Peripheral arterial embolectomy ranks among the longest established operations in vascular surgery. The first successful case was in 1911, when Labey removed an embolus from the common femoral artery. Jefferson (1925) reported the first successful case in Great Britain and Griffiths (1938) reported the first successful aortic embolectomy in this country. Numerous authors have published large series of cases. Key (1936), in a series of 382 embolectomies performed in Sweden, was able to report a cure with restoration of the circulation in 86 cases (22.5 per cent.). Amputation was subsequently required in 18 per cent. of the cases and 60 per cent. of the patients died in hospital.

If embolectomy at the present time still carries a high mortality and often fails to save the limb, delay in performance of the operation must be accounted as the principal cause of these disappointing results. It has been repeatedly proven that early operation, undertaken within ten hours, is capable of yielding between 60 per cent. and 75 per cent. of good results, as compared with between 10 per cent. and 20 per cent. when operation is delayed beyond the tenth hour. A close parallel in this respect between arterial embolism and perforation of a peptic ulcer leaps to the mind. Grey Turner (1950) has recalled that Mikulicz quoted 35 operations for perforated ulcer with 34 deaths as proof that this condition should always be treated surgically; this declaration of faith was justified only when early intervention became the accepted rule. A similar obligation rests upon the physician or practitioner who is faced with an arterial embolism. Every surgeon interested in vascular surgery has cause to regret the wasted opportunities for successful embolectomy, due to hesitation and procrastination until gangrene is established and amputation inevitable.

In the majority of cases the diagnosis of embolism is easy and is correctly made at the outset. Delay is due to an unjustifiable hope that spontaneous restoration of the circulation will occur, and consequent reluctance to submit to operation a frail patient with serious cardiac disease. Paradoxically, the recent introduction of anticoagulant drugs and the recognition of the valuable effects of novocaine block of the sympathetic ganglia—powerful adjuncts in the surgical treatment of embolism, and measures which by themselves can occasionally avert gangrene—have had the tendency of further encouraging a policy of optimistic temporization.

Every case of peripheral arterial embolism should be regarded as an urgent surgical emergency and conservative treatment should be adopted only as a pre-operative measure with everything in readiness for immediate operation, except when advanced cardiac failure or severe debility are absolute contraindications to any kind of surgical intervention.

**Symptoms**

The vast majority of emboli lodging in peripheral arteries are derived from endocardial vegetations or mural thrombi in the left side of the heart. Every patient with endocarditis, mitral stenosis or auricular fibrillation is threatened by embolism. Any sudden disturbance of the circulation of a limb in such a patient should therefore be presumed to be due to an embolus and surgical help be made immediately available. Rarely, embolism occurs in the absence of cardiac disease. Thrombus on an atheromatous plaque in the aorta, or in the wall of an aneurysm of the aorta, or of one of the major peripheral arteries may be swept into and obstruct a more distal vessel. A normal heart should not, therefore, be assumed to exclude a diagnosis of embolism.

Characteristically embolism is proclaimed by the sudden onset of severe, often excruciating, pain in a limb. This is rapidly followed by loss of power of movement and of sensation, and by pallor and coldness of the skin, which may soon acquire a marbled appearance with patches of violaceous discoloration. At the same time the patient presents the picture of surgical shock. Whilst this dramatic onset is the rule there may be a more insidious course with only tingling, numbness or coldness of the limb at first. These symptoms, which may be relieved by the application of heat, recur at longer or shorter intervals. They are presumably due to the detachment of minute emboli. Any such symptoms, alone or in combination, especially in a cardiac patient, are a warning of impending massive embolism.
Physical Examination

Inspection and palpation of the limb suffice to confirm coldness, pallor and loss of sensation. Systematic search for the lowest point of palpable arterial pulsation reveals the site of the embolus. There may be localized tenderness at this point. Below it no pulse is palpable. The oscillometric index is similarly abolished below the embolus. Oscillometry may therefore help in localization of the embolus, but it is more useful in providing a quantitative measure of recovery of the circulation occurring either spontaneously, or as the result of conservative or operative treatment. The great majority of emboli lodge at the bifurcation of an artery; this knowledge, together with observation of the level of loss of pulsation, usually suffices to establish the localization of the embolus.

Differential Diagnosis

Though characteristic of embolism, sudden severe pain in a limb, accompanied by pallor, loss of sensation and muscular power, coldness and absence of the peripheral pulses, is in no wise diagnostic of this condition. In the presence of this clinical syndrome, embolism must always be postulated and preparations made to act on this assumption. At the same time an effort must be made to exclude other causes of sudden ischaemia.

Leriche (1947), in his lectures delivered at the College de France in 1945, critically examined the differential diagnosis in the light of numerous cases in which the expected embolus was proved to be absent, either by exploration at operation or autopsy, or by the clinical sequel. Postulating that an embolus, once diagnosed, must be operated upon, he affirmed that the diagnosis must be based upon:

1. The presence of cardiac disease capable of furnishing an embolus.
2. The elimination of a venous thrombosis accompanied by acute, painful arterial spasm.
3. The elimination of an obliterative endarteritis with acute onset of ischaemic symptoms.
4. The elimination of a pure spasm such as may occur in hypertensive patients.

Leriche stresses that venous thrombosis may provoke an acute arterial spasm, but that in such a case the limb is cyanotic rather than livid, and the superficial veins congested rather than empty and collapsed.

Arterial spasm, whether secondary to a venous thrombosis or idiopathic in certain cases of hypertension, will be abolished by novocaine infiltration of the appropriate sympathetic pathways. Paravertebral block of the sympathetic chain should therefore always be performed as a preliminary to operation. Besides the beneficial effect in all circumstances of the resulting vasodilatation, release of the vasoconstriction provides valuable diagnostic information in some cases. If the pain and ischaemia are relieved without a return of the peripheral pulse and of an appreciable oscillometric index, mechanical blockage is certain, the improved circulation being solely from dilatation of collateral vessels. Contrariwise, if appreciable oscillations return after sympathetic block the patency of the main vessels is proven and the ischaemia is evidently due to spasm.

Arteriography and sometimes venography should be performed if the diagnosis is still in doubt (Fontaine and Branzeu, 1939). In cases of embolus the arteriogram is characteristic. The main vessel is normal above the obstruction, with an even calibre and smooth outline. The shadow terminates like a cupola fitting the convex upper limit of the embolus. No filling of the main vessels occurs below the embolus. In pure spasm the artery is seen to be reduced in calibre but remains permeable and its outline everywhere is smooth. In cases of endarteritis the artery may show an irregular outline and an uneven calibre. The distal termination of the shadow lacks the cupola-like appearance characteristic of embolus, and in an early thrombotic lesion the obstruction to the lumen may be only partial. The collaterals are typically tortuous or corkscrew shaped. At the same time there is likely to be filling of the main vessel beyond the thrombus.

Treatment

Given that the diagnosis of embolism has been established and the site of the embolus determined, the surgeon should proceed to expose the vessel with a view to embolectomy with the same confidence and promptitude as he opens the abdomen in a case of perforated peptic ulcer.

Embolectomy should not be regarded as a difficult operation or one demanding specialized knowledge of vascular surgery. Access to certain sites, notably the aortic bifurcation and the iliac vessels, presents certain problems, but these are perfectly soluble in the light of general surgical experience. No special instruments are necessary, though arterial clamps are a convenience.

Pre-Operative Treatment and Anaesthesia

Shock should be treated by injection of morphia, \( \frac{1}{4} \) to \( \frac{1}{2} \) gr., which has the additional effect of promoting peripheral vasodilatation. Preliminary paravertebral sympathetic block has already been referred to. If pre-operative arteriography is employed, the opportunity may be taken of injecting 10 cc. of 2 per cent. novocaine into the artery as an additional means of vasodilatation. In any case this may be done as soon as the artery
is exposed. Appropriate measures should be taken to control fibrillation by digitalin.

General, spinal and local anaesthesia have all been used with success in embolectomy. The choice is largely a matter of individual preference in the light of the facilities available. General anaesthesia skilfully administered is generally well born by cardiac patients and either this or spinal anaesthesia are essential if the intra-peritoneal route to the aortic bifurcation is to be followed. Embolectomy on the more peripheral vessels can always be performed under local anaesthesia, which is to be preferred in aged or frail patients whose cardiac state is precarious. It can also be employed for the extra-peritoneal approach to the terminal aorta and iliac vessels.

**Approach**

It is a general and important rule of vascular surgery that there should be wide exposure of the vessels concerned, sufficient to allow the necessary manipulations for securing haemostasis above and below the site of operation. This applies particularly to the artery below an embolus, which is likely to be occupied by a secondary 'tail' thrombus. Clamps or other means of haemostasis must therefore be placed at a sufficient distance below the embolus to allow for complete extraction of the thrombus. The works of Fiolle and Delmas (1921) and of Henry (1945) should be consulted with regard to the exposure of individual vessels.

Access to the aortic bifurcation and common iliac vessels may be obtained either intra- or extra-peritoneally. The intraperitoneal route presents the more familiar territory to the general surgeon and a wide and clear view of the vessels. It has the disadvantage of being impracticable under local anaesthesia and of requiring a Trendelenburg tilt prejudicial to an embarrased heart. The intraperitoneal approach was used by Ewing (1950) in two cases of aortic embolectomy, and he stresses its simplicity and refers to its use in several recent cases reported by other authors. Murray (1943) reports on five cases in which the left extra-peritoneal approach was used. This approach is also recommended by Leriche (1947). The incision is similar to that for an extensive lumbar sympathectomy and allows a simultaneous removal of the sympathetic chain, including the first lumbar ganglion.

**Recognition of the Embolus**

After exposure of the vessel it is usually easy to identify the site of the embolus. Exceptionally this may be found at another than the expected level, as when an embolus migrates distally—an occurrence which may result from successful vaso-dilatation after pre-operative sympathetic block.

At the site of the embolus pulsation in the artery abruptly ceases, though in the larger vessels a to-and-fro movement may be transmitted beyond it. A spastic contraction often exists at the level of the embolus. Below this the artery is small and collapsed. The embolus itself can be felt as a rubbery swelling within the artery.

**Haemostasis**

The artery above and below the embolus and any major collaterals must be freed sufficiently to permit the control of bleeding, either by slings of tape or rubber secured by artery forceps, or by arterial clamps. Only the proximal clamp will be tightened until evidence is obtained that the secondary thrombus has been evacuated from the distal segment of the artery.

**Incision of the Artery**

A longitudinal incision of 1 to 2 cm. is sufficient for removal of the embolus. Usually this will be made directly over the embolus. In exceptional situations it may be placed, for greater ease, either above or below the obstruction. In this connection reference may be made to the method of "retrograde embolectomy" advocated by Key and used by Griffiths (1938), for removal of emboli at the aortic bifurcation and in the iliac vessels. The incision is made in the common femoral artery and the clot dislodged by retrograde probing or suction. This blind approach to the embolus is not without possibilities of damage to the intima, with the risk of subsequent thrombosis, and it may be difficult to make sure that the clot has been totally extracted. Milking down the clot by digital compression of the artery from the outside avoids the risk of trauma to the endothelium. The less elaborate dissection involved may make this the method of choice when operating on very feeble patients, but the precaution should be taken of exposing and temporarily obstructing the opposite common femoral artery lest a portion of the clot be swept down into it.

**Removal of the Embolus**

The ease with which the embolus is removed depends partly on the time that has elapsed before operation. In the first few hours the embolus lies free in the arterial lumen and is extruded spontaneously as soon as the vessel is opened, or it may be swept out by the blood stream when the proximal clamp or sling is momentarily released. In other cases, gentle milking of the vessel above the incision dislodges the embolus. After a few hours the embolus becomes adherent to the wall of the artery and probing or suction may be needed to liberate it. Later the clot becomes completely fixed and irremovable, as was found by Griffiths.
(1938) in one of his cases of aortic embolism operated upon 46 hours after the onset of the first symptom. The secondary thrombus in the artery distal to the embolus must be removed for a good functional result to follow embolectomy. It may come away with gentle traction, or may need retrograde milking of the distal segment of the artery. Griffiths (1938) has recorded a secondary thrombus 3½ in. length, with terminal branches so fine that they must have come from the arteries of the foot. Only when free, though non-pulsatile, bleeding from the distal end of the artery shows that the secondary clot has been removed will the distal clamp or sling be tightened in preparation for closure of the arterial incision.

**Closure of the Arterial Incision**

Fine black silk (5 x 0) mounted on round-bodied atraumatic needles is the material of choice for arterial suture, and should be made available in all operating theatres. Fine linen thread and fine chromic catgut mounted on intestinal needles are perfectly reliable substitutes. It is generally recommended that the suture material be vaselined or paraffined.

A plain over and over continuous suture taking all layers should be employed and care taken to see that accurate apposition of the intima is obtained. A preliminary removal of the adventitia assures that none of this layer with its thrombogenic property will protrude within the lumen of the artery. This also achieves a segmental sympathetic denervation which may be of value in countering spasm of the vessel, but to obtain this effect the adventitia must be removed over a distance of some 10 cm. If such a step is decided upon, it is most easily performed before the artery has been clamped and incised. After removal of the clamps a spurt of blood from the suture line may need to be secured by an additional interrupted stitch.

If the artery has been completely cleared of clot, pulsation will now be visible passing beyond the incision into the previously inert distal segment of the artery. The peripheral pulses will again become palpable and colour and warmth will return to the limb. Absence of these signs that the ischaemia has been relieved indicates the possibility of a second, more distal, embolus in the artery. Several such cases of multiple emboli in the same vessel have been reported since Key (1923) first drew attention to them. A second arteriography should be made to confirm and locate the remaining embolus, which must then be removed in the same way as the first.

A patch of muscle or of fibrin foam may be placed over the arterial incision as an added security against haemorrhage. The wound is then closed in layers. A soft rubber drain may be placed as a precaution against the formation of a haematoma.

**Causes of Failure of Embolectomy**

Various factors threaten the results of every operation of embolectomy. Of these, thrombosis is the commonest cause of failure. Pre-operatively, as the hours pass, thrombus extending distally from the embolus progressively obliterates the peripheral vessels. At first this secondary clot lies free in the arterial lumen and, by traction, milking or suction, can be removed at operation. Later the thrombus, like the embolus itself, becomes adherent to the arterial wall. Its dislodgement then becomes either impossible, or if achieved, exposes a damaged intima, prone to become the starting point of a new thrombus as soon as the circulation through the vessel is restored. Frequently the sequel to this is gangrene and amputation. In other cases, the collateral circulation may be sufficient to ensure survival of the limb, but the patient is crippled by claudication pain as soon as he attempts to walk. Occasionally thrombosis starts on the suture line, even though removal of the embolus appears to have left an intact intima.

The introduction of anti-coagulant drugs—and particularly of heparin—provides a powerful weapon with which to combat thrombosis, and its use in embolectomy, as in all vascular surgery, has become practically a routine. It is well to remember, however, that the largest published series of cases of embolectomy, with their very considerable proportion of success, date from the pre-anticoagulant era, when coating of the suture material with vaseline and irrigation of the wound with sodium citrate solution were the only available means of preventing coagulation. Then, as now, however, gentle handling, avoidance of all unnecessary trauma to the vessel and meticulous suturing, together with early operation, were the best assurances of success.

Hard and fast rules cannot yet be laid down for the use of heparin in arterial surgery, owing to the varying and unpredictable response to the drug by different individuals. A narrow margin may separate insufficient and ineffectual dosage from over-dosage with resulting severe haemorrhage from the operation wound or elsewhere. Frequent estimations of the coagulability of the blood are necessary. In operating theatre and ward this is best done by measuring the clotting time of a drop of blood on a vaselined glass slide. This method requires no special equipment or specialized knowledge and gives sufficiently accurate results for practical purposes. The normal clotting time, by this method, of 7-10
minutes needs to be kept constantly lengthened to not less than 15 minutes, and should not be allowed to exceed 30 minutes. Continuous administration in an intravenous drip infusion provides the most convenient method of controlling the dosage of heparin by regulation of the speed of the drip. About 400 mgms. of heparin will need to be administered in the first 24 hours. Heparinisation should be maintained, with diminishing doses, for at least 3 days. Should severe haemorrhage occur, the effect of heparin is reversible by blood transfusion or the administration of protamine sulphate. If a massive haematoma should form in the wound, this should be reopened to remove the clots, whose presence endanger the circulation of the limb and sound healing of the wound.

The administration of heparin should be started as soon as a diagnosis of embolus is made, with the aim of limiting or preventing secondary thrombosis in the interval preceding operation. This, combined with the vasodilatory effect of novocaine block, may, in the case of a patient who is a poor risk for operation, confer relative safety upon a short period of observation for signs of spontaneous improvement in the circulation of the limb. The use of an anti-coagulant concurrently with any surgical operation imperatively demands the most meticulous attention to haemostasis. Every recognizable bleeding point must be secured by ligature before the wound is closed. Nevertheless, in spite of every precaution, dangerous bleeding may necessitate the interruption of anti-coagulant therapy.

Statistics from numerous sources relating to the functional end results after embolectomy reveal a high proportion of cases marred by post-operative thrombosis of the vessel and terminating in amputation. Thus, Key reported 208 embolectomies with 133 deaths. Among the survivors there were 43 cures and 32 amputations.

The factors responsible for this post-operative thrombosis are without doubt multiple, and as yet imperfectly understood. Four principal causes may, however, be discerned.

1. Degenerative lesions of the arterial wall initiated at the site of contact of the embolus.

2. Retardation of the blood stream from arterial spasm, fall of blood pressure and stenosis at the site of arterial suture.

3. Imperfect suturing.

4. Disturbance of the coagulability of the blood.

Time, without doubt, is the principal factor in determining adherence of clot to the intima and the consequent occurrence of degenerative lesions of the arterial wall. That time is not the only factor is shown by the exceptional finding of endarterial lesions as early as the tenth hour, whereas the embolus has in other instances been found lying free in contact with apparently normal intima as late as the 11th day (Ipsen) and the 28th day (Nicolaessen, quoted by Leriche, 1947).

The operator who has the good fortune to intervene early, as well as he who perforce arrives late on the scene, must therefore be prepared to find that after extraction of the embolus the intima presents a hyperaemic, velvety, irregular surface prone to initiate a post-operative thrombosis. In these circumstances he must decide whether sacrifice of an abnormal arterial segment by arterectomy may not be a preferable alternative to suturing the incision in the face of probable subsequent obliteration of the artery by thrombosis. This question has been thoroughly examined by Leriche (1947). Arterectomy suppresses the afferent, sympathetic vasoconstrictor impulses initiated by adherence of thrombus to damaged intima and thus allows the collateral circulation to fill the main artery distal to the resected segment, whence a blood flow sufficient to prevent gangrene may be expected. This effect of arterectomy has often been observed in cases of obliterative endarteritis and should be all the more effective in cases of embolism, where the vessels of the limb are otherwise healthy. Leriche advises that the sympathetically effect of arterectomy should be reinforced by novocaine infiltrations of the lumbar sympathetic chain.

Arnulf (1950) reports that more recently Dos Santos has proposed removal of the obstruction by endarterectomy, in preference to arterectomy. This procedure, as modified and elaborated by Reboul (1950), has proved its worth in cases of chronic endarteritis obliterans, and is a resource to keep in mind when confronted by secondary arterial lesions resulting from an embolus.

Inevitable Gangrene—Amputation

As has already been indicated, failure to save the circulation of the limb still attends many of the operations performed for embolectomy. Once gangrene is established and its extent clearly demarcated there is no advantage in delaying amputation. If it is performed before infection complicates the issue the limb can be safely removed through healthy tissue close to the upper limit of the gangrene, with primary suture of the flaps. If, however, there is widespread degenerative disease of the arteries of the limb, amputation will have to be performed at a higher level, e.g. through the lower third of the thigh for gangrene of the foot. The view recently expressed by Learmonth (1950) that ‘the first amputation should be the final one’ carries special weight with reference to frail individuals with a poor expecta-
Illustrative Case Histories

CASE 1. Auricular fibrillation; embolus at bifurcation of brachial artery; embolectomy; recovery.

J.C., male aged 52, was admitted to hospital on July 25, 1950, with the history that at 7 a.m. on the same day he suddenly felt faint and at the same time his left forearm and hand went cold, numb and powerless. There was pain from the elbow downwards. Slight spontaneous improvement occurred a little later. The patient said that he had suffered from rheumatic fever and endocarditis in 1918, but had not been under any medical treatment since then.

On examination. The left forearm and hand were cold and cyanotic. Finger movements were unimpaired. There was some loss of sensation in the fingers. The radial and ulnar pulses were absent at the wrist. The brachial artery was pulsating visibly in the cubital fossa. The heart was in auricular fibrillation, was enlarged and there was a pre-systolic murmur. A diagnosis of embolism at the bifurcation of the brachial artery due to mitral stenosis and auricular fibrillation was made.

Treatment. Procaine block of the brachial plexus was induced forthwith. The forearm and
hand became warm from the resulting vaso-
dilatation. There was no return of the radial or
umlar pulses. Oscillometry gave an index of $\frac{1}{2}$ in
the left forearm as compared with 4 on the sound
side. At 3 p.m., eight hours after the occurrence of
the embolism, the brachial artery was exposed under
general anaesthesia. There was a rubbery in-
duration at its bifurcation; the radial artery was
contracted and pulseless; the origin of the ulnar
artery was a little larger than that of the radial,
but did not pulsate. Pyelosil was injected into
the brachial artery, and arteriography showed a
cupola-shaped arrest in the brachial artery just
above the level of the elbow joint. There was no
filling of the radial artery, but the ulnar, radial and
ulnar recurrent and interosseous arteries were
faintly visible (Fig. 1a). The termination of the
brachial artery was incised for 1 cm. over the
embolus, after placing proximal and distal clamps.
Red, recent looking thrombus presented and was
extracted in five fragments. It was slightly ad-
herent to the intima and the smaller fragments
were dislodged by probing. After release of the
clamps the artery bled from both ends. The open
vessel was irrigated with heparin and the arterial
incision closed with a continuous 5 x 0 silk suture.
Arteriography was repeated, and showed con-
tinuous filling of the radial artery and improved
filling of the ulnar and interosseous arteries (Fig.
1b). A heparin intravenous drip was started dur-
ing the operation, and the wound was closed with

Progress. There was serious bleeding from the
wound during the night following operation, for
which one pint of blood was transfused.

Eighteen days after operation there was a
sudden onset of pain in the right side of the chest,
with fever and blood-stained sputum. There were
no signs of venous thrombosis in the legs and the
apparent pulmonary embolism was thought to
originate in the right side of the heart and was
treated by a further course of heparin. A fortnight
after the embolectomy the colour, temperature,
movements and sensation of the hand were normal.
The oscillographic index had risen to 2 $\frac{1}{2}$ and the
radial pulse was palpable at the wrist. The
patient looked and felt well when discharged from
hospital on August 29, 1950.

Case 2. Arteriosclerotic popliteal aneurysm;
embolus at bifurcation of tibio-popliteal trunk;
amputation.

G.C., male aged 71 yrs. At the beginning of
September 1950 this man had a sudden attack of
numbness and tingling in the right foot, which
became painful. This was relieved by immersion
in hot water. After resting for a week he was able
to return to his work as an accountant, though he
had some intermittent claudication in the calf.
Three weeks after the first onset of symptoms
there was a sudden recurrence of pain in the same
foot and in the leg. The foot was now cold and
blue and the pain was not relieved by morphia.
He was admitted to hospital on the following day
—September 23, 1950. Seven years previously the
patient had been treated for a coronary throm-
boasis. He had remained well during the
intervening years.

Examination. The toes of the right foot were
white. There were violaceous patches on the
dorsum of the foot. There was an abrupt change
from warm to cold at the junction of the middle
and lower thirds of the leg, and the limb was
anaesthetic below this level. There was some
oedema of the lower leg, and the right calf
measured 2 in. more in circumference than the
left. The femoral pulse was easily palpable
throughout the thigh. The popliteal pulse was
exaggerated and expansile. The posterior tibial
pulse was absent, but the dorsalis pedis artery
was felt to be beating strongly. On the left side
the femoral pulse was palpable in Scarpa’s triangle.
The popliteal, posterior tibial and dorsalis pedis
pulses were absent. The oscillographic index in
the upper third of the leg on the right side was
$\frac{3}{4}$ compared with $\frac{5}{2}$ on the left side. A systolic
murmur was audible over the right femoral and
popliteal arteries.

A diagnosis of popliteal aneurysm of the right
leg and endarteritis obliterans of the left was
made. The sudden ischaemia of the right
extremity was attributed to the detachment of a
fragment of mural thrombus from the aneurysm,
with formation of an embolus which had been
arrested at the bifurcation of the tibio-popliteal
trunk into the posterior tibial and peroneal arteries,
both of which were thereby occluded. This point
is below the origin of the anterior tibial artery,
which had remained patent, as shown by the
strong pulsation in the dorsalis pedis.

X-ray of the limb showed extensive calcification
of the femoral and popliteal arteries, with expan-
sion of the latter to a diameter of $1\frac{1}{2}$ in. In
the left leg the popliteal artery was also calcified and
expanded to a diameter of $1\frac{1}{2}$ in. (Fig. 2, a and b.)
Arteriography showed the expanded popliteal
artery on the right to have a central channel of
$\frac{1}{2}$ to $\frac{3}{4}$ in. diameter. The Wassermann reaction
was negative.

Management and Progress. As the embolism
had occurred more than 24 hours previously and
the foot was already beyond salvation, embo-
lectomy was not contemplated. Treatment was
directed to efforts to limit the extent of the inevi-
table gangrene. A para-vertebral sympathetic
procaine block was performed on September 25—
10 cc. of 1 per cent. procaine being injected at the level of each lumbar ganglion. This produced an immediate sensation of warmth down the outer side of the leg, which felt warmer than on the opposite limb. The patient volunteered the information that the foot warmed up during the night. The next morning the leg was warm down to the level of the malleoli. The para-vertebral block was repeated the next day and an intra-arterial injection of 10 cc. of 2 per cent. procaine was made into the right femoral artery.

During the next three weeks the foot regained its warmth as far as the middle of the sole and to within an inch of the base of the toes on the dorsum. The tissues distal to this level underwent a dry, mummifying gangrene and a similar patch of gangrene the size of a half-crown piece developed on the heel. The dorsalis pedis artery conserved its strong pulsation. But for a patch of gangrene on the heel a Syme's amputation would have been perfectly justifiable, and in a younger man might still have been attempted. At this patient's age, however, it was felt that the advantages of early return to activity outweighed those of retaining a longer stump, and a below-knee amputation at the site of election was performed, without a tourniquet, on November 16. The equal anterior and posterior flaps were sutured and the stump healed by first intention.

Comment. Leriche (1949) refers to embolism...
resulting from an aneurysm as a condition seldom seen. He states that Key records only five instances in his statistical surveys of embolism—and he reports the only case which he has personally observed, which was an embolism at the bifurcation of the brachial artery originating from an axillary aneurysm.

**Case 3.** Embolus of unknown origin at bifurcation of femoral artery; embolectomy; gangrene of foot; amputation.

**History.** W.W., male, aged 34, was admitted to hospital on the morning of February 23, 1946, with a tentative diagnosis of perforated peptic ulcer. Whilst on his way to work on that day, he was suddenly seized by violent pain in the epigastrium and left loin which caused him to collapse in the street. Shortly afterwards he vomited and noticed numbness in the left leg. For the past four years he had suffered from epigastric pain after meals and three years previously the presence of a gastric ulcer had been revealed by radiography, leading to his discharge from the Army on this account. During the past seven months he had had three attacks of sudden pain in the legs after walking short distances. This chiefly affected the backs of the calves, which felt ‘paralysed.’ After each attack the pain persisted longer in the left leg than in the right. There had been no abdominal symptoms on any of these occasions. In other respects he had always been perfectly healthy.

**Clinical examination.** When seen in the ward the patient was very restless and complained loudly of severe abdominal pain, which radiated to the left thigh. Examination of the abdomen revealed tenderness and muscular guarding, chiefly in the left upper quadrant. Contractions of the anterior abdominal muscles coincided with spasms of pain. The pulse was regular at a rate of 88 per minute, the heart was not enlarged, and there were no cardiac murmurs, nor any evidence of cardiac failure. The patient’s excited demeanour was in sharp contrast to that normally associated with
perforation of a peptic ulcer and it was decided to keep him under observation.

In the evening of the same day circulatory changes were observed in the left leg. From the knee to the middle of the foot the skin was cold and blanched. The distal part of the foot and the toes were blue and insensitive. No pulsation could be detected in any of the arteries of the limb below the common femoral, which was pulsating normally for about an inch below Poupart's ligament. A diagnosis of embolus at the bifurcation of the left common femoral artery was made, and 15 hours after the onset of symptoms the vessel was explored.

Operation. Under spinal anaesthesia the femoral artery was exposed in Scarpa's triangle. The embolus was recognized by distention and bluish discoloration of the artery, which was collapsed and pulseless below the embolus. An incision \( \frac{1}{2} \) in. long was made in the artery immediately below the embolus, and the embolus dislodged with a Volkmann's spoon. No thrombus was present in the distal part of the artery. The incision was closed with vaselined silk and the wound closed.

Post-operative progress. Dicoumarol was administered in daily doses of 300 mg. for the first three days after operation. Circulation failed to return to the skin covering the distal half of the foot and the lower 9 in. of the leg on the outer side, so that a below-knee amputation was performed one month after the embolectomy. The patient has now been under observation for five years.

At no time were there any cardiac symptoms or irregularity of the pulse, nor any evidence of further embolic phenomena. X-ray examination showed a normal heart shadow and no calcification of the aorta was visible. The Wassermann reaction was negative. At the time of the patient's discharge from hospital his blood pressure was 160,100 mm. Hg.

Microscopical examination of the main vessels of the amputated limb showed a normal posterior
tibial artery. The anterior tibial artery contained an organized thrombus; the intima showed marked thickening, the elastica and media were degenerate, and much peri-arterial fibrosis was present. (Fig. 3, a and b.) The distribution of the gangrene was evidently related to the obliteration of the anterior tibial artery, probably due to a small fragment of the embolus carried distally and arrested in this vessel.

Conclusion

Decision is the keynote of success in the management of peripheral emboli. Embolism should be assumed when, in the words of Hopkins (1945), 'something sudden happens to a limb' in a patient with any cardiovascular disease liable to form detachable thrombi. Exceptionally arteriography may clinch a doubtful diagnosis. Preparations must be made for operation at the earliest possible moment. Temporizing measures should only be considered when the cardiac state of the patient absolutely contraindicates operation—a rare contingency when it is remembered that most embolectomies can be performed under local anaesthesia. In the interval between the onset of symptoms and operation all possible measures should be employed to promote the collateral circulation and to delay thrombosis. Occasionally such an improvement in the circulation of the limb will follow sympathetic block, and administration of heparin that postponement of operation will be justified. Only recovery of such degree that the peripheral pulses re-appear can justify persistence with non-operative measures beyond 8 or 10 hours. After this interval embolectomy is menaced by rapidly diminishing chances of success, but with the use of heparin and sympathetic block the period for possible successes may come to be appreciably extended. When exploration reveals adherence of the embolus, secondary thrombosis or a damaged arterial lining, arteriectomy and perhaps disobliterative endarteriectomy offers the best hopes of conserving limb, function and life.

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