A NEW TYPE OF EXTRA-LARGE FILM CHANGER FOR SERIAL WHOLE LIMB AORTO-ARTERIOGRAPHY AND ITS CLINICAL APPLICATIONS

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ABSTRACT

To perform efficient arteriography for patients with arterial occlusive disease of the lower limbs, a new system for serial whole-limb arteriography with extra-large-film changer was developed and clinically applied. This system consists of a motor driven cassette-film changer with four pieces of film sized 35.4×106.2 cm per frame, and ancillary fluoroscopic facilities. The source-image distance is 1.6 m high to cover a wider field and to minimize radiographical blur. The film is 35.4×106.2 cm, sufficient to cover the pelvis and both legs in average sized Japanese patients. The serial angiographic mode can be timed at 1 frame per 1.5 sec exposures at a shorter range and at 1 frame per 10 sec exposures at a longer range. A intensifying screen and an equalized alminium wedge filter are adopted to obtain an adequate density as uniform as possible in the abdomen down to the calf. Last 2 years, the author performed 67 occasions of Aorto-arteriography for 46 patients with arterial occlusive disease of the lower limbs. They were 25 patients with arteriosclerosis obliterans, 14 patients with thromboangitis obliterans, and 7 patients with other arterial occlusive disease. Excellent results were obtained with our new system in serial whole-limb arteriography.

INTRODUCTION

Direct operation for reestablishment of circulation has been increasingly popularized in the management of arterial diseases of the lower limb in our country. The objective of such an approach is not merely to reconstruct the involved vessels anatomically but too to save the affected limb with minimal operative stress so that the patient can enjoy an active life subsequently. Ac-
curate diagnosis is indispensable to this end. There are a variety of procedures available for the diagnosis of peripheral vascular diseases. Arteriography of the lower limb, in particular, is one of the most important means of visualizing organic and functional disorders of the arteries of the affected limb precisely and thereby making a rational plan of operation. In cases of occlusive arterial diseases we have obtained satisfactory results\textsuperscript{1,2,3} by means of thromboendarterectomy or other techniques for reconstitution of flow. The necessity for more efficient whole limb arteriography has led us to make a new type of extra-large film changer for the serial arteriograph. Using this apparatus we have performed arteriography of the lower limbs with satisfactory results on a total of 67 occasions in 46 cases, including 25 cases of arteriosclerosis obliterans and 14 cases of Buerger's disease. The procedures employed and results obtained in these cases are presented as follows.

**AN OUTLINE OF THE APPARATUS**

An outline of the apparatus is given in Table 1. Four extra-large cassette changers of the drum rotation type are geared to a roentgenograph for gastrointestinal diagnosis (Toshiba). The cassettes are 14×42 inches or 40×110 cm; the film is of the size of three large rectangular films combined, measuring 35.4×106.2 cm. The arteriogram was taken at intervals of 1.5 seconds×10 seconds with a source-image distance of 160 cm and a film-object distance of 6 cm. The cassettes were set independently of each other. The arteriogram was taken 0.8 second after stopping the drum, the duration of its rotation being 0.7 second. Differences in photographing conditions were corrected by using an inclined aluminium filter for continuous absorption and intensifying screens US-II for continuous sensitivity compensation (Kyokko). Medrad Mark II injector was used for injection of contrast medium; a standard or universal flow module was resorted to, if necessary.

**METHODS**

1. **Procedure A**

Under lumbar anesthesia a pig-tail catheter was inserted by the Seldinger technique through the groin on the unaffected side into the upper margin of the third lumbar vertebra to take pictures of arteries distal to the bifurcation of the abdominal aorta. Isopaque 440 as contrast medium was injected in an amount of 12 ml per kg body weight, the injection being programmed by means of a universal flow module (Table 2). Three arteriograms were taken first at intervals of 4 seconds following the injection of contrast medium and then another 6 seconds later. The timing of filming may vary with the degree
Whole Limb Aorto-Arteriography

Table 1
An outline of the apparatus of serial whole limb arteriography using the extra-large cassette changer

<table>
<thead>
<tr>
<th>High-voltage apparatus KXO-1000 (150 kVp, 1250 mA) (Toshiba)</th>
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<tr>
<td>High-voltage generator Model DG-15DB-5</td>
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<tr>
<td>X-ray controller Model DC-150D</td>
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<tr>
<td>X-ray TV fluorograph Model DT-AE-1 (Toshiba)</td>
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<tr>
<td>X-ray tubes: For fluorograph DRX 190D (Toshiba) For arteriography DRX 290HD, 2.1/1.0 mm, (Toshiba)</td>
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<tr>
<td>Serial whole limb arteriograph: Drum rotation type, high-speed rotation 8600–9000 (Orion Electric, Chita Central Roentgen)</td>
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<tr>
<td>Number of cassettes to be set: 4</td>
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<tr>
<td>Cassette size: 14”×42” (40×110 cm)</td>
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<tr>
<td>Film size: 35.4×106.2 cm, Fuji RX</td>
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<tr>
<td>Intensifying screen: LH-00—LT-II—LF-II, continuous sensitivity compensation type (Kyokko)</td>
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<tr>
<td>Lithform blend: 14”×42”, 8 : 1 34 lines/cm, parallel type (Mitaya)</td>
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<tr>
<td>Filter (aluminium): 18×27.5 cm, continuous absorption, inclined type</td>
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<td>Automatic contrast medium injector: Medrad Mark IV; Universal flow module</td>
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Fig. 1 -Arteriography of lower limbs using the extra-large cassette changer.
The method of inserting the catheter for lower limb arteriography is illustrated. A) A pig-tail catheter is inserted to the level of the third lumbar vertebra contralaterally. B) Catheters are inserted through the femoral into the common iliac artery contralaterally.
of severity of vascular lesion under investigation.

2. Procedure B

Catheters were introduced by the Seldinger technique into the groins and then the tip of each catheter advanced to the common iliac artery level contralaterally before injection of contrast medium through a Y-tube. Contrast medium was injected in a volume of 80 ml regardless of body weight, the injection being programmed by means of a standard flow module (Table 2). One arteriogram was taken 4 seconds after the beginning of injection of contrast medium and then three more at intervals of 2 seconds. Procedure A was first performed in all cases, procedure B being added as appropriate in cases in involvement of peripheral arteries.

| Table 2
<table>
<thead>
<tr>
<th>Injector program</th>
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<tr>
<td>Weight of Patient (kg)</td>
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<tr>
<td>------------------------</td>
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<tr>
<td>Universal Flow Module</td>
</tr>
<tr>
<td>40</td>
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<tr>
<td>50</td>
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<tr>
<td>60</td>
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<tr>
<td>70</td>
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<tr>
<td>Standard Flow Module</td>
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<tr>
<td>80</td>
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REPORT OF CASES

Case 1—A 68-year-old man

Chief complaints: Cold sensation and paresthesia in left lower limb.

Arteriography: Because of arterial pulses being inpalpable below the left groin aortoarteriography was performed with a pig-tail catheter inserted through the right groin (Fig. 2). As a result, a tortuous course of the abdominal aorta was visualized together with occlusion of the left iliac artery, leading to a diagnosis of arteriosclerosis obliterans. Thromboendarterectomy of the left iliac artery was performed in consideration of the runoff being as satisfactory in arteries distal to the left common femoral artery as on the uninvolved side. The postoperative course has been excellent.
Fig. 2 - Arteriogram in Case 1
An occlusion of the left iliac artery due to arteriosclerotic changes is seen.

Fig. 3 - Aorto-arteriogram in Case 2
An occlusion of the left superficial femoral artery is seen along with collateral vessels between left deep femoral and the left popliteal artery.
Case 2—A 53-year-old woman

Chief complaint: Intermittent claudication of left leg.

Arteriography: The procedure employed was the same as in the Case 1 (Fig. 3). A diagnosis of arteriosclerosis Obligaterans was made on the ground of stenosis of the left common iliac artery and occlusion of the left superficial femoral artery which were thereby visualized. The finding that blood supply to the left leg was maintained through collateral vessels between the deep femoral and the popliteal artery led to the presumption that the collateral circulation was well compensatory for the occlusion of the superficial femoral artery that was present. Thromboendarterectomy of the left iliac artery was therefore performed. The postoperative course has been excellent with relief of intermittent claudication.

Case 3—A 46-year-old man

Chief complaint: Ulceration of left second toe with pain and cyanosis.

Arteriography: Arteriography of the legs was performed with catheters inserted into the common iliac artery contralaterally through the groins under lumbar anesthesia (Fig. 4). No changes suggestive of arteriosclerosis were detected in arterial wall but segmental occlusion present in the posterior tibial

Fig. 4 -Arteriogram of the legs in Case 3
Segmental occlusion of the posterior tibial arteries and the left anterior tibial artery can be seen.
arteries and the left anterior tibial artery. A diagnosis of Buerger’s disease was made and lumbar sympathectomy performed because no direct operation is indicated in such a situation.

Case 4—A 31-year-old man

Chief complaint: Ulceration of right first toe with intermittent claudication of the left leg.

Arteriography: The procedure employed was the same as in the Case 3 (Fig. 5). Arteriographic findings included segmental occlusion of the right posterior tibial artery, complete occlusion with a tree root configuration of the left popliteal artery and tapering with cork-screw signs of small arteries of the legs. A diagnosis of Buerger’s disease was made and lumbar sympathectomy performed.

Fig. 5 -Arteriogram of the legs in Case 4 Segmental occlusion of the right posterior tibial artery is seen together with occlusion of the left popliteal artery and tapering with a cork-screw sign of small arteries.

DISCUSSION

In arteriosclerosis obliterans which has rapidly increased in recent years and in which a direct operation is best indicated, multiple lesions occur so frequently as to make it necessary to take photographs of all arteries of the lower extremities from the abdominal aorta distal to the origin of the renal arteries to the arteries of the legs before a rational plan of restitution
of circulation can be made. In Buerger's disease and other inflammatory arterial diseases, in which more peripheral arteries are often involved, photography of arteries up to the level of the iliac arteries is required since there are some reported cases of skipping lesions located in less peripheral arteries. In arterial diseases of the leg, in which it is important to determine the degree of functional impairment as well as to locate the organic changes in vessels, arteriography must be able to provide images of high quality and resolution. Under such circumstances an apparatus for serial arteriography that enables precise visualization of intraarterial hemodynamics is called for.

There are some procedures available for whole limb arteriography using various equipments such as a motor driven film changer, a roll-film changer and an extra-large cassette changer. Two problem areas can be identified with these procedures: One is concerned with how to correct the differences in photographing conditions between different anatomic sites in order to obtain images of quality, including how to achieve uniform contact of the film with the intensifying screens to prevent radiographic blurring, how to determine the proper size of the film, the proper number of arteriograms to be taken, the proper amount of contrast medium to be injected, the proper way of its injection and so forth. The other problem is how to interpret arteriographic findings more accurately and precisely as regards the hemodynamics of the limb as a whole.

Procedures utilizing the cassette-film changer are considered to yield images of the best quality. Because of the limited coverage per exposure, on the other hand, such procedures are suitable for the diagnosis of localized lesions such as tumors but not adequate for visualization of overall hemodynamic changes in the affected limb. With the roll-film changer there is no problem of blurring of images nor any serious limitations on the number of arteriograms to be taken or the length of photographing intervals. A disadvantage of such a procedure is that the film will roll up even when unrolled and hence tends to come into no uniform contact with the screen, leading to blurring of images. With the extra-large cassette changer, the number of photographs that can be taken is limited and, in addition, there is the possibility of the film moving during photography due to a heavy weight and big inertia of the cassette. The rate of blood flow in the lower extremities is so slow, however, that four to six arteriograms taken at proper time intervals are adequate for our purposes. Immediately after the rotation of the film, the cassette is still shaking and thus this may cause the blurring of arteriogram. In our procedure, arteriogram is taken after the rotation of film with a short lag time. An arteriographic procedure employing the extra-large cassette changer therefore appears to be most practical at present. These con-
Whole Limb Aorto-Arteriography

Considerations led us to adopt the extra-large cassette system for our apparatus developed to improve the efficiency of whole limb arteriography in cases of circulatory disturbances in the lower extremities.

A wedge-shaped filter or intensifying screens must be used in order to cope with the great differences in photographing conditions among different anatomic sites ranging from the abdomen to the tip of the foot. Our attempt at such correction by using a wedge-shaped aluminium filter alone showed that a filter serving this purpose should have a thickness of up to 3 cm with resultant considerable flattening of images. This induced us to turn to the intensifying screen for correction of such differences in photographing conditions: screen for continuous sensitivity compensation (Kyokko), LH-II—LT-II for the pelvis or more distal areas and LF-II for the feet. Because of its size the film was difficult to bring into uniform contact with the screen. It was hence necessary to reinforce and increase the number of clasps for the cassette. After some preliminary studies it was decided to take the arteriogram at an interval of 0.8 sec. after arrival of the cassette to the proper position in order to avoid movement of the film during photography due to the inertia of the cassette. The film was of the size of three large rectangular standard films combined, measuring 35.4×106.2 cm. It is wide enough for arteriography of the lower limbs, as different from the Angiorapid 2 (Siemens) which measures 30×120 cm, although it may not be long enough in certain situations. An ideal size would be of four large rectangular films combined, or 35.4×141.6 cm. Investigation in this respect is now under way. A coverage adequate for practical purposes is down to the legs in cases of arteriosclerosis obliterans and up to the iliac arteries in cases of inflammatory arterial disease. In this procedure a total of four arteriograms can be taken at one time, a number which appears to suffice if proper filming intervals are meticulously selected. Some six arteriograms might be required, however, in cases of arteriovenous fistula, for instance. Medrad Mark II is used for injection of contrast medium. In aorto-arteriography additional use of a universal flow module makes it possible to visualize on a single film a wide extent of arteries ranging from the aorta to small vessels of the feet.

Such is an outline of our apparatus for serial whole limb arteriography using the extra-large cassette changer as well as of our clinical experience with the apparatus. Satisfactory arteriograms have been made available by this means up to the present. Further investigation in larger series is needed to solve some problems mentioned above.
ACKNOWLEDGEMENT

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REFERENCES