

## EXTERNAL ILIAC ARTERY BLOOD FLOW IN PATIENTS WITH ARTERIOSCLEROSIS OBLITERANS\*

By YACOV ITZCHAK, M.D., M.Sc.,†‡ MICHAELA MODAN, M.Sc.,§  
RAFAEL ADAR, M.D.,|| and VICTOR DEUTSCH, M.D.‡  
TEL HASHOMER, ISRAEL

### ABSTRACT:

Blood flow in the left external iliac artery was measured by means of a densitometric technique in 21 patients with arteriosclerosis of the lower extremities and in 21 controls. Normal flow volumes were (mean  $\pm$  S.D.)  $604 \pm 104$  ml./min. for males and  $478 \pm$  ml./min. for females. Flow volume was significantly lower in the patients with ischemia of the legs. There was no correlation between flow volume through the artery and the degree of stenosis at its narrowest point. The diameter of the iliac artery and the flow volume were significantly larger in males than in females; however, flow velocity was significantly larger in females.

**A**CCURATE assessment of the circulation of the lower extremities is essential in reconstructive vascular surgery. The clinical examination will indicate the severity of the ischemia and routine angiography will supply morphological information. Not infrequently, however, in the presence of several lesions of different severity along the arterial tree, more accurate information regarding the volume of flow through the different segments would be helpful in determining the correct plan of action.

A recent modification of cineangiodesitometry has enabled us to study flow volume and velocity through segments of the arterial tree in patients.<sup>5</sup> This study is performed at the time of routine angiography and does not necessitate a separate catheterization.

The present report describes the results of flow measurements through the external iliac arteries of 21 normal subjects and 21 patients with clinical arteriosclerosis obliterans of the lower extremities.

### MATERIAL AND METHOD

Our method has been previously described.<sup>5</sup> It consists of cineangiographic recording of the artery in question during

injection of a bolus of contrast material, and a densitometric evaluation of the washout of this material at 2 selected sites along the vessel using an optic electronic system. This densitometric analysis yields 2 indicator dilution curves. The time interval between these 2 curves corresponds to the transit time of the bolus between the 2 points along the vessel.

By measuring the diameter of the vessel and the distance between the 2 points, flow volume and velocity can be derived:

$$\text{Flow volume} = \text{Volume/Time} = \pi r^2 L/T$$

$$\text{Flow velocity} = L/T$$

Where  $r$  is the radius of the vessel,  $L$  is the distance between the 2 points and  $T$  is the transit time.

This densitometric system for flow measurement has been shown to be both accurate and reproducible *in vitro*,<sup>5</sup> with an error of  $\pm 5$  per cent.

The examination is performed by catheterization of the femoral artery using the Seldinger technique. The tip of the catheter is advanced above the bifurcation of the aorta. Twelve cc. of dye are injected and a cineangiographic recording of the left external iliac artery is performed. The

\* From the Department of Electronics, Weizman Institute of Science, Rehovot,† and Departments of Diagnostic Radiology,‡ Clinical Epidemiology,§ and General and Vascular Surgery,|| The Chaim Sheba Medical Center, Tel Hashomer, and Tel Aviv University Medical School, Tel Aviv, Israel.

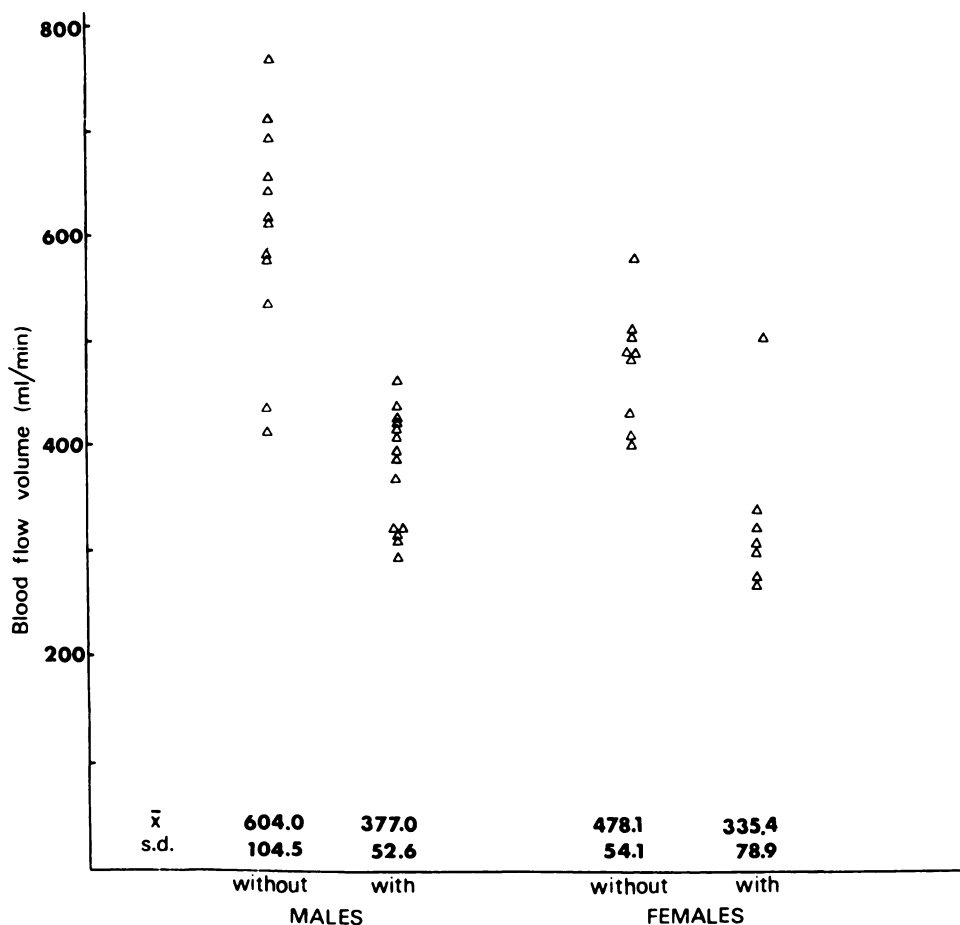


FIG. 1. Distribution of blood flow volume in external iliac artery in males and females over the age of 50, with and without clinical arteriosclerosis obliterans of the lower extremities.

planned angiography is then completed with the same catheter.

Twenty-one subjects over the age of 50 (12 males and 9 females) with no symptom or sign of vascular disease of the lower extremities were studied during abdominal angiography performed for evaluation of non-acute conditions. These 21 patients were used as controls ("normals").

Twenty-one patients over 50 (14 males and 7 females) with moderate to severe intermittent claudication due to arteriosclerosis obliterans were studied during aortography performed as part of the pre-operative evaluations ("patients").

Statistical methods: Comparison of mean blood flow volume was performed by the

Mann-Whitney non-parametric test because of unequal variances in the various groups.<sup>6</sup> Comparisons of mean diameter and flow velocity were performed using the *t* test.

#### RESULTS

The value for blood flow volume (ml./min.) for the 21 normals and 21 patients is given in Figure 1. The mean blood flow volume for the normal males was 604 (ml./min.) with a s.d. of 104.5 and 90 per cent tolerance limits for 90 per cent of the population 353-855. For the normal females the respective values were  $478 \pm 54.1$  for the mean and s.d., and 336-620 for the tolerance limits. For the male patients the

TABLE I  
INDIVIDUAL VALUES FOR DIAMETER OF EXTERNAL ILIAC ARTERY, DIAMETER AT ITS NARROWEST POINT, AND BLOOD FLOW VELOCITY IN PATIENTS

Case No.	Sex	Age	Diameter (mm.)	Narrowest Point (mm.)	Flow Volume (ml./min.)
1.	M	52	6.5	4.8	323
2.	M	54	6.7	6.1	298
3.	M	56	6.1	5.1	415
4.	M	57	7.3	5.1	410
5.	M	58	8.2	3.9	420
6.	M	58	7.0	4.6	394
7.	M	64	7.3	5.6	389
8.	M	64	5.8	5.0	317
9.	M	65	7.2	3.8	323
10.	M	66	6.2	3.6	462
11.	M	67	8.2	5.9	436
12.	M	68	5.6	3.1	370
13.	M	71	6.0	4.9	315
14.	M	71	5.2	5.2	406
15.	F	54	5.0	3.9	310
16.	F	55	4.8	4.1	281
17.	F	60	5.6	4.9	346
18.	F	61	5.7	5.3	323
19.	F	61	6.2	4.1	506
20.	F	64	4.7	3.9	305
21.	F	69	4.1	3.5	277

mean and s.d. were  $377 \pm 52.6$  and for the female patients  $335 \pm 78.9$ . The mean blood flow volume for the patients was significantly lower than for the normals. (For males  $p$  (Mann-Whitney)  $< 0.0001$ , and for females  $p$  (Mann-Whitney)  $< 0.01$ .) The mean blood flow volume for females was significantly lower than for males in both normals ( $p$  (Mann-Whitney)  $< 0.01$ ) and in patients ( $p$  (Mann-Whitney)  $= 0.04$ .)

Individual values of flow volumes, diameter of the external iliac artery, and the diameter of the vessel at its narrowest point in the 21 patients are given in Table I. The correlation between the degree of narrowing and flow volume is plotted in Figure 2. The absence of correlation between these 2 variables is striking ( $r = 0.014$ ).

The mean diameter and blood flow velocity (in cm./sec.) for the 21 normals is given in Table II. For the diameter in males the mean and s.d. were  $7.72 \pm 0.87$  mm. and for females they were  $6.37 \pm 0.59$  mm.

For the blood flow velocity in males the mean and s.d. were  $21 \pm 4.29$  cm./sec. and for females they were  $26 \pm 4.64$  cm./sec.

Whereas both diameter and blood flow volume were significantly larger in males than in females (for diameter  $p[t] < 0.001$ ; for flow volume  $p$  (Mann-Whitney)  $< 0.01$ ), blood flow velocity was significantly lower in males ( $p[t] = 0.02$ ).

#### DISCUSSION

The results of flow measurements in this series fall within the range of results of flow measurements performed by several other methods.<sup>1,3,4</sup> Our results for flow volume in normals are higher than in some series<sup>2,3</sup> and approach the levels recorded by Ganz *et al.*<sup>4</sup>

The advantage of the present method is that it does not necessitate an additional intervention, and can be performed during routine angiography.

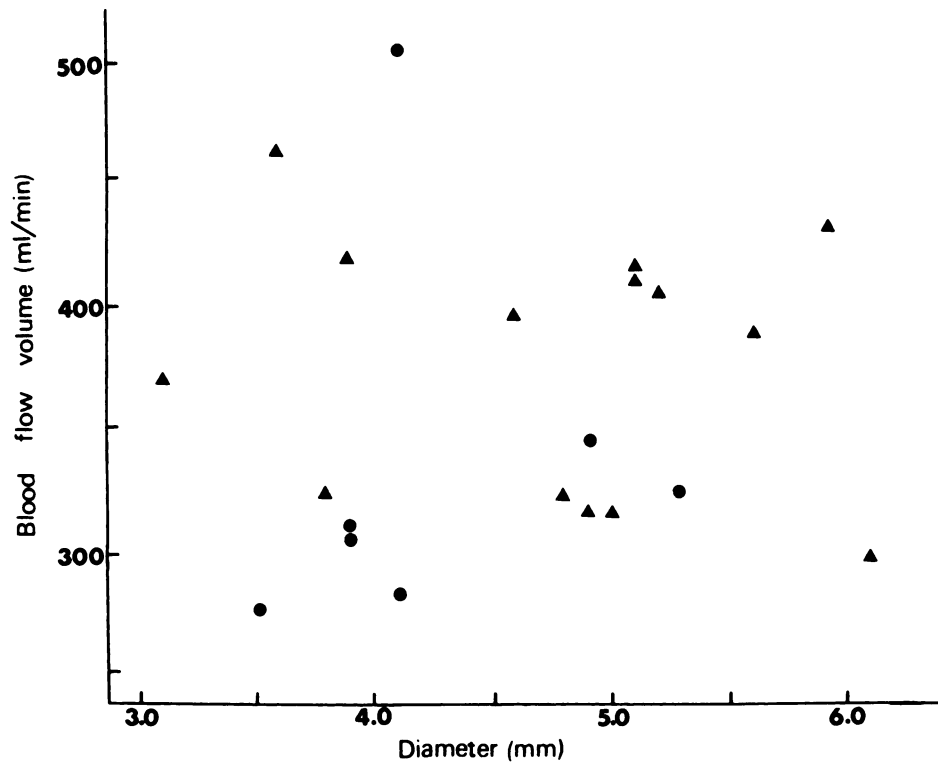


FIG. 2. Correlation of blood flow volume with diameter at the point of greatest narrowing of the external iliac artery in males (black triangles) and females (black dots), with arteriosclerosis obliterans of the lower extremities.

TABLE II  
INDIVIDUAL VALUES FOR DIAMETER OF EXTERNAL ILIAC ARTERY, BLOOD FLOW VELOCITY AND BLOOD FLOW VOLUME IN NORMALS

Case No.	Sex	Age	Diameter (mm.)	Flow Velocity (cm./sec.)	Flow Volume (ml./min.)
1.	M	51	7.8	24.1	695
2.	M	54	6.9	25.9	581
3.	M	55	7.6	22.7	615
4.	M	56	6.6	28.5	585
5.	M	58	9.1	18.1	711
6.	M	60	7.8	22.3	640
7.	M	63	8.3	13.5	438
8.	M	67	8.7	17.3	620
9.	M	68	6.5	23.7	766
10.	M	70	6.7	19.6	415
11.	M	72	8.2	16.7	528
12.	M	74	8.4	19.6	654
13.	F	54	5.4	31.7	435
14.	F	55	6.1	30.0	512
15.	F	61	5.8	26.0	405
16.	F	63	6.6	23.1	479
17.	F	64	7.2	21.0	510
18.	F	66	7.1	20.0	485
19.	F	69	6.1	33.1	578
20.	F	71	6.6	23.6	484
21.	F	78	6.4	27.0	415

The absence of correlation between the degree of stenosis of the external iliac artery and the flow volume was not unexpected. The degree of narrowing of the diameter in the anteroposterior projection in these patients was not extreme and exceeded 50 per cent in only 1 patient. With this degree of narrowing, the effect of the peripheral resistance on flow appears to be more marked than the effect of the decrease in diameter. This explains relatively large flow volumes in some patients with a considerable narrowing of the vessel, as well as low flow volumes in some patients with a relatively minor narrowing. For this reason an angiographically demonstrated decrease in the diameter of a blood vessel in 1 projection cannot be considered in any way as an index of flow.

The lower flow volumes in females, both in normals and in patients, is probably related to the smaller muscle mass of the lower extremities. The higher flow velocity in females has not been stressed previously, and might possibly be a compensatory effect for the smaller diameter. Further data obtained from different vascular beds and using other methods of flow velocity mea-

surement may contribute to an understanding of this observation.

Victor Deutsch, M.D.  
Department of Diagnostic Radiology  
Chaim Sheba Medical Center  
Tel Hashomer, Israel

#### REFERENCES

1. BLISS, B. P. Pressure, flow and peripheral resistance measurements during surgery for femoropopliteal occlusion. *Scandinav. J. Clin. Lab. Invest.*, 1973, Suppl. 128, pp. 179-184.
2. DEDICHEN, H. Prognostic significance of intraoperative flow and pressure measurements in reconstructive vascular surgery. *Scandinav. J. Clin. Lab. Invest.*, 1973, Suppl. 128, pp. 189-194.
3. DEDICHEN, H., and KORDT, K. F. Blood flow in normal human ileofemoral arteries studied with electromagnetic technique. *Acta chir. scandinav.*, 1974, 140, 371-376.
4. GANZ, V., HLAVOVA, A., LINHART, J., and PREROVSKY, I. Measurement of blood flow in femoral artery in man at rest and during exercise by local thermodilution. *Circulation*, 1964, 30, 86-93.
5. ITZCHAK, Y., YERUSHALMI, S., and DEUTSCH, V. Blood flow measurements in iliac arteries by improved angiographic cinedensitometric technique. *Invest. Radiol.*, 1975, 10, 1-9.
6. SIEGEL, S. Non-parametric Statistics for Behavioral Sciences. McGraw-Hill Book Company, Inc., New York, 1956, pp. 116-126.

