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KEYWORDS: arteriosclerosis obliterans, asymptomatic legs, Doppler, exercise test, ankle pressure index

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THE EVALUATION OF ASYMPTOMATIC ARTERIAL OCCLUSIVE DISEASE OF THE LEGS USING AN EXERCISE TEST

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Abstract. The Doppler-derived ankle pressure index (API) is a useful indicator of the necessity for peripheral vascular reconstruction of the lower extremities. But the API at rest dose not reflect the functional capacity of leg circulation, especially in the early stage of disease. Therefore, an asymptomatic but hemodynamically significant lesion in one leg is sometimes missed by pressure measurement at rest when there is a severe lesion with symptoms in the other leg. In this study, the API not only at rest but also after exercise was measured in twenty normal subjects and thirty-two patients with angiographically proven arteriosclerosis obliterans. About 60 % of the patients had unilateral symptoms, although they had significant disease bilaterally. The API after exercise proved to be more sensitive than the API at rest and may be useful in assessing asymptomatic legs of such patients and determining their surgical indication.

Key words : arteriosclerosis obliterans, asymptomatic legs, Doppler, exercise test, ankle pressure index.

Arteriosclerosis obliterans (ASO) commonly affects the large arteries of the lower extremities. Although the arterial lesions are usually bilateral, the symptoms are often unilateral. Therefore it is necessary to assess not only the symptomatic side but also the asymptomatic side accurately, because the symptoms of the less diseased (asymptomatic) side may be masked by the more diseased (symptomatic) side.

Optimal preoperative planning for vascular reconstruction now requires not only arteriographic assessment to determine the location of disease, but also hemodynamic assessment to determine the functional significance of the disease. Although the commonly used Doppler-derived ankle/brachial blood pressure ratio (ankle pressure index, API) is an excellent indicator of the presence or absence of arterial occlusive disease in the lower extremities (1), the pressure measurements at rest do not adequately reflect the functional capacity of the circulation of diseased legs, especially of asymptomatic legs. Exercise tests have been advocated by many to detect the early stage of disease (2-5). The present study was undertaken to assess the condition of asymptomatic legs of ASO patients with an exercise test.

SUBJECTS AND METHODS

Subjects. This study included twenty normal control subjects and thirty-two patients with arteriographically proven ASO, and was conducted from January, 1982 through June, 1983. The normal subjects included 14 men and 6 women whose ages ranged from 22 to 77, with a mean of 50.0 years. All normal volunteers were free of symptoms of arterial occlusive disease and had normal peripheral pulses. Arteriograms were not obtained in these subjects. The patients included 29 men and 3 women whose ages ranged from 45 to 81, with a mean of 64.1 years. All patients had symptoms of claudication, rest pain or ulceration. All patients underwent arteriography. The patients were divided into three groups according to the symptoms and angiographic findings. There were four patients in Group A in which both legs were symptomatic and had occlusion or stenosis angiographically; 17 in Group B in which only one leg was symptomatic but both had occlusion or stenosis angiographically and 11 in Group C in which only one leg was symptomatic and had occlusion or stenosis angiographically. In this study, stenosis was defined as more than 50 % reduction in diameter on the arteriogram.

Resting ankle pressure. Two Doppler flow probes were placed over the dorsalis pedis or posterior tibial artery and the brachial artery at the cubital fossa with the subjects in the supine position. The systolic blood pressure was determined at the time of reappearance of the distal Doppler arterial signal on deflation of the pneumatic cuffs. Blood pressure studies were obtained on both legs of the normal subjects and patients with ASO.

Exercise test. The subjects were placed in the supine position and ordered to pedal a Monark bicycle ergometer for 5 min at 25 watts. Immediately after termination of the exercise. the brachial and ankle pressure were determined.

RESULTS

In normal subjects, the ankle pressure index at rest (API rest) was always equal to or greater than 1.00 (1.14 ± 0.08, mean ± S.D.), and ranged from 1.00 to 1.31 (Table 1). Fig. 1 indicates the typical curves obtained from a normal leg. The ankle systolic pressure (ASP) showed either no change or a small initial rise following exercise. The brachial systolic pressure (BSP) usually showed a small initial rise. As a result, the ankle pressure index (API) showed a slight initial drop and a short recovery to a resting level. The ankle pressure index just after exercise (API exercise) was 1.07 ± 0.08, ranging from 0.94 to 1.25. The API rest was significantly higher than the API exercise ($p < 0.001$).

In the patients with ASO, the API rest and API exercise were 0.59 ± 0.23 and 0.30 ± 0.23, respectively. Both were statistically smaller than those of normal

TABLE 1. API REST AND API EXERCISE IN NORMAL SUBJECTS AND PATIENTS WITH ASO

	API rest	API exercise	t-test
Normal	1.14 ± 0.08	1.07 ± 0.08	$p < 0.001$
ASO	0.59 ± 0.23	0.30 ± 0.23	$p < 0.001$
t-test	$p < 0.001$	$p < 0.001$	

mean ± S.D.

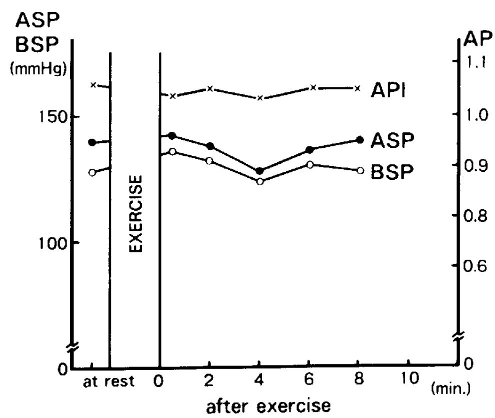

Fig. 1. ASP (ankle systolic pressure), BSP (brachial systolic pressure) and API (ankle pressure index) changes following exercise in a normal subject (26-year-old man, right leg)

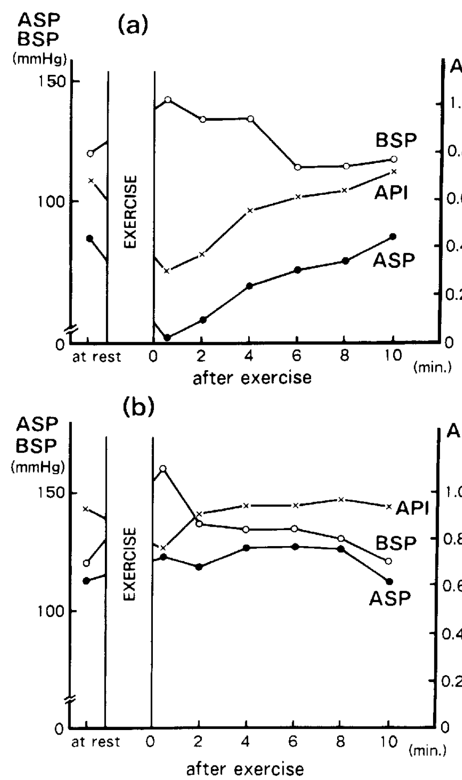

Fig. 2. ASP, BSP and API changes following exercise in patients with ASO (arteriosclerosis obliterans), ASP, BSP, API, see Fig. 1. (a) 67-year-old man, right leg, (b) 60-year-old man, left leg.

subjects (both, $p < 0.001$) (Table 1). Fig. 2 (a) indicates typical curves which show that the ASP and API drop following exercise with a slow recovery to a resting level. This pattern was observed in 46 of 52 diseased legs. Fig. 2 (b) indicates atypical curves which show only a drop in the API following exercise. This pattern was seen in only 6 diseased legs. In the ASO patients, the API rest was usually less than 1.00 and ranged from 0.05 to 1.13. In only two legs was the greater than 1.00. The API exercise ranged from 0.76 to 0.

The normal ranges for the API rest and API exercise were calculated from the 95 % confidence intervals of the data from normal subjects (Table 2). In discriminating between the presence or absence of disease, both the API rest and API exercise were specific measures. However, the API exercise appeared to be more sensitive than the API rest.

The API rest and API exercise of each group of patients are given in Fig. 3 (a) and 3 (b). The API of the less diseased legs are illustrated on the left side, and the API of the more diseased legs on the right side.

In Group A, the API rest (0.46 ± 0.09 and 0.26 ± 0.16) and API exercise (0.11 ± 0.11 and 0.05 ± 0.05) of both legs were much lower than the normal ranges.

TABLE 2. NORMAL RANGES, SENSITIVITIES AND SPECIFICITIES OF API REST AND APIEXERCISE

Measure	Normal range	Sensitivity (%)	Specificity (%)
API rest	> 0.99	50/52 (96)	40/40 (100)
API exercise	> 0.92	52/52 (100)	40/40 (100)

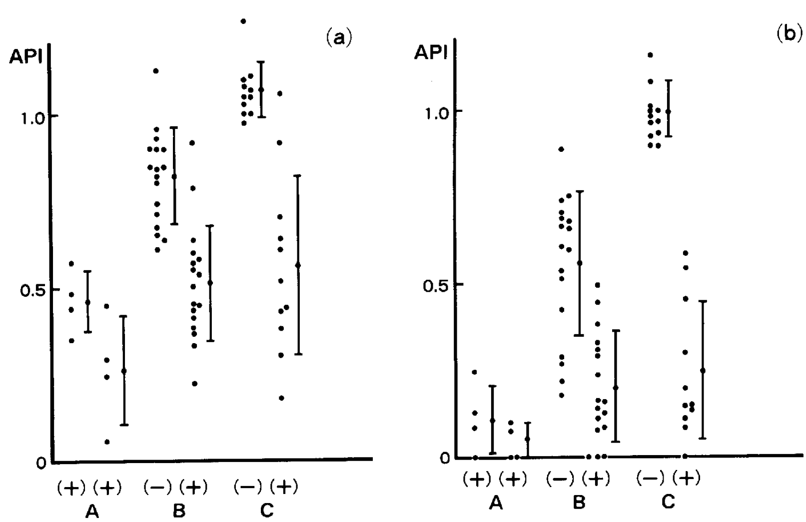

Fig. 3. API (ankle pressure index) of each group of patients. (a) API at rest. (b) API after excercise. (+) symtomatic legs, (−) asymptomatic legs.

In Group B, the API rest of asymptomatic legs (0.82 ± 0.14) was significantly lower than that of normal legs ($p < 0.001$), though one leg did show an API rest of greater than 1.00. The API exercise of asymptomatic legs (0.56 ± 0.21) was significantly lower than that of normal legs ($p < 0.001$), and it was always lower than 0.92. The API rest and API exercise of more diseased legs in Group B (0.51 ± 0.17 and 0.20 ± 0.16, respectively) were significantly lower than those of normal legs (both, $p < 0.001$).

In Group C, the API rest and API exercise of asymptomatic legs were 1.07 ± 0.08 and 1.00 ± 0.08, respectively. Both were statistically less than those of normal legs (both, $p < 0.02$), probably because these legs were slightly atherosclerotic. The API rest of symptomatic legs (0.56 ± 0.26) was significantly lower than that of normal legs ($p < 0.001$), though one leg did show an API rest of greater than 1.00. The API exercise of symptomatic legs (0.25 ± 0.20), which was significantly lower than that of normal legs ($p < 0.001$), was always lower than 0.92.

DISCUSSION

The aim of surgery in cases of arterial occlusive disease is not the complete correction of anatomical deficits, but rather the correction of physiological deficits such as intermittent claudication and rest pain. The presence of lesions dose not always necessitate surgery. However, to avoid overlooking a lesion which requires surgery in a leg having another, more severe lesion, various methods for evaluating the hemodynamic significance of lesions have been devised (6-12).

The resting ankle pressure index is well accepted as a useful diagnostic measure to determine the presence of peripheral vascular disease (1). The functional capacity of limb circulation especially in the early stage of disease is not fully reflected by the API at rest. However, the API after exercise may reflect the post-exercise hyperemic state and reveal hemodynamically significant lesions.

A stress test has been designed by many investigators to detect minimal disease and to ensure a more accurate diagnosis (2-5). Most previous methods have involved the measurement of limb blood flow using venous occlusion plethysmography after the termination of the stress test (13, 14). Lately, the measurement of the ankle pressure response to a constant load using an exercise test or reactive hyperemia test have been employed for the evaluation of arterial occlusive disease (3, 4). The reactive hyperemia test is performed rapidly, with the recovery time for ankle pressure measurement seldom exceeding two minutes, even with advanced disease. For this reason, the reactive hyperemia test requires rapid blood pressure measurement to avoid missing hemodynamic alteration during reactive hyperemia (15). On the other hand, in the exercise test, the ankle pressure recovers more slowly, so it is easier to measure the blood pressure changes.

Presently, the most widely used mode of exercise test is the treadmill method, but in our department, the Monark bicycle ergometer is applied. DeCossart *et al.*

(16) showed that there was no statistical difference in the results obtained on the ergometer compared with the treadmill. From our experience, the bicycle ergometer is preferable because the stress test can be performed with the subjects in the supine position and the pressure measurement following termination of the exercise is easier and earlier than with the treadmill test. Thus the bicycle exercise may be the most sensitive method for assessing minimal disease.

In this study, about 60 % of the patients with ASO had unilateral symptoms although they had bilateral disease. This shows that the symptoms of the less diseased (asymptomatic) leg is masked by the more diseased (symptomatic) leg. It is difficult to assess the asymptomatic leg when the API at rest is around 0.9, and it is more difficult to determine whether or not surgical intervention is warranted. From our results, it is suggested that arterial reconstruction should be done if the API after exercise is below 0.70, because no leg whose API after exercise was above 0.70 had symptoms.

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