LYMPHANGIOGRAPHY

A TECHNIQUE FOR ITS CLINICAL USE IN THE LOWER LIMB

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Arteriography and phlebography have been used in clinical medicine since their development some twenty years ago. The early work with these techniques was done by dos Santos *et al.* in 1931, Moniz *et al.* (1932), and dos Santos (1938). A comparable method of studying the lymphatic circulation would be of obvious value, but its development has been delayed by technical difficulties. Lymph vessels, or at least normal ones, are much smaller than the arteries or veins used in angiography. They contain colourless lymph, which makes them difficult to see, and under normal circumstances they may be empty or nearly so, existing as potential spaces like the pleura or peritoneum (Kinmonth, 1952). Special methods have therefore been developed to make the lymph trunks visible to the naked eye at operation and opaque to *x* rays so that radiographs could be made to study their role in disease in man. Some of our findings have already been described (Kinmonth, 1951, 1952, 1954; Kinmonth and Taylor, 1954). This paper describes a method which has proved useful in practice and which embodies certain technical improvements. The general principle is that the lymph trunks are made visible to the naked eye by subcutaneous injection of a diffusible blue dye so that radio-opaque solution can be injected direct into them through a small needle.

Lymphangiography of the Leg and Thigh

(1) The diffusible dye patent blue* (also known as patent blue violet or patent blue V) is made up into an isotonic solution (11%) in distilled water and sterilized by autoclaving. About 2 to 2.5 ml. of this solution is injected subcutaneously between the toes, roughly 0.5 ml. into each web, which is massaged with gauze for about half a minute.

(2) The ankle-, knee-, and hip-joints are then passively moved repeatedly through their full range for five minutes. The dye, which permeates the lymph trunks soon after injection, is thus moved along them so that they are filled as far as the pelvis. In this dosage (up to 2.5 ml. for an adult) the dye is without toxic effects. It is, however, absorbed into the blood stream, and the patient soon becomes blue in colour. The anaesthetist and the nursing staff in the ward are warned of this. It is excreted in the urine, and the patient regains a normal complexion in about 24 hours. Severe oedema of the limb should be reduced so far as is possible by elevation and massage for a few days beforehand, because the flow of dye through the lymph trunks may be retarded if they are waterlogged by tissue fluid.

*Obtainable from G. T. Gurr, 36, New King's Road, London, S.W.6.

(3) A bloodless field is helpful in the next stage. This can be produced with a rubber bandage and air cuff, but a better way is to tilt the patient into a full Trendelenburg position so that the limb is sharply elevated.

(4) A transverse incision is made in the skin of the dorsum of the foot about 2 in. (5 cm.) proximal to the webs of the toes (Fig. 1). The lymph trunks run upwards in the line of the long axis of the foot, and it is sometimes possible to see them filled with the blue dye through the skin before the incision is begun. They lie very close to the skin, which is thin in this situation, and so the incision must be deepened by cautious light strokes of the scalpel.

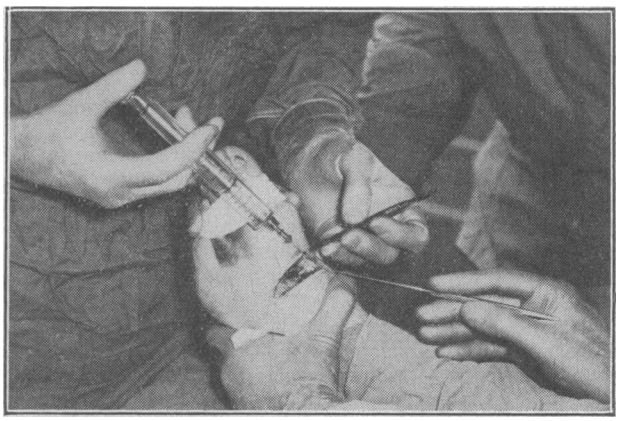

FIG. 1.—Injection of diodone into a lymphatic (see description in text).

Small bleeding points are coagulated with the diathermy. Lymph trunks of normal size are just under 1 mm. in diameter. A length of some 5 or 6 mm. is exposed by gently pushing apart the edges of the incision with the scalpel. A clean exposure of the superficial aspect of the vessel is necessary, but its whole circumference must not be free or it may collapse and make injection impossible.

(5) At this stage it is helpful to distend the lymph trunk with dye. An assistant places a finger on the skin an inch (2.5 cm.) above the incision, and presses gently to obstruct the lymph trunk, and the surgeon massages the interdigital area so that the dye passes up and fills the exposed length. The exposed length of lymphatic is held as straight as possible by grasping the areolar tissue next to it in the distal part of the incision. All is now ready for the injection.

(6) The radio-opaque solution used is 70% diodone. The preparation known as "pyelosil" has given good results in our experiments. It has been kept warm until required, when a 10-ml. syringe is filled with it. A No. 18 hypodermic needle is firmly mounted on the syringe. This is the smallest needle of the standard sizes and its bore will just allow the viscous solution to pass. The needle point is introduced some 2 mm. into the lymph trunk and the piston tentatively advanced. If it is accurately placed, diodone enters and the vessel becomes white and transparent. If, however, the needle point lies in adventitia a bleb forms and the injection must be stopped and another attempt made, often in another reach of the lymphatic or in another vessel. If all is going well the injection is continued, the surgeon watching the needle-point and an assistant telling him of the progress of the piston along the barrel of the syringe. The diodone is injected as rapidly as the small bore of the needle will allow. The full 10 ml. is injected if possible, but sometimes rapid extravasation around the needle occurs before this and the injection is then stopped. Surprisingly good delineation is sometimes obtained with injections as small as 1 ml. Minor leakage of diodone around the needle during the injection is gently mopped up with cut pieces of gauze by an assistant, who takes care not to disturb the needle point.

(7) The needle is withdrawn when the injection is complete and the table immediately altered from the Trendelenburg to the horizontal position.

(8) The *x*-ray tube is moved into position and radiographs are made of the whole limb with as little delay as possible. The sooner they are made the better will be the definition, because the diodone starts to diffuse through the permeable walls of the lymphatics after a few minutes, giving rise to blurred outlines in the film. The films have been placed in position under the limb in the beginning so that no time is lost at this stage.

Radiological Technique

As with all radiographic procedures in operating theatres, radiography in these cases is carried out under certain difficulties. Examination is even more difficult when the thicker parts of the body such as the pelvis, abdomen, and thorax have to be radiographed.

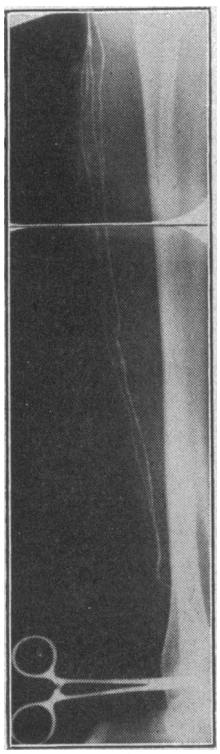

FIG. 2. — Normal lymphangiogram: 6 ml. of 70% diodone was injected and the films were exposed one minute later.

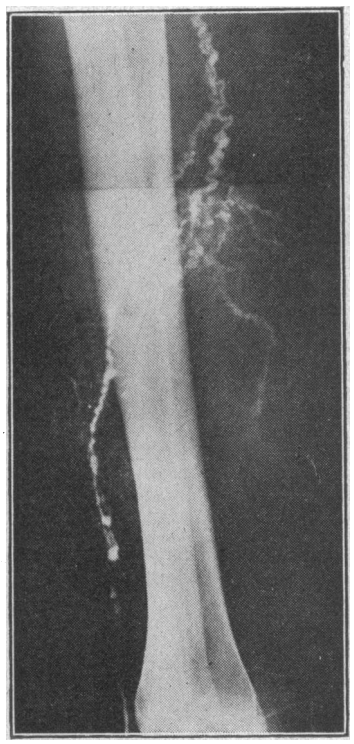

FIG. 3.—Lymphangiogram in a patient with idiopathic lymphoedema: 10 ml. of 70% diodone was injected and the films were exposed one and a half minutes later.

Good definition and reasonable contrast are essential, as normal lymphatics are demonstrated as fine opaque filaments in the soft tissues.

It has been found advantageous to use non-screen film for the extremities and screened films for the thicker parts. Exposure times need not be as critical as in arteriography, as the flow of opaque medium through the lymphatics is comparatively slow, but immobilization is essential, and undue delay may result in blurred lymphatic outlines, due to seepage through the walls of the vessels.

The films or cassettes are placed in boxes, under the sterile towels, below the part to be examined and prior to the injection. Several non-screen films can be used if necessary, each protected from the other by lead-protected trays, the box being long enough to carry on each tray two 15 × 6-inch (38 × 15-cm.) films placed end to end. There is no appreciable gap between the end-to-end films, so that little of the lymphatic system is undemonstrated. Almost the whole length of a limb can be radiographed at one time with a special type of tube arm which we use on these mobile units to give adequate focus–film distance. The trays are removed one by one from the distal end of the box as each exposure is made.

In general, it is unnecessary to take serial films of each area (such as are required in arteriography) unless more of the lymphatic system has to be filled by a further injection. It is of great advantage to have a wedge filter to compensate for the varying thickness of the lower limb, and the recent use of such an accessory, similar to that which we use in arteriography, has been of much value in improving the quality of the films. A difficulty may be to make interchange of the filter simple, as it is not always practicable to have the same mobile *x*-ray set available for this type of operating-theatre work.

A cassette and a fixed grid, usually in a cassette tunnel, are used for the successful demonstration of the inguinal glands and pelvic lymphatics, and the abdominal lymphatic channels have also been so demonstrated. As stated above, it is surprising how small quantities of opaque medium, such as 1–1.5 ml., give good delineation of the lymph vessels when there is little sign of dilatation. If, however, gross dilatation and varicosity exist, a much larger quantity may be necessary to demonstrate all the ramifications of these vessels and to outline the more proximal lymph vessels in leg and arm. With care and co-operation much interesting information concerning the state of the lymphatic system can be gleaned by this type of examination.

For the limbs our technique has been as follows. Non-screen film: 65 kV, 65 mA; time, 2 seconds; distance, 48 in. (122 cm.).

For the thicker parts :— cassette and grid : 80 kV, 45–50 mA; time, 1.5 seconds; distance, 48 in. (122 cm.).

It is important that each new technique should be thoroughly supervised by a radiologist, as difficulties occur in operating theatres which may require special equipment, and discussion between surgeon and radiologist may be necessary to reconcile the problems with which each is faced, in order to evolve a satisfactory solution to the problem and obtain the best possible results.

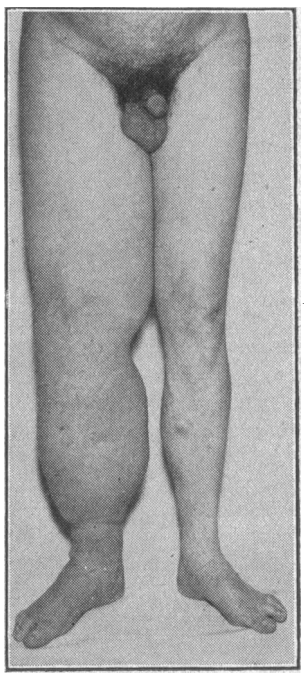

FIG. 4.—Idiopathic ' lymphoedema. Lymphangiogram shown in Fig. 3. Operation gave considerable amelioration.

Results

The method has been used to study lymph vessels in lymphoedema praecox, post-mastectomy oedema of the arm, post-phlebitic ulceration and oedema of the leg, congenital arteriovenous fistulae, and other diseases. Some of the findings have been reported elsewhere, and it is not proposed to give further details here, but instead to describe some examples illustrating the technique.

A normal lymphangiogram is shown in Fig. 2. The lymph trunks remain the same width in their course up the limb, unlike veins which become wider. Bifurcation occurs frequently, so that the trunks appear to multiply as they pass upwards. The ampullae of valves are often seen.

The lymphangiogram shown in Fig. 3 was taken from the leg of a patient with idiopathic lymphoedema (Fig. 4). The lymph vessels are tortuous and wide. There is both

lateral and retrograde flow of the dye into other lymph vessels. These features are never seen in normal lymphatics.

We wish to thank Professor Sir James Paterson Ross and the other members of the Surgical Professorial Unit at St. Bartholomew's Hospital for their help and encouragement in developing this method.

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THE DELLWOOD FIRE

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In the early morning of Easter Sunday, April 18, 1954, a fire occurred in the nursery of Dellwood Maternity Home, Reading, which resulted in the death of 13 newborn babies. Dellwood is a general-practitioner obstetric unit of 17 lying-in beds dealing with normal cases. The hospital staff serve in a consultant capacity. The building is about fifty years old and there have been a few structural alterations during the twenty-four years of its use as a maternity home. The nursery measures 20 by 12 ft. (6.1 by 3.6 metres), with two doors and two windows: the floor boards are of deal covered by linoleum.

The fire was caused by the flue of a hot-water boiler which in September, 1953, had been moved so that it ran beneath the floor of the nursery. It has been established by subsequent inquiry that the installation of the flue complied with the local building regulations, though the experts who assisted the Regional Board in their inquiry agreed that the regulations need overhauling. It seems likely that the fire began slowly, with much smouldering of wood over a large area of floor. This, the destructive distillation of soft wood and also of some linoleum, filled the room with thick smoke, until finally part of the floor caught alight and the flames spread to one of the cots. It is thought that the room may have been filled with smoke for between 20 and 30 minutes.

There were 15 babies in the nursery, the doors of which were closed, while the windows were kept slightly open. A gas fire was burning. A nursing staff of two were on duty and the nursery was visited at intervals during the night, the last visit before the fire being about 3.15 a.m. The fire was discovered by one of the sisters* at 4 a.m., and she immediately began to remove the babies from the room while help was being called. While removing the first babies she received considerable burns of face and arms and was in great distress from inhalation of smoke; she continued to bring them out one by one, and finally collapsed when the last one had been carried out. She was subsequently admitted to hospital.

One of us (R. A. R.) first saw the babies at 4.30 a.m. One whose cot had caught fire was dead following extensive burns involving the whole body, with some charring. Three others were transferred to the Battle Hospital at once and placed in oxygen boxes. One of these had some superficial burns of the face. All three were limp and pallid and in great respiratory distress. There was much clear viscid discharge from nose and eyes and complete nasal obstruction. The remaining 11 babies were in good general condition, but all were coughing a little and had some discharge from the nose and eyes. Their colour was generally good apart from slight occasional cyanosis produced by coughing attacks and interference with breathing by nasal obstruction. During the day there was some deterioration. Respiratory rates were rising, and in all cases cough had increased: a little clear yellow fluid was occasionally coughed up or aspirated. Scattered rales, in every case, became audible in the afternoon and evening. Oxygen boxes had by this time been obtained for all the cases.

That evening it was decided to clear a hospital ward and make special arrangements for nursing staff, and early on Monday morning all the surviving babies were transferred in oxygen boxes to the Royal Berkshire Hospital. An alarming increase in respiratory obstruction developed in all the cases, and on Monday evening it seemed unlikely that any of the babies would survive. The appearances were similar to those with which we are familiar in asphyxia due to hyaline membrane, with, in addition, signs of upper respiratory tract irritation; but these were strong infants several days old, and were making very forcible efforts to breathe, whereas in hyaline membrane asphyxia we are dealing usually with a shocked or feeble baby. Thus the characteristic contrast between struggling respiratory effort and poor breath sounds on auscultation was very striking.

Two of the babies began to improve after the third day and finally appear to have made a good recovery. There is no reason to suppose that these two suffered less exposure to the smoke than any of the others.

Treatment

All the babies were given oxygen, the first three being placed in oxygen boxes on admission to hospital, and the remainder (who at first stayed at Dellwood) being similarly treated later on the first day when chest signs were appearing and extra boxes had been obtained. Before this, some oxygen was given by tube and funnel or catheter when coughing attacks led to cyanosis. Mucous secretions were aspirated at intervals as needed, and 5% sulphacetamide was applied to the nose and eyes. Penicillin was given in all cases, starting on the morning of the first day with 100,000 units eight-hourly by injection. The dose was later reduced and given orally to the babies who survived. Humidification was maintained by electric steam-kettles.

At midday on Monday, the day after the fire, streptomycin (100 mg. eight-hourly) and cortisone (50 mg., then 25 mg. eight-hourly) were added to the treatment.

The babies were nursed with the foot of the cot raised and were kept for most of the time in a high concentration

*Sister E. M. Holland was later decorated with the George Medal by Her Majesty the Queen.