. The tourniquet must be carefully applied either to the femoral or popliteal artery; then introduce the sound into the track traversing the artery, from one wound to the other, if there are two, giving it in charge of an assistant. The limb having been placed on its outer side, with the knee somewhat flexed, make an incision over four inches in length, according to the extent of the tumor, if there is aneurism. This incision

*We must here explain that the precept, "never ligate an artery unless it bleeds," is not violated by ligating in cases of diffused aneurism before any external effusion of blood takes place. In such cases the artery of course is bleeding, only the surrounding tissues retain the effused blood. We always recommend, and have acted upon the principle—ligation of the vessel as soon as the traumatic aneurism is discovered. It would be useless to wait for the external bleeding when a trunk of large size is pouring blood into the tissues in the form of a traumatic aneurism. This practice we have pursued both in the case of the posterior tibial in its upper third and also in the femoral artery.
must be made about an inch behind, and along the inner edge of the tibia. It will divide the integuments and probably expose the internal saphena vein, which must be drawn to the inner side; now divide the fascia to the extent of the first incision, exposing the inner edge of the gastrocnemius muscle. This muscle must be raised and drawn outwards, when the origin of the soleus from the oblique line of the tibia will present itself. The artery lies under this muscle and about one inch from the inner edge of the tibia, covered by the deep fascia of the leg. Some recommend now to introduce the director and cut the soleus from its attachment at the oblique line; we prefer the following: make an incision cautiously through to the soleus, about three-quarters of an inch from the edge of the tibia, using the director, if it is thought necessary, to divide the fibres, layer by layer; in doing this, be careful not to mistake the shining fibres of the aponerotic attachment of the soleus for the deep fascia which is not yet reached and which has a pearly appearance. The soleus having been raised from its attachment, or divided, must be drawn aside. The fingers may be passed now between the two layers of muscles—that is, under the soleus—and the posterior tibial can be felt pulsating under the fascia, provided the accumulation of clotted blood and fibrine do not interfere. The fascia may now be divided on the director, the sound will be seen and the opening in the vessel found, and the aneurism needle passed from without inwards. In case of large accumulations of blood, these must be removed as the operation advances, and the sound felt for on raising the soleus muscle; the wounded artery will be found on the same level with the sound—the sound resting between the two ends of the severed vessel. The posterior tibial nerve on its outer side and the vena comites must be avoided. From the depth at which the artery lies, and its proximity to the bone, much difficulty is sometimes experienced in passing the ligature. This will be somewhat increased if the artery is completely severed. Each end must be sought for on either side of the sound, seized with the forceps and isolated, and the two ligatures applied.

Mr. Guthrie* recommends "an incision six or seven inches long through the gastrocnemius and soleus muscles, down to

* Commentaries, page 271.
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The deep fascia.” This we regard as an unnecessary cutting of muscular fibres, risking a crippling of the limb. When we are certain that the posterior tibial is the artery wounded, it can be more easily reached by the incisions above recommended, and with less injury to the important muscles concerned. If there is doubt whether the bleeding vessel be the peroneal or posterior tibial, Mr. Guthrie’s recommendation should be adopted. There are two great objections to dividing extensively the muscular fibres: first, the injury to the muscle which, though it finally perfectly recovers, remains a long time stiff and consolidated after being cut; and secondly, to cut through the calf, gives rise to embarrassing hemorrhage during the operation from division of the sural arteries.

Explanation.—Plate VI. figure 29, Arteries: a, the fascia of the leg; b, the venæ comites; c, the posterior tibial artery; d, the internal edge of the gastrocnemius. The nerve is to the outer side, and pulled out of the way.

III. AT THE UPPER THIRD OF THE LEG.—Quite high up, the artery rests upon the tibialis posticus and is covered by the deep fascia, the soleus and gastrocnemius muscle. The nerve is here to the inner side of the artery and its accompanying veins.

Operation.—This operation does not differ greatly from the one just described. Malgaigne’s method is thus described by Bernard and Huette: At the distance of two-thirds of an inch from the internal border of the tibia, make an incision at least four inches in length, through the integuments and deep fascia, carrying the index finger into the wound, detach and push outwards the internal head of the gastrocnemius muscle, and divide also the attachments of the soleus, thus exposed, from the posterior surface of the tibia; whilst an assistant keeps this muscle held backwards and outwards with a blunt hook, divide the layer of aponeurosis upon a director and search for the vessel immediately beneath it; lastly, detach the artery and pass the ligature beneath it with the artery needle.

The operation of ligating the posterior tibial above the ankle, in the upper part of the lower third is sometimes described as the operation in the middle third. The vessel is here easily reached without dividing the soleus; it is here found about three-quarters of an inch from the inner border of the tibia, and the incision is made midway between the internal border
of the tibia and the tendo-achillis. The muscles are drawn outwards, the deep fascia cut through on a director and the vessel secured as in the preceding operations.

The Peroneal Artery.—This artery arises from the posterior tibial a short distance below the popliteus muscle; it is nearly as large as the anterior tibial artery, and passes outwards to the fibula. It then runs downwards along the inner border of this bone to its lower third, being closely applied to the interosseous membrane, and a little above the ankle, it divides into the anterior and posterior fibular arteries. It is very deeply situated, resting on the tibialis posticus muscle, on the inner side of the fibula, and is covered by the soleus, intermuscular fascia and flexor longus pollicis muscle.

This vessel most frequently is injured in gun-shot wounds, the circumstances of which, leave considerable doubt on the mind of the surgeon as to whether the bleeding vessel is the peroneal or the posterior tibial, or sometimes even, the popliteal. In this remark many surgeons of our army will coincide. This doubt existing, it is better to perform such an operation as will admit of the ligation of either the peroneal or posterior tibial, or which, being modified, may be made subservient in reaching the popliteal. The following is Mr. Guthrie's method.*

Operation.—An incision, from six to seven inches long, should be made rather nearer to the inner edge of the leg than to the centre, and should be carried through the gastrocnemius muscle, the plantaris tendon and soleus muscle, down to the deep fascia, under which the arteries lie, with their accompanying veins, having the posterior tibial nerve on the fibular side of the artery. If the incision is made in the upper part of the calf of the leg, the peroneal artery will be exposed by it; but if it be certain that the peroneal is the vessel injured, the incision should be made towards the fibular side of the leg. When the fascia has been divided the peroneal artery will be found covered by the fibres of the flexor longus pollicis muscle at any distance, below three inches and a half, from the head of the fibula. These fibres being divided, the artery will be found close to the inner side of the bone. Above that part, the peroneal is under the fascia and upon the tibialis

* Commentaries, page 277.
posticus muscle. It has no accompanying nerve. Both arteries will be readily found by either of the incisions if the surgeon be acquainted with their situation.

**The Popliteal Artery.**—The popliteal region is a diamond-shaped space, comprehending about the inferior fourth of the thigh, and superior sixth of the leg on their posterior aspect, formed by the approximation, base to base, of two triangles, the one above caused by the divergence of the hamstring muscles, and that below by the union of the two heads of the gastrocnemius. Stretched between the boundaries of this space, are the skin, the superficial fascia and the deep fascia, and beneath this last a large quantity of fat, in which the vessels and nerves of the region are embedded, besides a number of lymphatic glands. The popliteal artery, the continuation of the femoral, enters this space from above, through the opening in the adductor magnus, and with its accompanying vein, joins the nerve and descends through the centre of it into the leg. When at the lower border of the popliteus muscle, it terminates in the anterior and posterior tibial arteries. In the cellular tissue under the skin, the external saphena vein ascends through the middle of the space and perforating the deep fascia, terminates in the popliteal vein. Besides cutaneous branches of nerves and the veins, the relation of the more important of the contained parts to each other is the following: 1st, the *popliteal artery* traverses the space resting on the posterior surface of the femur and ligament of the knee-joint; 2d, the *popliteal vein*, superficial and a little external to the artery, and closely united to it by dense areolar tissue; 3d, the *internal popliteal nerve*, the continuation of the sciatic, crosses both vessels, superficially and obliquely, from the superior external, to the inferior internal boundary of the space. With the patient in the prone position, the order of superposition is: saphena vein, popliteal nerve, popliteal vein, and lastly, popliteal artery. This artery may be ligated by the following operations:

I. *By Lateral Incision.*—This method proposes to reach the popliteal artery under the inner margin of the gastrocnemius muscle.

**Operation.**—Place the patient on his back or side, with the limb abducted, slightly flexed and laid on its outer border, the knee being supported by a pillow. Now find the groove be-
between the inner border of the gastrocnemius and the internal margin of the tibia. In this groove, make an incision, three inches in length, beginning just below the tendons of the inner ham-string muscles; the internal saphena vein and nerve, being exposed, are drawn forwards, and the superficial fascia and the deep-seated thick aponeurosis of the leg are divided on a director. The internal head of the gastrocnemius, now exposed, is to be separated and drawn strongly outwards. At about the depth of an inch, the popliteal artery may be found. The vein lies nearest, the artery being to the external side, the nerve being behind them both. The vein should be separated from the artery and carefully drawn backwards and outwards by the fingers of an assistant. The artery may now be felt and seen resting on the popliteus muscle, where it may be raised and the ligature applied.

Explanation.—Plate VI. figure 30, Arteries: \(a\), the internal edge of the gastrocnemius muscle; \(c\), the popliteal vein, drawn backwards and outwards; \(e\), the popliteal nerve; \(d\), the popliteal artery, with ligature under it; \(f\), the internal saphena vein, exposed by the incision in the skin.

The artery is tied in two places, above and below, by posterior incisions:

II. The vessel should never be interfered with in this situation, unless wounded and bleeding, on account of the depth at which it lies and its proximity to the knee-joint.

Operation.—The patient should be laid on his face, with the limb extended. The bleeding and the pulsations will point to the exact situation of the artery, between the two heads of the gastrocnemius muscle. Make an incision, about three inches long, somewhat external to the median line. The integument and superficial fascia, having been divided, the external saphena vein and nerve are to be avoided and drawn aside; carefully divide the deep fascia on a director and draw apart the heads of the gastrocnemius muscle; first the nerve, then the vein, and, lastly, the artery, will be found deeply situated and surrounded by fat and cellular tissue. The nerve in this situation should be drawn inwards and the vein outwards, in order to introduce the ligature.

Explanation.—Plate VII. figure 31, Arteries: \(a\), the deep fascia divided—exposing \((c)\) the popliteal nerve, \((b)\) the popliteal vein, and \((d)\) the popliteal artery, somewhat external
and most deeply seated; \( f \), the external saphena vein, penetrating the deep fascia and winding round the nerve to empty into the popliteal vein.

III. In its Upper Third—The vessel here enters the popliteal space, from the inner side of the thigh, and lies along the outer side of the inner ham-string. The nerve is external and superior to it, and the vein rather upon its inner side, but superficial to the artery.

Operation.—The most convenient posture for the patient is on the face. Make an incision, three inches in length, along the outer border of the semi-membranosus muscle, through the skin and superficial fascia; divide the deep fascia, as before, on a director; flex the leg, to relax the tension of the parts; feel for the artery along the inner ham-string; the nerve will first be found, then the vein, and, lastly, the artery. Isolate the vessel with the fingers and director, and introduce the ligature from within outwards.

In connection with wounds of the popliteal artery, it may be well to remember, that the dense aponeurotic popliteal fascia has the effect, by the resistance it offers, of preventing the enlargement of aneurismal tumors posteriorly, and they are forced to ascend into the lower and inner part of the thigh. Popliteal abscesses, also from this cause, point in the above region.

The Femoral Artery.—The external iliac, emerging from beneath Poupart's ligament, assumes the name of the femoral artery. It then passes obliquely downwards, backwards and inwards—at first being superficial, but gradually becoming more deeply seated—till, at the junction of the middle and lower thirds of the femur, it passes through the tendinous opening of the adductor magnus, where the vessel again changes its name to that of the popliteal artery. The artery in this course bi-sects the isosceles triangle, called Scarpà's, formed externally by the sartorius muscle and internally by the adductor longus. It is covered by the skin, superficial and deep fascia of the thigh, and has enclosed with it, in a dense sheath, which is a prolongation of the abdominal fascia, the femoral vein and internal saphenous nerve, a branch of the anterior crural. Below, the vessel is covered by the sartorius muscle, and soon after enters Hunter's canal, to pass through the opening in the adductor magnus. A line drawn from the centre of Poupart's ligament, to the inner
surface of the internal condyle, will very nearly indicate the course of the artery. The femoral is accessible in any portion of its course. The following are the operations thought worthy of description:

I. IN HUNTER'S CANAL.—For a case of popliteal aneurism, Mr. Hunter first tied the femoral artery in the tendinous canal, formed between the adductors and vastus internus muscle. The operation at this point, though abandoned at the present time for aneurism, is often required for hemorrhage from gun-shot wounds. It is more difficult than that in Scarpa's triangle, but, in case of hemorrhage, there is no choice.

Operation.—The limb should be placed in the semi-flexed position and turned on its outer side. Make an incision, about four inches in length, along the anterior margin of the sartorius muscle as it winds over the internal surface of the thigh. The internal saphena vein must be sought for by pressure above; it lies a little internal to the line of incision. The integuments and superficial fascia are cut through, and the fascia lata divided on a director. The anterior margin of the sartorius will be exposed; draw the muscle to the inner side, and the tendinous wall of Hunter's canal will be seen stretching from the adductor longus to the vastus internus muscle; introduce carefully the groove director, and cut through the tendinous fibres. The nerve will be found in front of the artery and the vein behind it. The union between the artery and the vein at this point is very intimate; they should be cautiously separated and the aneurism needle passed round the artery, excluding the nerve. The anastomotica magna artery sometimes may be wounded in this operation. It should be tied to avoid the embarrassment its bleeding would occasion. If the femoral is wounded in the canal, both ends should be secured, as the free anastomosis with the popliteal, just below this point, through the articular arteries, will ensure recurrent hemorrhage.

Explanation.—Plate VII. figure 32: a, the fascia lata divided; b, Hunter's canal laid open; c, the sartorius muscle, drawn upwards and outwards; d, the femoral artery, lifted on a director, with the ligature passed under it.

II. NEAR THE Apex OF SCARPA'S TRIANGLE.—The vessel here begins to be over-lapped by the sartorius muscle, and is somewhat more deeply seated than in the middle and upper
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part of the thigh. The femoral vein is here behind it and somewhat to its outer side, the long saphenus nerve is closely applied to the artery, within the sheath, rather upon its anterior and internal side, and a pretty large muscular branch of the anterior crural, supplying the vastus internus, follows the course of the vessel on the surface of the sheath. The skin, superficial fascia and fascia lata cover the region, and the trunk of the saphena vein generally runs immediately in the line of the incision.

Operation.—Place the limb on its outer side, with the leg semi-flexed and the thigh a little elevated; make an incision, about four inches in length, along the line of the artery, being guided somewhat by the prominence of the sartorius muscle, through the skin and superficial fascia. The saphena vein, which now appears, must be avoided. Open the fascia lata and introduce the director, dividing it in the line of the first incision. The inner border of the sartorius muscle will be exposed, overlying the artery; lift this out of the way, if necessary, and divide the deep layer of its sheath on a director, if it obscures the vessels. The sheath of the femoral vessels will now appear, with a muscular branch of the anterior crural nerve lying upon it; avoid this and carefully open the sheath, introduce the director and slit it a few lines; feel for the pulsations of the artery and introduce the needle from within outwards, avoiding injury to the vein, and excluding the long saphenus nerve from the ligature.

III. AT ITS MIDDLE AND UPPER PORTION.—The relations of the vessel do not differ materially in the middle and upper portions. The sartorius, while it can still be used as a guide, being the outer boundary of Scarpâ's triangle, no longer serves as the directing line for the incision. The true line is found midway between the sartorius and adductor longus muscle—from the middle of the base, formed by Poupart's ligament, to the apex of the triangle at the crossing of the two muscles. The saphena vein—always directly in the way—runs, here too, along the course of the artery, superficial to the fascia lata.

This is a region very much exposed in action, and the artery is here constantly found wounded in the course of ball-tracks traversing the limb in every variety of direction; direct, oblique, transverse, and sometimes longitudinal tracks plough through the artery and leave wide gaps between the proximal
and distal ends. From the denseness of the fascia lata, and probably from the fact that many of the wounds are received when the soldier is advancing, the anterior muscles contracted, preventing the track from being uniform, arterial wounds in this region are frequently complicated with diffused aneurism, obscuring the relation of parts and increasing the difficulties attending ligation. The importance of using the sound to re-establish the track, in searching for the arterial lesion, as described in a former paragraph,* apply usefully, we think, to the present region. To economize space, we here describe the simple operation.

Operation.—Place the patient in the recumbent posture, the limb being in a state of easy extension, rotated somewhat outwards and a little abducted. The course of the vessel being ascertained—by its pulsation or by rule—an incision, four inches in length, is made through the middle of Scarpa's triangle, beginning one or two inches, according to the situation of the wound, below Poupart's ligament. This divides the skin and superficial fascia, and, if high enough, exposes the superficial lymphatic glands of the groin. The internal saphena vein is more conveniently left in the internal side of the incision. Separate the edges of the wound and expose the fascia lata; open into it, introduce the director and divide upon it, the fascia to the full extent of the first incision. By the use of blunt instruments and sponges, the sheath of the vessels will soon be brought into view and the pulsations of the artery felt on relaxing the tourniquet. Pinch up a portion of the sheath with the fingers, to the outer side of the artery, make a small opening in it—unless, in case of wound, there is one—introduce the director through this and slit the sheath for a few lines. The femoral artery being thus exposed, it should be carefully isolated from the vein on the inner side and the saphenous nerve on the outer side,† and the ligature passed from within outwards.

Explanation.—Plate VII. figure 33, Arteries, exhibits the

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* Re-establishing the track, page 123.
† Expressions of pain on the part of the patient, when the ligature is tightened, are no certain indication that the nerve is included. The artery itself is sensitive. We scarcely ever ligate for secondary hemorrhage, when there is always more or less arteritis near the wound, that the patient does not manifest pain, unless deeply quieted by anaesthetics.
operation somewhat higher up than described above, the artery being represented too near the sartorius muscle for the region figured: \(a\), the fascia lata divided; \(b\), the sartorius muscle; \(c\), the femoral vein; \(d\), the femoral artery, with the ligature passed.

IV. Beneath Poupart's Ligament.—The relations of the femoral artery, under Poupart's ligament, are the following: The vessel passes from the abdominal cavity under the centre of Poupart's ligament, enclosed in a dense infundibuliform sheath, derived from the abdominal and pelvic fasciae. The artery is placed externally to the vein, with fibrous septa separating them from each other and the vein from the crural ring. The anterior crural nerve passes out half an inch externally to the artery, but a branch of the genito-crural nerve passes out upon its upper surface. In addition to the fascia superficialis and lata, the vessels are overlain in the groin, with quantities of loose cellular tissue and fat, besides numerous lymphatic glands. The pulsations of the artery are here, however, more distinct than elsewhere. The proper sheath of the vessels is, for some distance down the limb, larger than its contained structures. The trunk here passes over the pubic bone.

Operation.—Place the patient on his back, with the pelvis a little elevated and the thigh somewhat extended. The position of the artery being determined by rule and by its pulsations, the surgeon makes an incision, from two to three inches, in the course of the artery, beginning at the middle of Poupart's ligament; this divides the skin, superficial fascia and fat, and exposes the lymphatic glands—perhaps cuts one or two of them, which does no particular harm. Profuse bleeding is apt to follow this incision, from the numerous small vessels here given off from the femoral; these should be tied or twisted, and the fascia lata carefully opened and divided on a director—here, another bleeding is apt to occur—the deep external pudie lies generally under the fascia lata and is apt to get on the director. The funnel-shaped sheath of the vessels, formed by the descending abdominal fascia, is now exposed. This should be carefully opened in front of the artery on a director; the proper use of blunt instruments will now easily isolate the artery, when the ligature may be applied, without endangering the vein, or including the filament of the genito-crural nerve generally, closely connected with
the artery. The anterior crural nerve is not usually endangered in the operation, as it is ordinarily half an inch external to the artery, in the groove between the psoas and iliacus muscles.

Remarks—The operation just described, while it is sufficiently easy of performance, is yet one of the most dangerous—indeed, fatal—of all the ligations of the lower extremity. Military surgeons are compelled to ligate arteries at the seat of lesion often, even when the chances of success are of the faintest kind; we cannot, therefore, fully coincide with Mr. Erichsen in saying that ligations of the common femoral should be banished from surgery. The operation, however, should never be performed when it can possibly be avoided. The causes of its almost constant unsuccess are of two classes: 1st, failure in formation of internal clot, endangering, in so large a vessel, fatal subsequent hemorrhage;* and 2d, failure of collateral circulation ensuring fatal gangrene of the entire limb. This artery, both before and after its exit from the abdomen, gives off a number of vessels, which endanger the success of ligation at this point; above Poupart's ligament, the deep circumflexa ilii and deep epigastric, and also, sometimes, the obturator, as branches of the external iliac. Just after the trunk has passed the crural arch, numerous vessels also spring from it: the superficial epigastric, and the superficial and deep external pudic arteries, all have their origins clustering around the point, where the clot would have to form; and, if arrest of blood-movement is necessary for the formation of a coagulum, we certainly cannot expect one under such circumstances. Of twelve cases on record, in which the common femoral was tied, only three were successful; all the other nine being followed by secondary hemorrhage. Most of these twelve cases underwent the ligation for spontaneous aneurism, which dis-

* We are perfectly familiar with Mr. Guthrie's original observations and ingenious reasoning on the subject of the internal coagulum and the healing of the arterial coats after ligation. "A coagulum," says he, "contrary to the usually received opinion, is not necessary to the permanent closure of the artery, though it certainly assists in maintaining it." The question is otherwise determined by statistics, however, at least in regard to this particular artery at the region in question; and while we regard Mr. Guthrie's discovery and doctrine on this subject as of high value, we cannot deny that it seems to fail in application to the present case.
case, from its long obstruction to the main channel, fully establishes the collateral circulation, and obviates, in a great measure, the danger of a deficient blood-supply.

But, in cases of hemorrhage, with which the military surgeon has almost exclusively to deal, there is a more immediate and more inevitable disaster attending this ligation, than any failure of occlusion at the point of ligature—almost certain and fatal gangrene of the entire limb. The vessel in this case is here blocked up above the origin of both the great nutrient channels of the extremity. There is no profunda now left to re-inforce the obstructed superficial femoral, and the lesser avenues of collateral supply, thus suddenly called upon, cannot be soon enough dilated to furnish an adequate supply for so large and, in great part, so distant a region. That innervation necessary to blood-movement fails for want of the normal stimulus of nutrition, a universal paralysis of the circulation takes place throughout the limb, even the veins seem to fail to return the blood; general edema takes place, the surface becomes cold and mottled, and a progress of degeneration, both local and constitutional, the most rapid that can be described, soon terminates the case.

The present war has doubtless afforded, in many instances, the undesirable opportunity of witnessing the results above described where ligation of the common femoral was unavoidable. At the present moment the notes of only our own cases are before us. We mention them briefly in view of the paucity of records on this subject in surgical works. These are two cases in which we were called in consultation and requested to operate. One in General Hospital No 13,* the other in the First Georgia Hospital.+ In both of them, the circumstances of the hemorrhage, it seemed to all present, were such as to preclude the adoption of any other measure than the one practised. Both were cases of comminuted fracture in the upper third of the femur; there was great tamponade in the limb above the injury; both patients had been greatly exhausted, and the hemorrhage proceeded from a wound of the femoral, near the seat of fracture. The condition of each of these patients was plainly such as to forbid either, ligation at the seat of injury or ligation of the external

* In charge of Surgeon W. D. Hoyt.
† In charge of Surgeon J. A. S. Milligan.
iliac, or the amputation of the limb; any one of which three alternatives, though more formidable in the first place, would have been gladly preferred by us, if practicable. The result of both operations—for they were much alike in all important points—has been faithfully described in the foregoing paragraph.

The Profunda Artery.—This vessel, when bleeding, should be cut down upon and tied with two ligatures, and the attempt should not be made to arrest the hemorrhage by ligating the common trunk, above it.* The deep femoral is nearly as large as the superficial, and arises from the outer and back part of the common femoral, about one or two inches below Poupart's ligament. It first runs along the outer side of the sheath of the femoral vessels, but after some distance, passes beneath it and beneath the femoral vein, to the inner side of the femur, finally, passing through the adductor magnus. It rests, first on the iliacus, then on the adductor brevis, and lastly on the adductor magnus muscle. It is covered by the superficial fascia and the fascia lata, and has passing over it, a number of branches of the anterior crural nerve. Ligation of the profunda is seldom described in surgical works from the fact that it is not often the subject of spontaneous aneurism. As it is apt to require ligation in gun-shot wounds, we describe the operation as we have performed it in one case of hemorrhage, that of a wounded soldier in the First Georgia Hospital, and repeatedly, but a few hours ago, on the dead subject.

Operation.—Place the patient in the recumbent posture, with the thigh extended and somewhat abducted. An incision, beginning just below Poupart's ligament, and extending

* Finding no satisfactory description of this operation, and having performed it but once, we made three dissections, with the view of securing accuracy in our description. The relation of the profunda, to the femoral sheath and to the lish of anterior crural nerves, did not vary, but, in the two subjects examined, the point at which the common femoral bifurcated did not agree—in one only an inch, and in the other, nearly two inches, from the crural arch. We also proved the practicability of Mr. Guthrie's proposition to ligate the internal carotid by dividing the lower jaw. The stylo-hyoid ligament was much in the way, but did not actually require division. It seemed more convenient also to draw the par vacum outwards, instead of inwards, as Mr. Guthrie recommends. We think the internal pterygoid should be spared, if possible.
fully four inches down the thigh, should be made, as if to expose the common and a portion of the superficial femoral artery, except that to expose the profunda, the incision should be somewhat more external, its whole course being kept to the outer side of saphena vein. The superficial and deep fascia are now divided in a director. The fasciae and integument being held apart with bent spatulas, the sheath of the common femoral will appear in the centre of the wound. Feel now, first for the pulsations of the femoral, and then, less than half an inch external to it, for the profunda. This latter pulsation will be found generally, to begin at little over an inch from Poupart's ligament. Only blunt instruments should now be used to search for the vessel. The cellular tissue immediately around the profunda is quite tough and dense. We first come across many branches of the anterior crural nerve, running nearly parallel with the vessel, and rather external to it; by continuing the search between these branches and the femoral artery, we soon expose the trunk of the profunda. The isolation may be carried up to its origin or down the thigh, past the point where the two circumflex vessels are given off—but the situation of the wound must determine the point at which to apply the ligatures. The needle should be introduced from within outwards to avoid the femoral vein and profunda vein which are on the inner side and somewhat in front of the artery. The branches of the anterior crural nerve are easily excluded. Assisted by the sound in the track, the operation is even more simple than above described, unless the vessel be wounded very deeply in the neighborhood of the bone.

The External Iliac Artery—The external iliac artery, on each side, passes obliquely downwards and outwards from the division of the primitive iliae, along the inner border of the psoas muscle as far as Poupart's ligament, where it becomes the femoral artery. In this course the external iliac vessels are behind the abdominal muscles and the peritoneum and are enveloped by a thin layer of fascia derived from the iliac fascia, serving as their proper sheath. The artery is crossed at its commencement by the ureter, and near Poupart's ligament by the genital branch of the genito-crural nerve and by the circumflex ilii vein. It is separated externally from the psoas muscle by the iliac fascia; and posteriorly, it is in relation with the external iliac vein, which, at Poupart's lig-
ament, lies on its inner side. Lymphatic vessels and a few glands lie in the course of the artery. The trunk is free from branches till about to pass under the femoral arch when it gives off two of considerable size, the deep epigastric and deep circumflexa iliæ. The course of the external iliæ is indicated by a line drawn from a point a little external to the umbilicus to a point midway between the anterior superior spinous process of the ilium and the symphysis pubis.

There are several methods of operating recommended, but only two can be said to be of frequent practice—the one originally practised by Mr. Abernethy, and the other that of Sir Astley Cooper. The original operations are seldom performed without some modification, yet one or other of the two methods is generally adopted.

**Mr. Abernethy's Method.**—The patient should be laid on his back, but a little inclined to the opposite side, that the intestinal mass may gravitate away from the region to be operated on; the shoulders should be elevated and the limbs somewhat flexed. Make an incision three and a half or four inches in length in the course of the artery, beginning on a plane somewhat below and external to the umbilicus. This will be nearly perpendicular to the centre of Poupart's ligament, terminating about half an inch outside the external abdominal ring, falling short of the ligament. The skin and superficial fascia having been cut through, the external oblique should be divided on a director. The instrument should now be passed beneath the lower edge of the internal oblique and transversalis muscles, and these divided successively and cautiously to the extent of the first incision. The transversalis fascia being thus exposed, must also be similarly divided. The peritoneum now being reached, must be gently raised with the fingers, out of the iliac fossa, and pressed inwards toward the linea alba, when the artery will be felt pulsating along the inner side of the psoas muscles. The vessels are enveloped in a dense cellular membrane connecting it with the vein on the inner side; this must be torn through with the nail and the aneurism-needle passed between the vein and artery, and the point made to emerge on the outer side of the latter. It is safest to secure the vessel at some distance above the origins of the epigastric and circumflexa iliæ arteries. The anterior crural nerve is out of the way, being on the outer edge of the psoas muscles.
LIGATION OF EXTERNAL ILIAC ARTERY.

Sir Astley Cooper's Method.—The patient being placed in a position somewhat similar to the above, a similar incision, about four inches in length, is made, with its concavity directed upwards and inwards towards the umbilicus. This should extend from a little above and internal to the anterior superior spinous process of the ilium to the outer side of the external abdominal ring; by this, the skin and superficial fascia are divided and the external oblique tendon exposed. Make a hole in this, external to the outer column, and divide it on a director, thus exposing the inguinal canal, and the lower edge of the internal oblique and transversalis may be pushed upwards. The internal abdominal ring being now brought into view, is gently dilated and the finger, passed through this space, is directly applied upon the artery above the origin of the epigastric and circumflexa ili arteries. It is recommended to introduce the ligature from without inwards in the operation, but Mr. Guthrie prefers that it should be applied from within outwards, as he has seen the vein injured by the opposite proceeding.

Explanation.—Plate VII. figure 34, does not represent either of the above operations, but a modification described by Bernard and Huette: a, the internal oblique and transversalis muscles divided; b, the external iliac artery, with the ligature under it, and the vein to its inner side; c, the aponoeosis of the external oblique divided; d, the peritoneum pressed towards the median line. See also figure 35, plate VIII, for the anatomical relations of this vessel, and for the several lines of incision: a, Mr. Abernethy's line of incision; c, Sir A. Cooper's line of incision; b, dotted, showing Bogros's line of incision; f, the external iliac.

The points chiefly to be guarded against in ligation of the external iliac are: wound of the epigastric artery, or of some of the constituents of the spermatic cord, or laceration, or too great disturbance of the peritoneum, or puncture of the external iliac vein, or including the genito-crural nerve in the ligature. The epigastric, if wounded, can be secured, but its ligation would close, as remarked by Dr. Holmes,* an important anastomosis, and the chance of gangrene would be increased, though Mr. Guthrie† thinks it is not a very serious matter.

† Commentaries, page 289.
THE EPigastric Artery.—This artery arises from the inner side of the external iliac, near Poupart’s ligament and passing inwards between the peritoneum and transversalis fascia; it ascends to the margin of the sheath of the rectus abdominis muscle, and passes up the abdomen, in a line drawn from a point a little external to the umbilicus to about the middle of Poupart’s ligament. It is behind the inguinal canal and on the inner side of the spermatic cord at the internal abdominal ring. The operation for its ligation resembles somewhat that for reaching the external iliac, though it is not so extensive.

Operation.—An incision about two inches long should be made parallel with and a little above Poupart’s ligament. The centre of this incision should be at an equal distance from the spine of the ilium and symphysis pubis. The skin and cellular tissue being divided, introduce a director and divide the aponeurosis of the external oblique in the same direction. Follow the spermatic cord to the internal abdominal ring, which must be dilated with the finger. The epigastric may be felt on its inner edge; it has a vein on either side of it. The cord may be pressed a little outwards and the artery isolated and secured in the usual manner.

THE PRIMITIVE ILIAC Artery.—The common iliac arteries, the terminal branches of the abdominal aorta, are about two inches in length, and extend generally from the body of the fourth lumbar vertebra, divergently at each side, to the margin of the pelvis, opposite the sacro-iliac symphysis, where they each divide into the internal and external iliac arteries. The relations of the two vessels differ on the two sides of the body. The right is in relation in front with the peritoneum, and is crossed at its bifurcation by the ureter, behind with the two common iliac veins, and externally with the psoas magnus. The left is also in relation in front, with the peritoneum and ureter, but, in addition, is crossed by the rectum and superior hemorrhoidal artery. It is in relation only with the left iliac vein, which is behind it, and with the psoas muscle externally. Gun-shot wounds of the primitive iliac are generally immediately fatal, only the fortunate accident of traumatic aneurism ever allowing the opportunity for ligation as a result of such injuries.

Operation.—Place the patient in a position similar to that in which the external iliac is tied. Make a slightly curved
incision four or five inches in length, extending one half above, the other half below the anterior superior spinous process of the ilium. This divides the skin and superficial fascia down to the external oblique muscle, and should commence nearly on a level with, and external to, the umbilicus. The muscles should then be carefully cut through in succession on a director till the fascia transversalis is arrived at; this also must be very cautiously opened and the director slipped between it and the peritoneum, so as to divide it to the requisite extent. Now draw the peritoneum upwards and inwards, towards the umbilicus. The ureter should be raised with the peritoneum from over the vessels that it may be out of the way of the ligature. The common iliac artery may now be felt and seen, if the wound is properly held apart; the vessel should be carefully isolated, with the fingers, and the aneurism needle passed from within outwards on the left side, and from without inwards on the right, to avoid injury to the vein in its varying relation to the artery on the two sides. The ligature should be applied a short distance—little over half an inch—above the bifurcation of the trunk. See plate VIII, figure 35: d, the common iliac; r, line of incision for common iliac.

The exact location of the incision, so far as reaching this artery or the external iliac, is not of vital importance, but it is best not to make it too perpendicular on account of the bulging or the bag of the peritoneum with the intestines, which seems greater as the incision approaches the median line. The quillsuture or silver wire, will be found the best mode of stitch to be used in closing these wounds.

THE ABDOMINAL AORTA.—The aorta enters the abdomen between the two pillars of the diaphragm. In its course downwards it rests on the vertebral column to the left of the median line terminating on the fourth tendon vertebra, in the common iliac arteries. It has the vena cava on its right side, and on its left side a number of veins and sympathetic nerves. The vessel has been exposed and ligated, as is well known, by Sir Astley Cooper and several other surgeons—each time with a fatal result.

Operation.—The vessel could be reached by an incision similar to the one recommended for the ligation of the common iliac. Sir Astley Cooper made an incision along the linea alba, about three inches in length, a little to the left of the umbilicus. After opening the peritoneum, he pushed aside
the intestines, detected the vessel by its pulsations, and tore through the intervening layer of serous membrane, with his finger-nail, on the left side, then carried the finger under the vessel, and introduced the needle from left to right. The vessel may be ligated about an inch above its division. It is difficult to conceive of any circumstances, of either the field or hospital, which would justify this last and most desperate resort for the staunching of hemorrhage.

**The Internal Iliac Artery.**—The other terminal trunk of the primitive iliac is intended to supply the visceræ and walls of the pelvic cavity. The internal iliac is a short, thick vessel, about an inch and a-half in length, extending from the point of bifurcation of the common iliac downwards, to the upper margin of its great sacro-sciatic foramen, where it divides into an anterior and a posterior trunk. Like the primitive and external iliac arteries, it has the peritoneum spread over it in front and near its origin, the ureter crosses it to reach the lower fundus of the bladder. On the other side is the psoas magnus muscle, and behind it is the internal iliac vein, lumbo-sacral nerve and pyriformis muscle. The artery has been tied a number of times, for aneurism of one or other of its branches.

**Operation.**—The patient is placed, as in the preceding operations, on the primitive and external iliac. Make an incision, about five inches in length, slightly convex outwards, commencing about half an inch to the outer side of the external abdominal ring and an inch above Poupart's ligament, so as to avoid the spermatic cord. The line of incision should be nearly parallel with the course of the epigastric artery, but a half or three-quarters of an inch to its outer side, and should terminate little over an inch above, and to the inner side of, the anterior superior spinous process of the ilium. The skin and superficial fascia being divided, the several muscular strata should be divided on a director. It is probable certain branches of the superficial epigastric and superficial circumflexa illi may require tying in the course of the incision. The transversalis fascia having been reached, it must be carefully opened by pinching through it with the finger-nail, and the director introduced upwards and downwards, so as to divide it to the required extent. The peritoneum is then to be carefully separated on the iliac side with the index-finger, and drawn, with the bag of intestines towards, the linea alba. Continue
now carefully to separate the membranes towards the sacro-vertebral articulation, with the left hand, following up the movement with the thumb and finger of the right hand, till the external iliac artery is reached. This is our guide, first to the bifurcation, and secondly to the descending trunk of the internal iliac, which we are seeking. The point at which this divergence takes place is nearly opposite the centre of a line drawn from the anterior superior spinous process of the ilium to the umbilicus. Use the left fore-finger to isolate the artery on its inner side, and the right for the outer side. It may be either hooked up with the left fore-finger, or picked up between the fore-finger and thumb of the right hand, and pulled inwards from the wall of the pelvis. In passing the ligature, an object of particular care is to avoid the ureter, which is near the origin of the artery and on its inner face. The instrument, best adapted for introducing the ligature in a vessel so deeply seated, is that heretofore described (page 110) and represented on plate I. figure 7. The ligature should be passed, from within outwards, to avoid injury to the veins. The fore-fingers of both hands should be deeply introduced into the wound, back to back, so as to secure strangulation of the vessel in tightening the ligature. The parts should be properly drawn together afterwards and united with the quill-suture or with silver-wire. See plate VIII. figure 35, Arteries: c, the internal iliac artery, given off from the primitive; h, the ureter, passing over the vessel; m, the psoas magnus muscle.

Some of the branches of the internal iliac are interesting, on account of the frequency of gun-shot wounds of the buttock:

The Gluteal Artery.—This is a short, thick trunk, which passes downwards to the upper part of the great sacro-sciatic foramen. Escaping from the pelvis, above the upper border of the pyriformis muscle, it immediately divides into a superficial and deep branch. The trunk of the gluteal is deeply situated, being covered by the gluteus maximus and medius muscles, and often, by a very great thickness of dense fat; besides this, to reach it, we will encounter probably many of its muscular branches, the bleeding from which will much obscure the operation. The two branches of the gluteal, the superficial lying between the gluteus maximus and medius, and the deep, along the superior curved line of the ilium are
even more liable to be wounded than the main trunk. They are neither of them so deeply seated. A line, drawn from the posterior superior spine of the ilium to the trochanter major, marks the course of this vessel.

Operation.—Neither this artery, or its branches, should ever be searched for, except in case of their being wounded and bleeding. For aneurism, the ligature is applied to the internal iliac. In case of a gun-shot wound, the vessel can be best found by introducing the sound to re-establish the track of the ball. Then either follow the sound, or cut transversely to it, as near as possible the line of the branch suspected to have been wounded. The accumulation of clots will lead to the situation of the wound along the line of the sound. If the superficial branch is wounded, it will be found by reaching the intermuscular layer, between the gluteus maximus and medias muscle, and extending the separation up towards the crest of the ilium, till the beating of the vessel, or the fibrinous accumulation about the wound, shall indicate its position.

Mr. Guthrie* gives the following description of the operation: Place the body on the face, turn the toes inwards; commence the incision, one inch below the posterior spinous process and one inch from the sacrum; carry it on towards the great trochanter, in an oblique direction, to the extent of five inches. Divide the gluteus muscle and the aponeurosis beneath it, and seek for the artery as it escapes through the upper and anterior part of the sciatic notch, lying close to the bone. If the vessels of the gluteus muscle bleed so as to be troublesome and cannot be stopped by compression, they must be secured.

Plate VIII. figure 36, Arteries, exhibits the incision and the artery raised on an instrument.

The Sciatic Artery.—The sciatic artery is also distributed to the muscles on the back of the pelvis. It emerges from the pelvis, through the lower part of the great sacro-sciatic foramen, between the pyriformis and coccygeus muscles. It then descends in the interval, between the trochanter major and tuberosity of the ischium, in company with the sciatic nerves, and covered by the gluteus maximus muscle, dividing into two branches, which supply the deep muscles at the back of the hip, one branch accompanying the great sciatic nerve.

* Commentaries, page 269.
LIGATION OF INTERNAL PUBIC ARTERY.

some distance down the thigh. A line drawn from the posterior superior process of the ilium, to the tuberosity of the ischium, will traverse the point of exit of the artery at its centre.

Operation.—The patient should be laid with the body face-downwards, with the foot inverted. Let the centre of a vertical incision, over three inches long, fall upon the point of exit of the artery as given above. This incises the skin, cellular tissue and fat, down to the coarse fibres of the glutens maximus—dividing as few as possible—over the lower part of the sciatic notch. The sciatic nerve will soon be seen, which, being followed up, will lead to the artery which is found at its inner side, the vein is also to its inner side but somewhat posterior. There will be no difficulty in isolating and securing the vessel, provided the wound is held open with blunt spatulas.

Mr. Guthrie advises that an incision similar to, and in the same direction as that used to reach the gluteal be made to expose the ischiatic artery, only that it must be made an inch and a half lower down than the one for the gluteal. It must be recollected, however, that the two operations just described contemplate the ligation of each vessel at a particular part of its course. This selection is only allowable when these vessels are to be tied for aneurism; when they are wounded it is advisable to ligate the vessel in the track of the wound at whatever portion that may traverse it, applying two ligatures, one to each end of the divided vessel, otherwise recurrent hemorrhage is apt to prove the operation perfectly useless. The sound should be introduced if practicable—we know then that it transverses the arterial wound, and our duty is to cut through, by the nearest and most practicable route, all intervening tissues not endangering life, so as to arrive at and secure the bleeding vessel.

The Internal Pudic Artery.—The internal pudic is one of the terminal branches of the internal iliac. It descends to the lower part of the great sacro-sciatic foramen, through which it emerges from the pelvis between the lower border of the pyriformis and the coccygeus muscles. It here crosses the spine of the ischium, re-enters the pelvis through the lesser sacro-sciatic foramen, passes forward over the tuberosity of the ischium, about an inch from its border, to the ramus; now, ascending along the ramus of the ischium and pubis, it pierces the triangular ligament near the symphysis, and divides into
its two terminal branches the cavernous artery and the dorsalis penis. Like the gluteal and ischiatic arteries, it is covered by the gluteus maximus muscle while external to the pelvis, and is consequently very deeply seated. The artery may be reached at two places should it be deemed necessary to ligate it.

I. On the Spine of the Ischium.—The vessel is here, for a short distance—half an inch—on the outside of the pelvis, but it is most frequently covered by some of the dense fibres of the greater sacro-sciatic ligament. Place the patient on the face. Make an incision from about an inch below the posterior spinous process of the ilium for five inches towards the trochanter major, through gluteus maximus, and search for the vessel on the spine of the ischium, which separates the lesser from the greater sacro-sciatic foramen. Some of the fibres of the ligament overlying the vessel must be cut through and the artery may be isolated and tied as it crosses the outer surface of the spine of the ischium. It will be found here without fail.

II. In the Perineum.—The artery here is just within the ascending ramus of the ischium. The patient should be placed in the position for lithotomy. The rami of the pubis and ischium may be felt beneath the skin below the symphysis pubis; make an incision vertically along this line of projection dividing the fascia carefully, then feel, just within the inner border of the ramus, for the pulsation of the vessel. It may here be found and secured, care being taken to include nothing but the artery in the ligature.

Explanation.—Plate VIII, figure 88, Arteries, is a representation of the operation for ligature of the internal pudic in the perineum.

Anastomoses.—The anastomotic communications of the inferior extremity although, in general, not so abundant and direct as those of either the superior extremity or of the head and neck, are still sufficiently so to render the measure of ligation of the main trunks warrantable in almost every region of the limb, so far as the apprehension of a non-supply of nutrition is concerned. Indeed, unless for some object worthy the risk, as to combat destructive inflammation or to avoid increased peril to the patient, this freedom of inosculation is such as to render ligation in the continuity a somewhat doubtful measure in wounds of arteries, for fear of recurrent hemorrhage. In the foot and ankle we have seen that the anterior and posterior
tibial and the peroneal communicate freely through the plan-
tar arch and the perforating and the malleolar arteries; at the
tune, these vessels of the leg combine with those of the thigh
to form a network of communications—a universal and most
interesting *rete*—which enmeshes the joint externally and
penetrates into the interior of the bone, making its cancellous
structure, perhaps, the most vascular of any part of the osseous
system, and accounting for the obstinacy and destructiveness
of inflammation in this joint, by inoseulations between the re-
current and muscular branches with the articular arteries of
the popliteal. All along the thigh, a collateral chain estab-
lishes by-channels for the blood, from the upper to the lower
region, by the perforating branches of the profunda; and
lastly, around the hip-joint the communication seems so abun-
dant, that the internal iliac and its branches may be almost
considered the *grand anastomotic trunk* between the body and
the lower limb, accomplishing between the two, a thorough
community of circulation. The gluteal, the ischiatic, the in-
ternal pudic and the obturator anastomose freely with each
other, and by communication with arteries above and below
constitute an unfailing collateral circulation.

In consequence of this very free communication, anastomo-
tic aneurisms of the gluteal region are of frequent occurrence,
and ligation of the affected trunk does not always succeed in
curing them. For the same reason, has it been found neces-
sary in gun-shot wounds of these arteries to apply two liga-
tures at the point of lesion. We should not be deterred from
cutting down upon and searching for, either the gluteal or is-
chiatic when bleeding, by the depth and frightfulness of the
incision required to reach them. We all know with how lit-
tle ceremony and how indiscriminately a fragment of shell
often ploughs through and tears away a large portion of these
muscles, and also how little permanent injury is sustained,
and also how rapidly nature will replace the deficiency by
granulation, when she has the blood to do it with; certainly,
no amount of judicious cutting by the surgeon, to save this
blood, could be more irreparable than this.

In the surgical treatment of hemorrhage, *impossibilities*

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* These articular vessels enlarge greatly during inflammation of
  the knee-joint; and when amputation is necessary, after it has long
  existed, a large number of them require ligation.
sometimes stare us in the face, and the most conscientious dis-
charge of duty may prove entirely unavailing. When we have
faithfully carried out, however, the well considered determin-
ations of an enlightened judgment, we are free from blame
for the result, no matter how disastrous or however much to
be deplored. Suppose, in some extreme case, life should give
out in the very midst of our earnest efforts to save it—even
this sad event will be less painful to the military surgeon and
to the true man, than the enduring, bitter reflection that, he
had either carelessly, or indolently, or ignorantly, or procras-
tinatingly, or even timidly, allowed a wounded fellow-soldier—
to Bleed to Death.