Study on Peripheral Circulation Using $^{131}$I-Macro-aggregated Serum Albumin

HISAO SHIDA

Department of Radiology,
Tohoku University School of Medicine, Sendai

ITARU OHARA

The Second Department of Surgery,*
Tohoku University School of Medicine, Sendai

SHIDA, H. and OHARA, I. Study on Peripheral Circulation Using $^{131}$I-Macro-aggregated Serum Albumin. Tohoku J. exp. Med., 1970, 101 (4), 311-316 — The collateral circulation of the limbs was investigated by injection of radioiodinated macroaggregated serum albumin ($^{131}$I-MAA) into the brachial and femoral arteries of 31 patients with occlusive vascular diseases. The method was found useful as a subsidiary means in evaluating the peripheral circulation in these diseases. In 80% of cases of sympathectomy, arteriovenous shunts were increased by 25% of the control. Higher leakage of $^{131}$I-MAA of approximately 90% over the control was observed in a congenital arteriovenous fistula of the leg, which was confirmed by scintiscanning. Linear scanning along the body axis displayed accumulation of $^{131}$I-MAA in the lung of control and patients with vascular diseases, suggesting that $^{131}$I-MAA had passed through the arteriovenous shunts. Abnormally high radioactivity was observed occasionally at the toes and finger tips with chronic ulcers. —— collateral circulation; radioiodinated macroaggregated serum albumin; arteriovenous shunt

In order to detect occlusions of arterial trees of the limbs without using arteriography in patients with peripheral arterial occlusive lesions, scanning of a suspected area of the extremities with a scintillation detector after injection of $^{131}$I-macroaggregated serum albumin ($^{131}$I-MAA) into the main artery has been introduced into the diagnostic use. Occasionally, the site of occlusion of the main artery as demonstrated by arteriography is consistent with the findings by scintiscanning.1,2 However, the agreement is not always satisfactory. Jones et al.3 reported in 1965 that when $^{131}$I-MAA was injected into the femoral artery, normal and abnormal patterns of regional blood flow could be distinguished. Our study revealed that regional blood flow was greatly influenced by the collaterals, of which development depended on the site, extent and period of occlusion. In the present paper the anatomical and functional collateral blood flow in patients with occlusive diseases is described.

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METHODS AND MATERIALS

The patient was asked to lie in a supine position in a room kept at a constant temperature of 23°C. After a 10 minutes' rest, 1% xylocaine was infiltrated around the artery and the blood vessel was punctured. The arteries of both sides were used successively. Two ml of 100 μCi 131I-MAA were injected rapidly into either the femoral or brachial artery. Two scintillation detectors 2 inches in diameter and 2 inches in thickness were used. In the upper limb, one was placed over the arm and the other over the fingers, while in the lower limb, one was placed over the leg and the other over the toes. The detectors were led to spectrometers and recorders to obtain percentage of arteriovenous shunt. The percentage was calculated by measuring the initial peak of count per second (A) and the following stabilized level of count per second (B). The values were put into the following equation: \[(A - B)/A \times 100\%\] (Fig. 1). Subsequent to this procedure, linear scanning

![Fig. 1](image1.png)

**Fig. 1.** Method of calculating the percentage of arteriovenous shunt. CPS: count per second of 131I-MAA. A: the peak of radioactive count over the finger or toe. B: the stabilized level of radioactive count over the finger or toe. The percentage of arteriovenous shunt is calculated by the following equation: \[(A - B)/A \times 100\%\].

![Fig. 2](image2.png)

**Fig. 2.** Method of calculating the percentage of accumulation of 131I-MAA in the lung using linear scanning along the body axis. CPS: count per second of 131I-MAA. The percentage is calculated by the following equation. (The lung area in the linear scanning of body axis/the total area in the linear scanning of body axis) \times 100\%.
along the body axis was carried out to calculate the percentage of accumulation of $^{131}$I-MAA in the lung. The calculation was made by measuring the lung area ($a$) and the whole area ($b$) in the linear scanning of the body axis. The values were put into the following equation: $(a/b) \times 100\%$ (Fig. 2). Finally, the photoscanning of the leg and foot or arm and fingers was taken to check the distribution of $^{131}$I-MAA.

RESULTS

Thirty-one cases of various arterial diseases with organic occlusions, i.e., Buerger's disease, arteriosclerosis obliterans, vascular occlusion due to thrombosis, 

![Diagram showing the percentage of arteriovenous shunt in the toe and finger tip in patients with and without vascular diseases.](image)

Fig. 3. The percentage of arteriovenous shunt in the toe and finger tip in patients with and without vascular diseases.

![Image of a 33-year-old man with congenital arteriovenous fistula of the left leg. $^{131}$I-MAA was lost through proximal arteriovenous shunts in the leg.](image)

Fig. 4. A 33-year-old man with congenital arteriovenous fistula of the left leg. $^{131}$I-MAA was lost through proximal arteriovenous shunts in the leg.
congenital arteriovenous fistula and Raynaud's syndrome were studied. Six cases without vascular diseases were used as the control. Twelve (80%) out of 15 cases with Buerger's disease showed arteriovenous shunts over 25% larger than the control (Fig. 3). These cases underwent either lumbar or thoracic sympathectomy. In two cases without sympathectomy, the value was the same as that of the control. All the 4 cases of obstructive arteriosclerosis undergoing sympathectomies showed marked arteriovenous shunts. Higher leakage of $^{131}$I-MAA approximately 90% over the control was observed in a congenital arteriovenous fistula of the leg. This was confirmed by scintiscanning of the left leg with the lesion (Fig. 4).

Scintigram in a control is shown in Fig. 5.

Fig. 5. Photoscintigram obtained by injecting radioiodinated macroaggregated serum albumin into bilateral femoral arteries. The patient did not have vascular occlusion.

Fig. 6. The percentage of accumulation of $^{131}$I-MAA in the lung in patients with and without vascular diseases.
Fig. 7. A 34-year-old man with Buerger's disease. The right ulnar artery was occluded. Chronic ulcer existed on the right 4th finger tip.

According to linear scanning of the body axis from the foot to chest, $^{131}$I-MAA was found accumulated in the lung in almost every case including controls, which suggested that $^{131}$I-MAA had passed through the arteriovenous shunts (Fig. 5). This method was consequently sensitive enough for the demonstration of collaterals in the limbs.

In some of the cases with chronic ulcers on the finger tips or toes, accumulation of $^{131}$I-MAA was evident (Fig. 7). It was also noticed that the distribution of $^{131}$I-MAA was low in the limb with congenital arteriovenous fistula.

**Discussion**

At present, $^{131}$I-MAA is widely used for the diagnostic purpose in lung diseases. The idea of using this radioisotope is based on the observation that pulmonary capillaries are blocked by the serum albumin particles and give positive scintigrams, while space occupying lesion is disclosed as a defect by the scanning. The size of pulmonary capillaries is approximately 7 $\mu$, while macroaggregated serum albumin particles are of dimensions of 10–30 $\mu$ with a preponderant distribution at 20 $\mu$ by a particle size analyzer. Initially, it was considered to be large enough to block the peripheral collaterals when injected into either the brachial or femoral artery. However, the escape of these particles through the arteriovenous shunts was unexpectedly high.
Arteriovenous anastomoses are found in the skin, where typical glomi are present. The role of arteriovenous shunts is primarily found in their effect of sparing cardiac activity. The shunts change their size according to environments, chemical and physical stimuli. Also in the skeletal muscle, the size of the capillary bed is variable at rest, in exercise and training. These anatomical structures and functional versatility in the peripheral circulation are quite different from that of the lung and make a proper interpretation of findings of the scintigram in the limbs difficult. Theoretically, the shunts and capillaries may be blocked by large-sized particles together with the site of arterial occlusion. Thus, negative shadow consistent with the arteriographical finding may be obtained. However, it is difficult at present to produce particles of a uniform size over 50 μ.

The reported technique, however, revealed that abundant collaterals and capillaries were demonstrated in the sympathectomized limbs. It also suggested that vasodilators, which are supposed to act on the collaterals, might not be so effective on the diseased site in the periphery on account of possible bypass of the drugs.

Accumulations of 131I-MAA in ulcers of the toe and finger is considered to be due to well development of capillaries in the ulcer regions.

References


