

ARTERIAL INJURIES IN A THEATER OF OPERATIONS

COL. JAMES A. KIRTLEY, JR., M.C., A.U.S.

A GENERAL HOSPITAL in a Theater of Operations receives a variety of arterial injuries. Battle-incurred arterial injuries are usually dealt with in Forward Hospitals, but not infrequently these injuries are not apparent until the patient has been evacuated to the Base, usually a matter of a few days. Arterial injuries seen at the Base may be divided as follows:

I—Traumatic vasospasm, without laceration of the artery.

II—Direct arterial injury:

A. Early results of injury.

B. Late results of injury.

III—Pulsating hematoma (traumatic aneurysm).

IV—Arteriovenous aneurysm.

I—Vasospasm is a protective response to trauma, but if the arterial tree of an extremity becomes, and remains, constricted, then thrombosis, trophic changes, fibrosis and lesions resembling Volkman's ischemic contracture may follow. It has been pointed out by DeBakey,¹ and Elkins,² that remote trauma may result in complete spasm of an artery. We have observed 12 patients with persistent posttraumatic vasospasm in which the arteries were not directly injured. The involved extremities were cold, cyanotic and often edematous. Vasospasm could be temporarily abolished by paravertebral injections of novocaine (1 per cent). In the more severe cases, preganglionic sympathectomy was performed, with good result. The following case history is typical of this group:

Case Report.—A 28-year-old, white, male, received shell fragment wounds of the right upper leg and right lower thigh in February, 1944, near Cassino, Italy. Fifteen hours later, at an Evacuation Hospital, the wounds were débrided and the shell fragment removed from the leg through an elective incision along the head of the fibula. Exploration of the posterior tibial artery showed it to be in marked spasm, but the popliteal artery could be felt to pulsate. Lumbar paravertebral injection was done immediately, as the foot was cold, with absent peripheral pulses. Three more injections were done within the next few days. The patient was admitted to this hospital 13 days after injury. The right foot was colder than the left, slightly swollen and the peripheral pulses were questionably palpable. The wounds were closed two days after admission, and it was necessary to repeat the paravertebral "block" as the foot became cyanotic and clammy. The wounds healed normally, but the foot continued clammy and cyanotic, becoming warm and pink only after "blocks." Femoral pulsations were normal, but neither the popliteal nor peripheral pulses could be felt. In all, eight paravertebral novocaine injections were done. A month after injury preganglionic sympathectomy was performed. The foot became flushed and warm in eight hours, and the peripheral pulses remained palpable.

Other patients in this group show that posttraumatic vasospasm may persist over long periods of time, and may be either segmental or may involve the entire arterial tree of the extremity. If vasospasm is not eliminated by a series of paravertebral "blocks," we feel that sympathectomy should be considered.

II—Direct Arterial Injuries.—A—*Early Results*: Direct trauma to major arteries usually leads to thrombosis at the site of injury, formation of a traumatic aneurysm, or formation of an arteriovenous fistula. The latter two were combined in one of our cases.

Ligation of the lacerated artery (and usually its concomitant vein) at the time of the initial débridement is the procedure usually carried out in most instances. The records show that few attempts at repair or end-to-end anastomosis have been attempted in the Forward Hospitals. Captain Pryor,³ in studying 361 major extremity amputations performed or admitted in this hospital, found that approximately 20 per cent were done because of inadequate blood supply alone. A study of 55 patients whose arterial injuries resulted in amputation showed almost half of them (25) were due to popliteal artery injuries alone and 18 followed femoral artery injuries. In all, we have observed 29 patients whose popliteal artery was ligated. Twenty-five of them had gangrene, which required amputation (86 per cent). It may be significant that of the four whose extremities remained viable, three had lumbar ganglionectomies, and the other one had repeated paravertebral injections. It is recognized that other factors may be of greater importance in determining viability of the leg.

Our experience with the nonsuture anastomosis of blood vessels, suggested by Blakemore, Lord and Stefko,⁴ has been limited to three patients, upon whom the procedure was done before admission to this hospital. Two of these soldiers had a viable foot, but the third developed dry gangrene of all toes. Since the anastomosis was undertaken because of laceration of the popliteal artery, we feel that the result obtained was better than that usually effected without the venous anastomosis. Peripheral pulses were not palpable in any of the three extremities, and arteriograms have shown that the medium did not go through the anastomosis.

In an effort to decrease the number of amputations secondary to arterial injury, sympathectomy has been performed upon eight patients (Table I). Two of them with popliteal ligation eventually required amputation through the leg. These two patients had been injured for five and four days, respectively, and had not received paravertebral injections. Three other patients had sympathectomy within 48 hours after popliteal artery injury, and the extremity remained viable. This series is too small for any definite conclusions, but the results suggest that early sympathectomy in major arterial injuries may help preserve a part, or all, of an extremity.

B—*Late Results*: The late results of major arterial ligation, also, deserve consideration. In a series of seven patients whose femoral or popliteal artery had been ligated, there was evidence of chronic arterial deficiency. This was characterized by intermittent claudication on walking, "muscle cramps" at rest, weak to absent peripheral pulses and trophic skin changes, as well as comparative coolness of the extremity. Preliminary paravertebral injections showed a favorable response, and sympathectomy gave excellent results (Table II). Bigger⁵ recently reported on 29 patients with aneurysm,

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TABLE I
LUMBAR SYMPATHECTOMY IN "EARLY" ARTERIAL INJURIES

Case No.	Age of Patient	Preoperative Findings	Interval v.s. Injury and Sym.	Operative Result	Remarks
1	31	Ligation com. femoral. D/3 leg cold. Gangrene of 2nd toe	6 days	Probably unchanged	Supracondylar amputation required 48 hours later, as the entire gastrocnemius appeared necrotic. Extremity had been elevated on 4 pillows prior to admission.
2	34	Comp'd fracture tibia and fibula. Early gangrene of toes, with cold foot	13 days	Improved	Foot became warmer following operation, but amputation at the ankle was done 10 days later for the preexisting gangrene.
3	47	Ligation popliteal artery. Cold, discolored foot	4 days	Little change	Gas gangrene developed in the leg wound on the 6th day after injury, and amputation was done. Extensive thrombosis of vessels throughout the leg was found on dissection.
4	28	Ligation popliteal and comp'd frac. fibula. Gangrene great toe	5 days	Leg became warmer	Amputation lower 3rd of the leg was done 3 days later because of fever, necrosis of gastroc. and soleus muscles. It was felt that sympathectomy probably permitted amputation at a lower level.
5	19	Ligation com. femoral. 4 lumbar "blocks." Cold, pulseless foot	2 days	Excellent	Foot became suddenly warm about 40 hours after operation, and remained as warm as the normal one.
6	20	Ligation popliteal. 1 lumbar block. Comp'd fracture head of fibula	1 day	Fair	Skin gangrene of tips of two toes developed, but foot remained warm.
7	19	Laceration popliteal artery and vein. Foot pulseless	8 hours	Good	This patient also had a nonsuture anastomosis, using segment of saphenous vein and vitallium cuffs (Blakemore).
8	27	Ligation popliteal. Foot cold	1 day	Good	Foot remained warm and viable.

TABLE II
LUMBAR SYMPATHECTOMY IN ARTERIAL DEFICIENCY

Case No.	Age of Patient	Preoperative Findings	Interval v.s. Injury & Sym.	Operative Results	Remarks
1	27	Ligation Common femoral. Angina crisis. Cold foot	34 days	Improved	There was marked increase in the warmth of the foot and leg and decrease in the cramping.
2	22	Ligation superficial femoral. Cool foot	30 days	Excellent	The foot remained much warmer than the uninjured extremity. Patient's walking range was greatly increased.
3	21	Ligation common femoral. Intermittent claudication	71 days	Excellent	Can walk about ten times as far, before cramping occurs.
4	21	Ligation superficial femoral. Claudication after 200 yards	86 days	Excellent	Foot remained much warmer, and claudication disappeared.
5	29	Ligation of popliteal comp'd fract. femur. Cold, swollen foot	11 days	Excellent	Preoperative "blocks" caused flushing of the foot. Postoperative, the foot could be elevated in skeletal traction without blanching as before operation.
6	22	Ligation femoral vessels. Claudication on walking	68 days	Excellent	Walking range greatly increased. Patient returned to duty.
7	20	Ligation popliteal vessels. Daily lumbar blocks for 6 days	19 days	Good	Patient had developed a small area of necrosis on heel. Foot became much warmer, and wounds healed promptly.

or A-V fistulae, followed over a period of years. He found that a high percentage of these patients had chronic arterial deficiency when the main artery had been ligated. He suggests that sympathectomy may help relieve this deficiency.

III—*Traumatic Aneurysms*.—Traumatic aneurysms (pulsating hematoma) may not be apparent until some days after injury. When present, conservative measures have been carried out unless strong indications for early intervention exist. Such indications were present in about 40 per cent of our patients with aneurysms (Table III). The remainder were returned to the Zone of the Interior. In three instances, the expansile pulsation and systolic bruit previously present, spontaneously disappeared while the patients were awaiting evacuation.

TABLE III
TRAUMATIC ANEURYSMS

Artery Involved	Interval v.s. Injury & Oper.	Indications for Operation	Operation	Comment
Rt. axillary (3rd portion)	24 days	Increasing size of mass. Pain — Pressure on brachial plexus	Excision of artery involved. Ligation of ant. circumflex humeral. Ligation of axillary vein	Paravertebral (T 1, 2, 3) blocks with novocaine. Extremity warm. Normal union of clavicle.
Rt. axillary (2nd portion)	13 days	Severe secondary hemorrhage from aneurysm	Excision of artery involved with the "false" sac	Stellate ganglion block. Extremity warm and viable. Edema subsided in five days.
Rt. external carotid	20 days	Increasing pulsatile mass. F.B. of neck	Excision of artery involved with the "false" sac	No cerebral changes.
Lt. radial (midportion)	28 days	Superficial expansile tumor	Segment of artery and aneurysm excised <i>en masse</i>	Duty.
Rt. axillary (3rd portion)	5 hours	Tremendous hematoma. Absent radial pulse	Division and ligation axillary artery. Ligation of post. humeral and subscapular	Two paravertebral injections. Hand warm, and sensation and motion improved.
Rt. subclavian (3rd portion)	15 days	Undébrided wound of clavicle. Absent radial pulse. retained M.F.B.	Excision of lacerated segment. Subperiosteal resection medial ½ of clavicle	Paravertebral "block." Nail bed circulation good. Plaster yoke for three weeks.
Lt. superficial femoral	38 days	Increase in mass and severe pain in extremity 7 hours previously	Common femoral isolated through separate incision. Excision of lacerated segment and aneurysmal sac.	Preliminary lumbar sympathectomy. (8 days prior).
Lt. superior gluteal	8 weeks	Sudden increase in mass, with pain. Bruit had disappeared	Excision of aneurysm	No complications.
Lt. ext. carotid	10 days	Profuse hemorrhage into mouth	Ligation of external carotid, and plication of aneurysmal sac	No cerebral changes.
Rt. popliteal	2 hours	Hematoma. Cold, pulseless foot	Ligation and division of artery and vein	Multiple paravertebral blocks. F.C.C. femur treated with leg elevated only a few inches. Extremity viable.
Lt. common carotid	0.5 hour	Hematoma. Hemorrhage from stab wound	Ligation with transfexion sutures	No cerebral changes.
Rt. common carotid	8 days	Massive sec. hemorrhage. Aneurysmal sac	Excision of bifurcation of carotid, with ligation of common, int. and ext. carotid arteries	No cerebral changes.

Case 1.—This 25-year-old male had multiple, severe battle injuries, resulting in exteriorization of the hepatic colon, a compound spiral tibial fracture, hematoma of the right anterior aspect of the shoulder, and other extremity injuries. The hematoma was partially evacuated and a drain inserted through an axillary stab incision. Three days after admission to this hospital (10 days after injury) there was sudden increase in size of the right subpectoral mass and severe "burning" pain which involved the right upper extremity. Function of the hand and forearm became greatly impaired with hypesthesia over the radial and median nerve distribution. Blood pressure, right, was 104/76, left, 130/78. The mass was expansile and a systolic bruit was present. The pain became severe and required morphine at frequent intervals.

At operation (24 days after injury), the subclavian artery was temporarily occluded through a separate incision after dividing the clavicle. The aneurysm was then opened and the lacerated axillary artery divided between ligatures. The anterior circumflex humeral was also ligated at its origin at the site of injury. The hand remained warm, and motor and sensory function improved rapidly. Two paravertebral blocks were done postoperatively.

Case 2.—The indication for operation on this patient was severe secondary hemorrhage 13 days after injury. The false sac and segment of axillary artery involved were excised, and stellate ganglion block performed, but there was never any doubt as to the viability of the hand.

Case 3.—The expansile, pulsating mass in the neck steadily increased in size. The damaged portion of the right external carotid artery and false sac were excised without any complications.

Case 4.—This aneurysm involved the left radial artery, and following excision the patient was discharged to full duty.

Case 5.—This 23-year-old, white male was shot just above the right breast. On admission to this hospital, five hours later, there was an enormous hematoma of the right axillary and right pectoral regions, absent right radial pulse, and the hand was cold. There was no bruit. There was a 15-mm. laceration of the circumflex humeral arteries, so that ligation of the three vessels was necessary. The axillary artery was divided between ligatures. The distal stump pulsated feebly. The concomitant vein was also ligated. Paravertebral injections were performed postoperatively, and the hand remained warm and steadily improved in strength.

Case 6.—This 19-year-old, white, male, sustained a penetrating shell fragment wound of the right clavicular region, and was in profound shock when admitted to a Forward Hospital. There was a compound comminuted fracture of the clavicle. External hemorrhage ceased, and no operative procedure was carried out. There was paralysis of portions of the brachial plexus. On admission to this hospital, 12 days after injury, the wound of entry was infected, with spicules of clavicle exposed, absent radial pulse, but a viable hand. Penicillin administration was begun 48 hours before operation. The wound of entry was excised, and the medial half of the clavicle resected subperiosteally. The hematoma surrounding the subclavian artery was undergoing organization. The artery was found to be almost divided just lateral to the anterior scalene muscle. The artery was divided between transfixion ligatures. The distal stump pulsated slightly. The postoperative course was uneventful. A figure-of-8 plaster yoke was removed after three weeks. The radial pulse could not be felt but the hand was quite warm.

Case 7.—This patient sustained a penetrating shell fragment wound of the left mid thigh. His record stated that the wound was débrided and the foreign body was not removed. A week later the patient had two secondary hemorrhages, and a large, pulsating hematoma was noted. On admission to this hospital an expansile mass the size of a grapefruit was present on the anteromedial aspect of the left upper thigh. There was a systolic bruit present. The foot was warm, though the peripheral pulses were barely palpable. The mass increased in size, and the patient complained of pain

in the thigh at all times. The second, third and fourth lumbar sympathetic ganglia and trunk were removed as a preliminary measure, since it was felt that the aneurysm might involve both the superficial and profunda femorals and the common femoral.

Eight days after sympathectomy the mass suddenly increased in size, and the pain became intense. The common femoral artery was temporarily occluded through a small, separate incision before exposing the large aneurysm. The aneurysm contained about 1,000 cc. of clotted and unclotted blood. The defect in the superficial femoral artery was too large for repair, so the entire segment just distal to the origin of the profunda down to a branch below the laceration was excised. There was bleeding from the distal stump. The vein was also sectioned between transfixion ligatures. The shell fragment was found in the clotted blood. The postoperative course was uneventful. The foot remained quite warm.

TABLE IV
ARTERIOVENOUS FISTULAE

Site of Fistula	Interval v.s. Injury & Oper.	Preoperative Findings	Operation	Comment
Post. tibial (M/3)	8 weeks	Machine-like murmur. Continuous thrill. Branham's sign	Quadruple ligation, and excision of fistula	Duty.
Post. tibial (M/3)	5 weeks	Machine-like murmur. Continuous thrill. Branham's sign	Quadruple ligation, and excision of fistula	Duty.
Lt. common carotid-jugular	5 weeks	Loud murmur; strong thrill; and large M.F.B. at site of fistula	Quadruple ligation, and excision of fistula	M.F.B. 1.5 x 1.5 x 1.0 cm found to lie in the aneurysmal varix sac. No cerebral changes.
Rt. axillary vessels (P/3)	9 weeks	Right brachial 80/70. Left brachial 130/70. Branham's sign — 18 min.	Quadruple ligation, and excision. Brachial plexus neurolysis	Proximal 2/3 clavicle resected subperiosteally. Hand warm. Pulsation distal axillary stump noted.
Lt. profunda femoris vessels	6 weeks	Machine-like murmur, and large aneurysmal sac	Ligation and excision of vessels. Evacuation of large hematoma	Patient had severe pain from false aneurysm. Good pulsation post-operative.
Lt. brachial vessels (M/3)	8 weeks	Murmur and thrill. Branham's sign. Radial pulse good	Ligation of vein and endo-aneurysmorrhaphy	Arteriogram showed artery to be patent post-operatively. Hand warm. Good radial pulse.
Rt. subclavian vein (1st portion)	8 weeks	Typical machine-like murmur, and thrill. Radial pulses equal	Excision varix proximal subclavian vein and adjacent scar tissue	No definite arterial communication with the dilated varix was found. Normal findings after operation.

Case 8.—This patient had multiple severe shell fragment wounds. A systolic bruit was noted over the left buttocks soon after admission to this hospital, but gradually disappeared. Two months after injury there was sudden pain and increase in the size of the mass. The aneurysm was excised.

Case 9.—This is the only instance in which the hunterian operation was carried out. The patient had a compound fracture of the mandible and secondary hemorrhage into the mouth. The intermaxillary bands were removed and pressure made over the carotid until the external carotid could be occluded. This checked the bleeding but the wound of entry was enlarged and plication of the aneurysmal sac carried out. There were no further complications.

Case 10.—This patient sustained a gunshot wound of the right lower thigh, with laceration of the popliteal artery and a compound fracture of the femur. On admission, two hours later, there was a large hematoma, and the foot was cold and pulseless. The popliteal artery was divided between ligatures after evacuation of the hematoma.

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The popliteal vein was then ligated. Repeated paravertebral injections were carried out postoperatively. The foot became cadaveric in appearance on even slight elevation, but remained viable, and the fracture healed normally.

Case 11.—This 39-year-old, colored, male, was stabbed in the neck with a meat knife by another neuropsychiatric patient. There was profuse hemorrhage which was partially controlled by digital pressure. Under endotracheal anesthesia, the wound was enlarged, and the left common carotid found partially divided after the large hematoma had been evacuated. The artery was ligated. There were no cerebral complications during the next six weeks, and the patient was returned to duty.

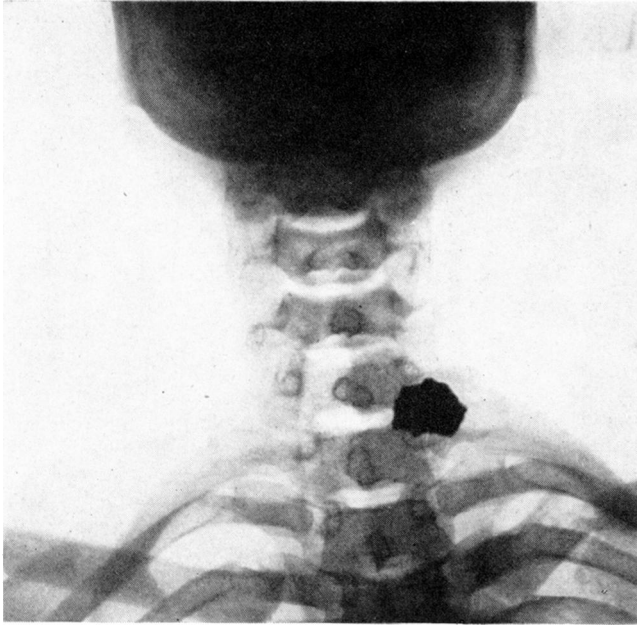


FIG. 1.—Anteroposterior roentgenogram.

Case 12.—This 30-year-old, white, male, had massive secondary hemorrhage into his mouth eight days after injury. There was an indurated, nonpulsatile mass in the right side of the neck, on admission, and Horner's syndrome was present. A small aneurysmal sac at the bifurcation of the common carotid was excised, necessitating ligation of the common carotid and the ends of the internal and external carotids. The excised segment showed marked atheromatous changes. There were no cerebral complications.

IV—Arteriovenous Aneurysms.—During the past year we have observed 13 patients with traumatic arteriovenous fistula. Seven of these were returned to the Zone of the Interior for definitive treatment later. Definite indications for operation were present in the remaining six (Table IV). There were no recurrences, gangrene, secondary amputations or deaths in any of the patients operated upon, for either aneurysm or arteriovenous fistulae.

It is important that the two conditions be differentiated, as both the local and systemic effects are different. An arteriovenous fistula is characterized

by a continuous machine-like murmur, which has been likened to the repeated whispered sound of the letter R. The palpable thrill or purr is also continuous. Branham's bradycardiac phenomenon is usually demonstrable when the proximal artery can be compressed.

Cases 1 and 2: Both patients had small arteriovenous fistulae involving the posterior tibial vessels. These were excised and the patients returned to duty.

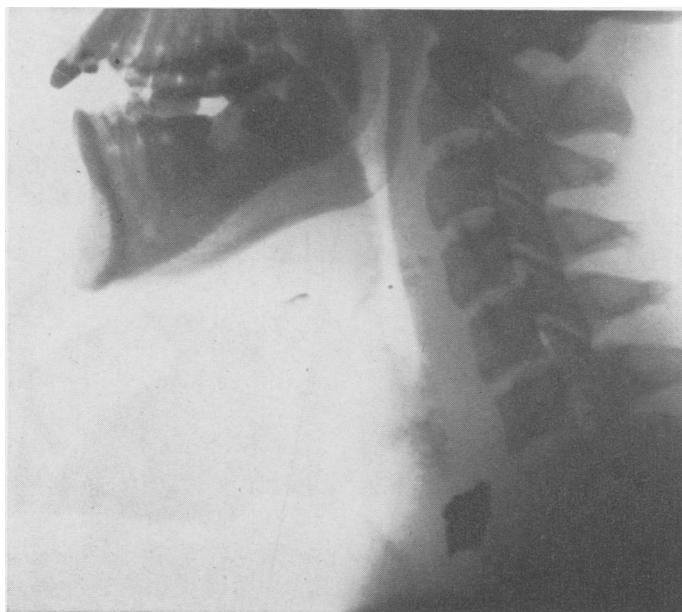


FIG. 2.—Lateral roentgenogram.

Case 3: This 20-year-old, white, male, sustained a penetrating shell fragment wound of the left infraclavicular region. A diagnosis of arteriovenous aneurysm was made 24 hours later (Figs. 1 and 2). On admission to this hospital, four days after injury, the wound of entry was healing. There was a very loud, continuous, machine-like murmur and thrill over the base of the left side of the neck. Pressure over the proximal vessels just above the manubrium caused the murmur and thrill to disappear. Brachial blood pressure determinations were equal. The murmur increased in intensity, but there was no evidence of cardiac enlargement. The patient was confined to bed because of extremity injuries as well.

At operation, a shell fragment, 1.5 x 1.5 x 1.0 cm., was found to lie within the aneurysmal varix sac, between the left common carotid artery and internal jugular vein. Quadruple ligation and excision of the sac and foreign body was carried out, as restoration of the artery was not possible. There were no postoperative complications (Fig. 3).

Case 4: This 26-year-old, white, male, sustained a perforating bullet

wound. The wound of entry was just below the medial third of the right clavicle, while the wound of exit was in the posterior axillary line. The right second rib and scapula were fractured by the bullet. The diagnosis was made, within 14 hours, at a Forward Hospital. On admission to this hospital, three days after injury, the thrill and bruit characteristic of an A-V fistula were present in the right infraclavicular space. Blood pressure, left



FIG. 3.—Ten days after quadruple ligation and excision of a common carotid-internal jugular fistula.

brachial 130/70, and right 80/70. The pulse rate slowed 18 beats per minute on compression of the proximal subclavian artery. There was some median nerve involvement. There was a progressive increase in the size of the heart shadow, though it remained within the upper limits of normal.

At operation, nine weeks after injury, the medial two-thirds of the clavicle were resected subperiosteally, to permit exposure of the vessels proximal to the fistula. The fistula was dissected out of a mass of scar tissue after the vessels had been secured both proximally and distally. Several trunks of the brachial plexus were freed from scar tissue and a small, superficial component of the median nerve was found to be divided and was sutured. The distal axillary stump pulsated. Convalescence was uneventful.

Case 5: This 28-year-old, white, male, sustained a shell fragment wound

of the anterolateral aspect of the left upper thigh. The missile traversed the left thigh, passed through the base of the scrotum, then the right thigh, fracturing the right femur. The wound of exit was on the posterolateral aspect of the right thigh. A large hematoma of the left thigh was evacuated at time of débridement.

On admission, a week after injury, the patient had a large mass in the anteromedial portion of the left thigh, which was slightly expansile, and quite tense. There was also a continuous, machine-like murmur of the upper left thigh and palpable thrill, which disappeared on compression of the common femoral artery. Skeletal traction was applied for the reduction of the right femoral fracture. A diagnosis of traumatic aneurysm and an arteriovenous fistula was made. The patient had severe pain in the left thigh, and burning and hypesthesia of the left foot and leg. The pain could not be controlled without morphine, therefore, operation was performed six weeks after injury. The foot was quite warm. At operation, the fistula was found to involve the profunda femoral vessels as well as communicating with an aneurysmal sac which contained over 1,000 cc. of old blood. The fistula was excised and the aneurysmal sac evacuated. The superficial femoral artery remained intact, so the circulation was adequate. Traction was continued until firm union of the femur was obtained.

Case 6: This 31-year-old, white, male, received multiple penetrating and perforating shell fragment wounds of the trunk and extremities. He was admitted to this hospital one month after injury. At that time, a diagnosis of arteriovenous fistula of the left midbrachial vessels was made. Compression of the artery proximal to the fistula caused a drop of 22 beats per minute of the pulse rate. On two occasions the patient had secondary hemorrhage from a small wound on the posterolateral aspect of the left arm. There was no nerve injury or cardiac enlargement. Operation was performed eight weeks after injury because of secondary hemorrhage and slight increase in the mass at the site of the fistula.

The fistula was dissected out after isolating the main vessels both proximally and distally. The vein was opened and a reparative endo-aneurysmorrhaphy was carried out, sacrificing the vein. An arteriogram, made at this time, showed the artery to be patent at site of repair. There was a good radial pulse postoperatively.

Case 7: This case was of interest because there was a typical machine-like murmur and thrill before operation, and yet no definite arterial communication could be found at operation. A 22-year-old Negro, male, received a pistol shot wound of the right side of the neck. The bullet entered just above the right sternoclavicular junction and the wound of exit passed through the scapula. For the first 12 hours the arm was cold and pulseless, then it became warm, and the pulse became normal. The patient was in a hospital in Corsica for one month, then returned to duty. Two weeks later he was readmitted because of numbness of the inner side of the arm, and a diagnosis of arteriovenous fistula of the subclavian vessels was made. The patient

was admitted to this hospital a few days later. The blood pressure of the two arms was equal, 110/70. The thrill and bruit were characteristic of an A-V fistula. However, the thrill and bruit could be obliterated by pressure proximal to the fistula *without* decreasing the volume of the right radial pulse or appreciably slowing the pulse rate. There were signs of compression of roots of C-7 and D-1, and impairment of pain and vibratory perceptions in the fourth and fifth fingers. There was no cardiac enlargement and the E. K. G. was normal.

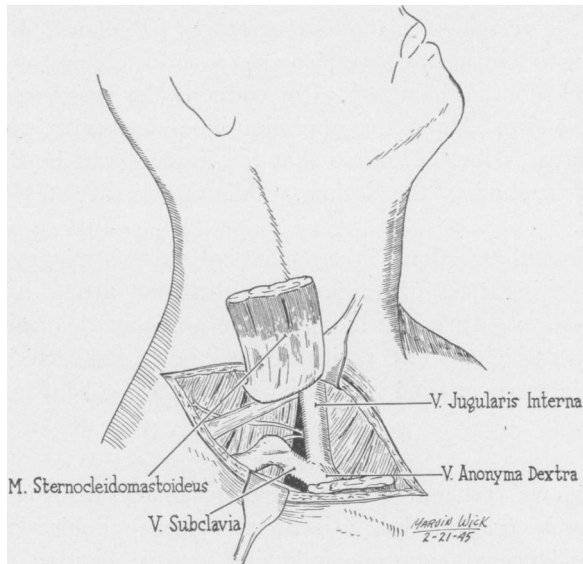


FIG. 4.—Drawing showing the angulation of the proximal portion of the subclavian vein.

At operation, the proximal portion of the subclavian vein was found to be angulated by scar tissue. At the apex of the angulation on the superior surface, the wall of the vein was quite thin, resembling a diverticulum (Fig. 4). Eddies of blood could be seen in the vein and the palpable thrill was quite marked. The thrill could be obliterated by temporary occlusion of either the proximal or distal segment of the subclavian vein. No arterial communication could be demonstrated. The involved segment, four centimeters in length, was excised. Postoperatively, the thrill and murmur were absent, and the patient was returned to full duty. Careful examination of the specimen failed to reveal any communication.

COMMENT: It is hoped that further experience with the nonsuture anastomosis, as advocated by Blakemore, *et al.*, will lower the incidence of gangrene following sudden trauma to major arteries. This method would seem especially feasible in popliteal artery injuries, since injury to this artery was followed by gangrene in 86 per cent of the patients observed in this hospital.

Early operative intervention in traumatic aneurysms was necessary in

about 40 per cent of the patients seen. This includes several patients with injuries of only a few hours' duration. The systolic bruit and expansile pulsation disappeared spontaneously in three patients while awaiting evacuation. The operative incidence in this hospital was less than 30 per cent in patients with arteriovenous fistulae, excluding those patients who were returned to duty shortly after operation. We have not seen the spontaneous closure of any of the arteriovenous fistulae.

The temporary occlusion of vessels has been accomplished by using a broad cotton tape ligature tied down on a segment of small rubber tubing laid on top of the vessel—a method suggested by Holman.⁶ Bulldog artery clamps not being available, we have also used a screw clamp to obtain partial, or complete, occlusion of the artery after encasing the vessel in a segment of tubing of suitable size. Manual compression by an assistant just proximal to the ligature decreases the tension so that the ligature can be tightened with less danger of rupturing the intima. All vessels are divided and the ends transfixed.

The subperiosteal resection of the medial half or two-thirds of the clavicle was done in two instances of axillary or subclavian artery injuries. This gives an excellent exposure and there is little apparent deformity or loss of function postoperatively. The periosteal bed is reconstructed at the time of closure. We have applied a figure-of-8 plaster yoke for three weeks postoperatively.

SUMMARY

In summary, we feel that persistent posttraumatic vasospasm should be eliminated either by paravertebral injections or preganglionic sympathectomy. Second, the incidence of gangrene following arterial ligation probably may be decreased by either early, repeated sympathetic injections or by early sympathectomy. Chronic arterial deficiency is common following ligation of the main artery of an extremity and in selected cases this may be greatly improved by sympathectomy. Finally, the results in 19 patients operated upon for traumatic aneurysm or arteriovenous fistulae are presented.

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Care of Dr. Barney Brooks
Vanderbilt University Hospital
Nashville 4, Tennessee