Discussion

Raeburn (1951) has restated the initiating causes of thrombosis as (a) venous stasis; (b) disordered metabolism of vascular endothelium, leading possibly to increased adhesiveness; (c) intimal trauma; and (d) sepsis. Venous stasis would certainly result from partial occlusion by a foreign body. The presence of aseptic inflammation has been shown by vein biopsy. Intimal damage may occur from repeated small traumata produced by limb movements with a foreign body in the vein lumen. Some of the criteria, therefore, for the production of venous thrombosis appear to be satisfied. Clinical implications of the method are obvious. The relation of the method to other forms of treatment has yet to be determined. A more definite assessment awaits the progress of adequate follow-up studies.

Summary

A new method of causing intravascular thrombosis is presented, with particular reference to the treatment of varicose veins.

It consists in leaving a length of silk ligature within the lumen of the vein.

Clinical and histological evidence is produced to show that complete obliteration of the vein invariably results without any ill effects, general or local.

The mechanism and clinical implications of the method are discussed.

I wish to thank Mr. Peter Martin for allowing me to publish these cases and for help in preparing this report. My thanks are also due to Dr. J. P. Whitehead, Director, Morbid Anatomy Laboratory, St. Margaret's Hospital, Epping, for preparing and reporting on the histological material, and to Mr. Kenneth G. Moreman for the photomicrographs.

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FRICITION INJURIES FOLLOWING ROAD ACCIDENTS

BY

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Modern road transport causes injuries which were unknown a few decades ago. The lesion described below is a torsional one, usually produced by the tyre of a motor vehicle trapping or passing over part of the body. It is not always recognized and the best treatment can be given only if its nature is understood. The one constant feature is the stripping of the skin and subcutaneous tissues from the deeper structures. The skin itself may be intact, but more often it is split wide open, and in these cases the friction may damage tendons and nerves. Fractures are present in less than half the cases, and are produced by some other mechanism—for example, angulation. Experience of 20 cases provided the basis for this paper.

Early Experiences

The first case encountered was that of a man aged 48 who was run over by a car and sustained a compound fracture of the right femur. There was a rather large puncture wound

on the antero-medial aspect of the upper part of the thigh. This was treated by excision, the wound being extended and quite a large haematoma evacuated. When the wound had been closed the fracture was controlled by skin extension in a Thomas splint. The patient had an irregular pyrexia. A week later the whole of the skin of the thigh was seen to be badly bruised and blistered, and after a few days became converted into the black leathery slough of local gangrene. Skeletal traction solved the problem of the femur, but the skin loss became very troublesome (Fig. 1).

FIG. 1.—Late stage of a "closed" injury. Initially a fractured femur with a puncture wound only, the leg is here photographed after the slough had separated. There is complete skin loss from abdomen to knee on all aspects of the thigh.

FIG. 2.—Late stage of an "open" injury. Healing time, six months. The skin flaps were so badly damaged that they were completely lost. Earlier healing would have followed a primary excision and skin graft.

Antibiotics were not available, and the extensive area became secondarily infected. Skin grafts were quite ineffective, and the man gradually became more toxic and emaciated. Four months after his accident he died.

The second case appeared to have little in common with the above when it was first seen. A boy aged 4 was run over by a van and was brought to hospital with a massive wound extending from the big toe to the top of the thigh. Enormous flaps of skin had been peeled off the muscles, which were heavily contaminated with road dirt. In spite of the widespread skin damage, x-ray examination revealed no injury to bone. After an extensive wound toilet and suture the child's progress was good. There was some sloughing of the skin, which was grafted one month later, but the leg was completely healed in just over three months.

Mechanism

In these injuries, with the assistance of the patient, eye-witnesses, and the police, one of three stories was obtained: (1) The patient was truly "run over"; (2) the vehicle pulled up with one wheel trapping the patient, and sometimes had to be reversed to release the patient; or (3) the patient was flung clear of the vehicle, skidding along the ground with some force.

It seems that the skin is gripped by the rubber of the tyre, and as the wheel is lifted a very strong rotational force

is imparted to the superficial structures only. The connexion between the subcutaneous tissues and the deep fascia breaks down before the stretched skin tears. Thus in cases with the skin intact the full extent of the damage may not be recognized early. If the skin gives it does so on the

opposite side of the limb from where the frictional force is applied (see Fig. 3B). The skin flaps are unequal in size, the flap nearest the frictional force being the longer.

There are a number of factors which determine the extent of the frictional injury:

(1) *Weight of Vehicle.*—It is the heavy vehicle, such as the motor-bus, which inflicts this injury.

(2) *Speed of Vehicle.*—Fast-moving vehicles may cause only slight bruising. This can be explained by the strain being more short-lived, but unevenness of the road and good springing may well be the important factors. The speed is most frequently 10–15 m.p.h.

FIG. 3.—A. As the wheel touches the part the frictional force is applied. B. As the wheel mounts the part the skin is drawn round. Whether the part is run over, trapped, or thrown clear, the damage is done. C. If the skin does not break apparent normality is restored. The lesion is concealed. D. If the skin breaks it usually does so in the region of X shown in B. The lesion is obvious.

(3) *Tyre Pressure and Road Conditions.*—A dry low-pressure tyre exerts the strongest friction.

(4) If the vehicle is swerving the outside wheels may be exerting less pressure, and could be actually clear of the ground.

Pathology and Chief Clinical Features

The skin, together with the loose connective tissues which move with it, is stripped off the less mobile muscles and the bones. The depth of the stripped layer varies even in one individual case—in parts it may be extremely bruised and thin, but in well-covered subjects it usually contains a rather generous thickness of fat. It is this layer, through loss of blood supply, which undergoes necrosis. Delayed skin gangrene will then follow, and secondary sepsis is to be expected. In the closed injury the haematoma may embarrass the vessels at the periphery of the tear and make the lesion more extensive. The subsequent history of the case depends on the success or otherwise of vascularization of the stripped flap, and any treatment must encourage this.

Electric mangle injuries to the extremities have the same pathology.

In a road accident of some severity the case with widely open skin flaps presents only a problem of how it should be treated. It is the closed injury, which is likely to go on to delayed necrosis, that needs to be recognized early. Here, shock is often greater than the deeper injuries would suggest. The coat, trousers, or footwear may give valuable information of the violence which caused this injury. The skin itself is abraded and bruised early, and may bear the imprint of the tread of the tyre. Wheals may be present. Unnatural mobility of the skin should be noted, or later an extensive haematoma.

Twelve Typical Cases Treated at Nottingham Children's Hospital, 1949–51

Sex/ Age	Type of Accident	Lesion	Final Healing	Progress Notes
M 3	Run over by bus wheel at 10 m.p.h.	Open. Foot. Extensor tendon of hallux torn	3 mths.	Late scarring, causing dorsiflexion contracture of toes. Cross leg flap—then tendon graft
M 6	Run over by trolley bus, at 12 to 15 m.p.h.	Open. Arm. Areas of complete skin loss. Fractured humerus, radius, and ulna	5 "	Repeated skin grafts. Late scarring ++, stiff elbow (movements half normal)
M 8	Run over by trolley-bus wheel	Open Ankle. Extensor tendon of hallux torn	3 "	Slight scarring only. Not complaining of trouble from big toe
F 8	Run over by bus wheel at 15 m.p.h.	Open Whole leg. No fracture. External popliteal palsy	4 "	Split-skin grafts. Moderate scarring of skin. Neurolysis of external popliteal nerve
M 5	Run over by bus wheel at 15 m.p.h.	Open. Ankle. Rupture tibia anterior and extensor longus hallucis	8 "	Graft on to bone. Area rubbed on shoe. Late cross-leg flap and then tendon grafts
M 6	Dragged by wheel of heavy lorry	Open. Leg. Bones of foot crushed—part of foot missing	3 "	Immediate amputation, below knee
M 4½	Trapped by bus wheel at 2 m.p.h.	Transverse burst foot. Fractured toes	2½ "	Suture under tension ++. Swelling slow to settle. Complete recovery
F 4	Tossed by wheel of lorry	Closed. Simple fracture of tibia	2½ "	Extensive superficial gangrene at two weeks. Sloughs removed and grafts applied one week later
M 11	Trapped by bus wheel	Closed. Foot and ankle	1 mth.	Early small incisions. No gangrene. Complete recovery
F 5	Tossed by 3-ton van	Open. Thigh and abdomen. Fracture of pelvis. Rupture of vagina	2 mths.	Extensive removal of fat from flaps. No flap sloughing. Suture line rather slow to heal. No scarring
M 8	Trapped by car wheel	Closed. Hand. Fracture of metacarpals	1 mth.	Swelling slow to settle
F 10	Tossed by Ford V8	Open "Sleeve" stripped from mid-arm to mid-forearm. Fracture clavicle same side	3 mths.	Fat trimming, but no drainage of posterior flap, which sloughed owing to haematoma below. Subsequent skin grafts

Treatment

Open Case.—A thorough wound toilet should be carried out under operating-theatre conditions. All severely contused skin as well as unhealthy skin margins should be excised. Avulsed skin with no blood supply can be replaced as a Wolfe graft if the underlying fat is removed; it may take well. The base of the wound must be extensively cleaned up, and damaged muscle and fascia removed, in order to provide a healthy vascular bed for the flaps, which are of doubtful viability. Fat should be completely removed from the deep surface of the flap at the torn margin, and towards the base of the flap until it bleeds freely. The wound is then treated with a fine dusting of penicillin-sulphathiazole powder, and the flaps sewn together, making sure there is no undue tension. A thin flap may die if a haematoma forms, but a few stab wounds in the lowest part of the flap, if possible through healthy skin, may prevent this. Any raw areas remaining should have split-skin grafts. A dressing is then put on with an even pressure, and splintage is usually necessary.

Closed Case (early).—If an extensive necrosis is anticipated, a long incision should be made and the case be treated as an open one. If only a suspicion exists, then any haematoma under high tension should be evacuated through a small incision and the part kept under observation until the danger is obviously over. Massive skin gangrene can be avoided by timely intervention.

Closed Case (late).—When skin gangrene has occurred the black slough should be removed surgically before secondary sepsis becomes established. If the base of the wound is then

deepened to healthy tissues, it will usually be possible to apply immediate split-skin grafts. After two weeks further grafts may be advisable.

In spite of the use of the methods outlined, final healing of extensive lesions often takes three months. With experience this time can be reduced to a minimum. When final healing does occur the skin is often puckered and scarred. This may be so severe that a flap or pedicle graft is required, especially if any further operation becomes necessary in the involved area. In this short series, two feet have required cross-leg flaps for this reason.

Summary and Conclusions

The open and closed varieties of friction injuries sustained in road accidents have been described and the importance of careful treatment has been stressed.

The open lesion is quite common, but good judgment is of great importance in its management. The antibiotics have made surgical treatment and early skin-grafting safer.

The closed lesion is rarer. If it is not recognized early, skin gangrene may be found when a plaster is removed. Medico-legally, it is important to realize that bandaging and splintage have in no way been responsible.

The cases were treated in the traumatic units of Liverpool Royal Infirmary and the Nottingham Children's Hospital. My thanks are extended to Mr. Norman Roberts for permission to publish the two cases illustrated. I also wish to acknowledge the helpful guidance of Mr. A. N. Birkett, under whose care most of the cases were admitted. (Fig. 1 was taken by the photographic department of the General Hospital, Nottingham, and Fig. 2 by the Central Photographic Department of the University of Liverpool.)

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DISOBLITERATIVE ENDARTERIECTOMY OF THE EXTERNAL ILIAC ARTERY

BY

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Case Report

A man aged 68 was referred to hospital on April 27, 1951, complaining that a month previously he had had a sudden pain in the right calf while walking. Subsequently he had cramp-like pain in the right calf which compelled him to halt after walking a distance of 300-400 yards. The pain was quickly relieved by rest. At the same time the right foot became cold.

On examination his general condition was good. His blood pressure was 140/80. The general appearance of the right lower limb was normal. The right foot was colder than the left. The pulse could not be felt in the right external iliac artery or in any of the arteries of the right leg. On the left side the external iliac, common and superficial femoral, popliteal, posterior tibial, and dorsalis pedis arteries pulsated strongly. The oscillometric index in the right thigh was $2\frac{1}{2}$ and in the right calf $1\frac{1}{2}$, as compared with $8\frac{1}{2}$ and 9 in the left thigh and calf respectively. A clinical diagnosis of thrombosis occluding the right external iliac artery was made. A plain x-ray film of the abdomen and lower limbs showed slight calcification in the walls of the lower abdominal aorta, but none in the arteries of the legs.

Aortography on June 26 showed an obliteration of the external iliac artery from its origin extending down as far as 1 cm. or so above the bifurcation of the common femoral

artery. Filling of the main vessel below the obliteration was through numerous collaterals derived from the branches of the internal iliac artery.

Operation

On July 5, under general anaesthesia, the iliac vessels were exposed extraperitoneally and the incision was continued across Poupart's ligament to expose the common femoral artery. The external iliac and common femoral arteries were pulseless. Clamps were placed on the common and internal iliac arteries and on the femoral artery below the obliteration. The external iliac artery was incised to a depth sufficient to expose the yellowish necrotic inner coat adherent to the contained thrombus. An easy plane of cleavage was found here between the inner and outer layers of the arterial wall and developed over the full length of the obliteration. Disobliterative endarterectomy was completed by severing the inner arterial coat at each end of the thrombus (see photograph). Free bleeding then occurred from each end. After tightening the clamps the 12-cm. longitudinal incision was closed with a continuous suture of 00000 black silk. On release of the clamps pulsation was seen and felt throughout the previously inert external iliac artery and in the femoral artery beyond the previously obliterated segment. At several points along the suture line a pulsatile leak of blood required supplementary interrupted stitches.

Intravenous heparin was given throughout the operation to lengthen the clotting-time between 15 and 30 minutes, and the interior of the artery was irrigated with heparin during the suture.

Post-operative Progress.—The patient made an uninterrupted recovery. The wound healed by first intention. There was no post-operative haemorrhage. He was discharged from hospital on July 26.

When seen on September 6, nine weeks after the operation, the patient was walking normally. He said he could do so at a slow pace for an unlimited distance without any cramps, though these still occurred in a mild form if he hurried. He had completely lost the sensation of coldness in the foot, and is fully satisfied with the result of the operation. On examination both feet were equally warm. Pulsation was palpable, though of small volume, in the right external iliac and common femoral arteries, and very faint pulsation was felt in the popliteal artery. It could not be detected with certainty in the posterior tibial and dorsalis pedis arteries.

Comment

The technique of disobliterative endarterectomy employed in this case is that devised by Reboul in 1947 and a modification of that first employed by Dos Santos (Reboul and Laubry, 1950). Its essential feature is that the endarterectomy is performed under direct vision through a longitudinal incision which opens the artery over the whole extent of the thrombosed segment. In this way complete removal of the obstruction is possible with the least risk of injury to the remaining coats of the artery. The vessel is left with a perfectly smooth inner surface, and the likelihood of re-obliteration by post-operative thrombosis is thus minimized. This contrasts with the blind removal of the obstruction through multiple small arteriotomies in Dos Santos's original method.

Orthodox methods of surgical treatment of arterial thrombosis aim at promoting the collateral circulation by interruption of sympathetic pathways, either centrally by ganglionectomy, or peripherally by arteriectomy of the thrombosed

Photograph of operation specimen. At the lower end a part of the central thrombus is exposed where its sheath of internal arterial coat is defective.