THE FATE OF RADIOPAQUE MEDIA INJECTED INTO THE CANCELLOUS BONE OF THE EXTREMITIES

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Since the work of Erhardt and Kneip (1943), and of Drasnar (1946), it has been known that solutions injected into cancellous bone are rapidly removed into the venous system. This has since been confirmed by Mallet-Guy and Micek (1949), Leger and Frileux (1950) and Olivier (1950) by injections of radiopaque media into the tibia and pubis. More recently Fischgold *et al.* (1952) and Tori (1954) found that the intravertebral and extravertebral plexuses of veins, and even the ascending lumbar vein and azygos system of veins, could be filled by 50 per cent or 70 per cent diodone very soon after its injection into a vertebral spinous process or a rib. Apart from this work by Continental investigators it does not appear that any observations have been made on the fate of materials injected directly into cancellous bone, except for those of Heald (1951) and others in an investigation of the method of treatment of fibrositis by Laughton-Scott. In view of the interesting radiographic appearances obtained by Heald (1951), it was decided to obtain further data on the cadaver after the injection of radiopaque media directly into cancellous bone.

Though the observations are as yet few, a preliminary communication seemed desirable in order to stimulate further investigations of this technique in the living subject.

MATERIAL AND METHODS

Observations were made on the cadavers of three men and three women, aged forty-six, fifty-three, sixty-one, sixty-three, sixty-eight and seventy-six years, death being due to coronary thrombosis in three cases, bronchopneumonia in two cases, and carcinoma of the bronchus in one. The experiments were performed forty-eight to seventy-two hours after death. In the first experiments Lipiodol was used as the injection medium, but it was later found that 50 per cent diodone (Pyelosil, Glaxo Laboratories Ltd.) could be injected more easily, because of its lower viscosity. It was finally discovered that a suspension of barium sulphate (Micropaque, Damancy & Co. Ltd.) could be used for injection and provided better contrast radiographically. The pressure necessary for injection was, however, slightly greater than with diodone.

The method of injection employed is like that of previous workers, and requires a sternal puncture or lumbar puncture needle ground so as to produce a symmetrical sharp point. This is pushed through the skin and tapped into the underlying bone with a hammer. The trocar can be withdrawn quite easily once it has perforated the compact bone and the needle is imbedded within the cancellous bone; till then, the trocar cannot be withdrawn except forcibly. In the living subject infiltration of the overlying skin with procaine makes the procedure quite painless (Plewes 1953). A syringe charged with radiopaque medium is attached to the needle, and the injection can then be made with ease.

Injections were made in a variety of situations, using 5–10 millilitres of radiopaque material. Much more could have been injected. The site of investigation was radiographed immediately after the injection, which never took more than forty-five seconds.

RESULTS

In several circumstances dissections were performed immediately after injection and radiography in order to determine exactly the route of drainage. In one experiment the skin

was reflected over the calcaneum, and injection made directly into the bone from the medial aspect; the opaque medium could then be seen passing rapidly into numerous minute veins, and from these directly into the dorsal venous arch of the foot, the long saphenous and posterior tibial veins. In a further experiment, during injection of 6 millilitres of Micropaque into the medial malleolus, the long saphenous vein could be seen to distend during the injection, and dissection of the leg afterwards showed that the suspension had travelled along the long saphenous vein as far as a point 17 centimetres proximal to the adductor tubercle of the femur. Further experiments, confirmed by dissection, showed that in every case in which the contrast medium was injected into cancellous bone, it was rapidly removed by small venous channels leaving the bone at various points near the site of injection.

FIG. 1

Right shoulder region after injection of 5 millilitres Micropaque into the acromion process. The injection needle can be seen just medial to the tip of the acromion process, the intra-osseous channels in which are clearly shown. Only a short segment of the axillary vein, seen superimposed on the lateral border of the scapula, is filled; it is markedly distended and shows the outline of valves. A communicating vein between the veins of the acromion process and circumflex humeral veins is superimposed on the head of the humerus.

Several attempts were made to inject radiopaque media into the compact bone of the diaphysis in certain situations, such as the shaft of the tibia and of the humerus, but it was found impossible to penetrate the bone with the needle.

The upper extremity. *The acromion process of the scapula*—Five millilitres of Micropaque injected into the lateral extremity of the acromion process of the right scapula produced rapid filling of neighbouring veins and those in the axilla. The acromion process was drained by small and tortuous intra-osseous channels which collect into two larger extra-osseous veins; these drain into the cephalic and the axillary venous system (Fig. 1). The lateral channel draining the acromion process also filled the circumflex humeral veins in a retrograde manner, and the medial channel could be recognised as an acromial tributary of the cephalic vein. The contrast medium was seen in only a short segment of the axillary vein because the valves

prevented retrograde flow; in the lower part of this segment the valves could be clearly seen ballooning out at the lower part of the lateral border of the right scapula.

The head of the humerus—Ten millilitres of Micropaque were injected into the region of the lesser tuberosity of the left humerus. At the point of the needle the contrast medium filled the interstices of the cancellous bone to give a diffuse stellate appearance (Fig. 2). This region was chiefly drained by one large venous channel emptying into the cephalic vein. Here the distribution of Micropaque passed mainly proximally into the axillary vein, where the progress of the medium in a distal direction was again prevented by a valve at a similar site to that shown in Figure 1. The circumflex humeral vessel, outlined lateral to the axillary vein pool of contrast medium, presented one valve obstructing retrograde flow. It was observed

FIG. 2

Left shoulder region after injection of 10 millilitres Micropaque into the lesser tuberosity. Intra-osseous channels may be seen to be filled at the point of the needle, draining inferiorly into the cephalic vein (C), the radiopaque medium in which was found, by dissection, to be continuous with that in the axillary vein (A). The site of injection is also drained by a circumflex humeral vein (C.H.) which, in turn, drains into the axillary vein just proximal to the site of its distension caused by valves.

that vessels following this route of drainage are smaller than those reaching the cephalic vein. This would confirm the observations of Mallet-Guy and Micek (1949) that, in certain circumstances, superficial veins are demonstrated more readily than the deep veins by this method of phlebography.

The radiographic appearances found in this experiment were confirmed by subsequent dissection.

The olecranon process of the ulna—On injection of 3 millilitres of 50 per cent diodone into the olecranon process of the right ulna, the radiopaque medium was found to drain through various intra-osseous channels, and then into the cubital veins just below the site of injection (Fig. 3). The diodone also filled the cephalic and basilic veins some distance proximal to the elbow joint. The vein mainly involved in draining the upper end of the ulna is one which

leaves the bone just below the coronoid process, removed from the nutrient foramen of the ulna. *The lower end of the radius*—Six millilitres of Micropaque introduced into the lower end of the right radius drained into venous channels as high as the elbow. The radiopaque medium filled the interosseous veins as well as the lower end of the cephalic vein (Fig. 4).

The lower extremity. *The ilium and greater trochanter*—In one experiment 6 millilitres of Micropaque were injected into the right greater trochanter; the radiopaque medium filled intra-osseous channels and then immediately drained into the circumflex femoral vessels and their branches, and eventually the femoral vein itself. Twenty minutes later a further

FIG. 3

FIG. 4

Figure 3—Elbow after injection of 3 millilitres diodone. The injection needle is seen penetrating the olecranon process. Intra-osseous channels draining inferiorly from the site of injection collect to form tributaries of the cubital veins which, in turn, drain into the cephalic and basilic veins. Dilations along the course of the veins indicate the presence of valves. Figure 4—Forearm after injection of 6 millilitres Micropaque into the lower end of the radius. Intra-osseous veins in the radius, the cephalic vein proximal and distal to the site of injection, and the interosseous veins, are well shown.

6 millilitres of Micropaque were injected into the right anterior superior iliac spine; branches of the superior gluteal and deep circumflex iliac veins were clearly shown immediately after injection. The composite radiograph (Fig. 5) demonstrated clearly the venous network in the right hip region. In this case, the deep veins draining this region have been injected.

Proximal end of the tibia—Four millilitres of diodone were injected into the proximal end of the right tibia just distal to the epiphysial line (Fig. 6). The popliteal vein was immediately and clearly outlined, together with the medial and lateral inferior genicular veins which appear to be draining the injection site. The short saphenous vein is also filled for some 12 centimetres distal to its termination.

The medial malleolus—Six millilitres of Micropaque were injected into the medial malleolus of the left tibia. Antero-posterior (Fig. 7) and lateral (Fig. 8) radiographs were taken within a minute. Both views show the delicate intra-osseous channels draining into small veins which on the medial side reach the long saphenous and posterior tibial veins, and on the lateral side the short saphenous vein. Subsequent dissection showed that the dorsal venous arch

FIG. 5

FIG. 6

Figure 5—Hip region after injection of 6 millilitres Micropaque into the greater trochanter and 6 millilitres into the anterior superior iliac spine. Intra-osseous channels in the greater trochanter are particularly well shown, draining into the circumflex femoral vessels. Branches of the superior gluteal and deep circumflex iliac veins are also shown in relation to the iliac crest. The two sites of injection eventually drain into the femoral and external iliac veins. Figure 6—Knee after injection of 4 millilitres diodone into the proximal end of the tibia just distal to the epiphysial line. The needle is seen end-on close to the tibial tubercle. The inferior genicular veins, short saphenous and popliteal veins are clearly shown.

of the foot was also filled with radiopaque medium. Reflux flow distally outlined the continuation of the posterior tibial veins on the medial aspect of the calcaneum. Proximally the vessels were more clearly outlined, and the valves in the venae comites of the posterior tibial artery were particularly well shown.

DISCUSSION

These researches confirm those of previous workers in demonstrating the rapidity of drainage into the venous system of solutions and suspensions introduced into cancellous bone. In the living subject, diodone introduced into the greater trochanter passes into the regional veins within half a minute of the termination of the injection, and is completely removed from these veins within three to four minutes after injection (Ross 1954). This may be an underestimate, however, since it was possible to introduce one and a quarter pints

of plasma through a sternal puncture needle into the manubrium sterni (which is composed of cancellous bone) of a collapsed woman in less than two minutes (Bailey 1947). Indeed, the sternum in the adult has been used as a site for blood transfusion (Tocantins and O'Neill 1941, Tocantins, O'Neill and Jones 1941), when the rate of flow has been up to 25 millilitres a minute with a head of pressure of 100–150 centimetres. This method of intrasternal transfusion was found useful during the last war because of the firm anchorage given by the sternum for the injection needle, the great vascularity of the sternum and its efficient drainage through internal mammary and innominate veins into the superior vena cava. The curious feature of the vascularisation of bone, however, is that, although the venous drainage is

FIG. 7

FIG. 8

Figure 7—Ankle region after injection of 6 millilitres Micropaque into the medial malleolus. The valves in the posterior tibial veins are well shown. Figure 8—Lateral view of the specimen shown in Figure 7. Reflux flow has outlined the continuation of the posterior tibial veins on the medial aspect of the calcaneum.

rapid, and quicker than that of soft tissues, the arterial supply through nutrient arteries is slow and at a low pressure (Lamas, Amado and Da Costa 1946).

The method of introduction of solutions and suspensions into cancellous bone is also of interest for the technique of phlebography. Apart from the investigations of Continental workers, this procedure does not appear to be generally recognised, although it is easily effected. The experiments here reported suggest that the venous system of a limb could be filled easily and safely through a needle inserted into cancellous bone at numerous sites. The simplicity and safety of this procedure (Tori 1954), and the fact that it can be used in oedematous limbs in which the superficial veins are not visible (Leger and Frileux 1950) further justify the clinical application of this technique. The danger of osteomyelitis after transfusion into the medullary cavity of infants (Gunz and Dean 1945, Ellison 1945) must, however, be remembered.

SUMMARY

Radiopaque solutions and suspensions introduced into cancellous bone in the extremities of the cadaver are rapidly removed into the venous system through regional superficial or deep veins. The experiments described in this communication confirm the simplicity of methods of introduction of fluids into cancellous bone and justify further observations on their clinical application for the technique of phlebography.

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