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Mini Review

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Ankle and Toe-Brachial Pressure Index after Exercise in Patients on Maintenance Hemodialysis

Kazuo Tsuyuki[1*], Kenji Kohno[1], Kunio Ebine[2], Susumu Tamura[2], Yasuhiro Ohzeki[2], Toshifumi Murase[2], Kaoru Sugi[3], Kenta Kumagai[3], Itaru Yokouchi[3], Kenji Yamazaki[3], Satoru Tohi[3], Takehiro Ohara[4], Takeshi Kawamura[4] and Shinichi Watanabe[5]

[1]*Laboratory of Physiology, Odawara Cardiovascular Hospital, Kanagawa, Japan*

[2]*Division of Cardiovascular Surgery, Odawara Cardiovascular Hospital, Kanagawa, Japan*

[3]*Division of Cardiovascular Medicine, Odawara Cardiovascular Hospital, Kanagawa, Japan*

[4]*Division of Nephrology, Odawara Cardiovascular Hospital, Kanagawa, Japan*

[5]*Department of Clinical Engineering, Kanagawa Institute of Technology, Kanagawa, Japan*

[*]**Corresponding author:** Kazuo Tsuyuki, Odawara Cardiovascular Hospital, 269-1 Yahagi, Odawara, Kanagawa, Japan, Tel: +81-465-48-7211; FAX: +81-465-48-1714; E-mail: tsuyuki47msd@yahoo.co.jp

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Abstract

In patients undergoing hemodialysis (HD), the incidence of peripheral arterial disease (PAD) is high, leading to a severe condition; therefore, examinations that facilitate early diagnosis are necessary. The diagnostic accuracy of the ankle brachial pressure index (ABI) after walking, of which the cut-off value was corrected for HD patients, is higher than that of the ABI or toe brachial pressure index (TBI) at rest. Furthermore, the TBI after walking transiently induces marked perfusion disorder of the toes. The two procedures are useful for the early diagnosis of latent PAD in HD patients.

Keywords: Peripheral arterial disease; Ankle-brachial pressure index; Toe-brachial pressure index, Exercise

Abbreviations ABI: Ankle-Brachial Pressure Index; TBI: Toe-Brachial Pressure Index; HD: Hemodialysis; Ex: Exercise; r-ZETS: Resting Zero TBI Sign; e-ZETS: Exercise-Induced Zero TBI Sign; PAD: Peripheral Arterial Disease

Introduction

The incidence of symptomatic peripheral arterial disease (PAD) in patients undergoing hemodialysis (HD) ranges from 19 to 23% [1,2], being higher than in the general population[3]. In some HD patients, PAD is asymptomatic, and rapidly progresses; critical limb ischemia (CLI) is detected without intermittent claudication. Refractory CLI requires lower-limb amputation, markedly reducing activities of daily life or leading to death from sepsis. Therefore, it is important to detect latent PAD in the early stage and perform treatment.

For PAD screening, the ABI is routinely used. However, in HD patients, the sensitivity of this index is low due to marked arterial calcification, delaying the detection of PAD. As a means to overcome this limitation, there is a method to measure lower limb blood flow after exercise [5-7]. In this article, we review the usefulness of these examinations.

One-minute test

Measurement of the ABI after walking (Ex-ABI) provides much information to evaluate perfusion disorder of the lower limbs. Ex-ABI is measured as follows: ABI was measured after 15 minutes at rest, and immediately after walking using the computerized treadmill system following a protocol. Each patient's 12-lead electrocardiogram and heart rate were monitored throughout the walking protocol for one minute (2.4 km/h, 12%). However, the walking speed was reduced to 2.0 km/h when the patient was more than 70 years old or was a low left ventricular function case. Trans-Atlantic Inter-Society Ⅱ (TASC Ⅱ) shows walk speed with 3.2 km/h, but uses speed of 2.4 km/h in a Japanese.

Walking was discontinued when one of the followings appeared: horizontal or downsloping ST depression of 0.1 mV compared with the resting ST at 80 msec after the J point, abnormal blood pressure responses (systolic pressure ≥ 250 mmHg, diastolic pressure ≥ 120 mmHg), dangerous or potentially dangerous arrhythmias, the maximum heart rate obtained using the equation "220 – age", difficulty in walking due to lower limb pain and symptoms of the cardiopulmonary or neurological system.

For Ex-ABI measurement to make a definitive diagnosis of PAD, patients are instructed to walk on a treadmill for 5 minutes (3.2 km/h, 12%) [8]. However, the walking speed and slope are stressful for HD patients with a reduced exercise tolerance. We shortened the walking time (5 minutes) to 1 minute [5,6]. Such shortening of the walking time may reduce the accuracy of examination, but the diagnostic accuracy of the Ex-ABI at 1 minute was similar to that at 5 minutes in our study [9]. In addition, 1 minute walking has a merit: heart disease-derived accidents may not occur during examination [10]. For HD patients, 1 minute Ex-ABI measurement is appropriate.

Some investigators recommended the Doppler method for ABI measurement. However, there is a strong correlation between the oscillometric and Doppler methods [11,12] and an automatic measurement device [13] using the oscillometric method is more convenient for Ex-ABI measurement or large-scale screening.

Measurement of the TBI after walking (Ex-TBI) is the same as Ex-ABI. However, small cuff for toes is used.

Ex-ABI

Ex-ABI measurement is useful in patients with symptoms suggestive of PAD and an ABI of ≥ 0.91. As there is a superior arterial-calcification-related shift of the ABI value in HD patients, the Ex-ABI is highly useful. However, few studies have performed Ex-ABI measurement involving HD patients.

We investigated the Ex-ABI in HD patients, and compared it with computed tomographic angiography findings (above the knee) [6]. The diagnostic accuracy of the Ex-ABI was higher than that of the ABI or toe brachial pressure index (TBI), which may be available for HD patients because there is no influence of arterial calcification (Figure 1).

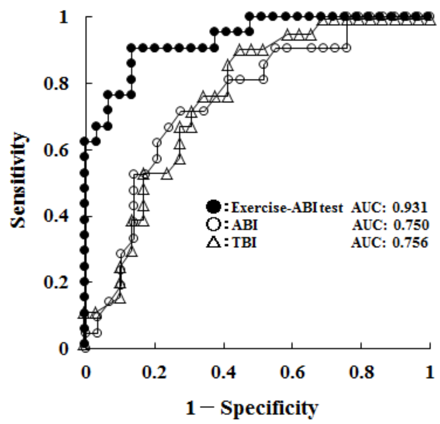

Figure 1: Receiver operating characteristics analysis of modality as a predictor of peripheral artery disease on computed tomographic angiography in HD patient.

However, in ABI and Ex-ABI, evaluation of blood flow disorder below the knee is difficult (Table 1).

	Advantage	Disadvantage
ABI	Simple	Low sensitivity
TBI	Simple	moderate sensitivity
Ex-ABI	Early detection	time-consuming
Ex-TBI	Early detection	time-consuming

Table 1: Advantage and disadvantage in Ankle and toe-brachial pressure index.

According to the TASC, the cut-off value of the Ex-ABI was 15 to 20% lower than the ABI. However, when establishing the cut-off value at this range in HD patients, the sensitivity of the Ex-ABI was 100%, but its specificity was markedly low (48.3%) [6]. This suggests that the cut-off value previously used is not appropriate for HD patients. On the other hand, when re-establishing the cut-off value of the Ex-ABI as a 35.0% decrease, which was obtained on the receiver operating characteristics analysis, the sensitivity and specificity were 90.5 and 86.2%, respectively [6]. When the conventional cut-off value is used as the Ex-ABI in HD patients, there may be a false-positive increase. Therefore, in HD patients, the cut-off value of the Ex-ABI must be changed to a 35% decrease, considering the condition.

Ex-TBI

In HD patients, the big toe is often amputated due to CLI. To diagnose perfusion disorder at the toe level, the TBI using the oscillometric method is used. Matsui et al. [14] regarded a toe pressure reaching a flat as a "zero TBI sign", and reported its usefulness as an index reflecting severe perfusion disorder of the toes. This sign refers to a state in which the toe pressure is below the measurement threshold of an automatic measurement device, 40 mmHg. If findings, such as ischemic pain at rest, ulcers, and gangrene, are present in addition to such hemodynamics, CLI may occur. Therefore, the "zero TBI sign" is important for CLI diagnosis.

Recently, we found that the "zero TBI sign" was observed after 1 minute walking, and termed this phenomenon the "exercise-induced zero TBI sign (e-ZETS)" [7]. Patients meeting the following conditions were regarded as showing an e-ZETS: measurement with an automatic measurement device using the oscillometric method, resting TBI measurement is possible, the toe pressure reaches a flat on measurement immediately after walking and the toe pressure transiently reaches a flat after the completion of walking, but serially appears again (Figure 2).

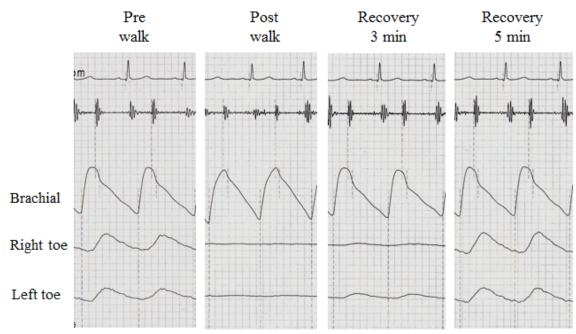

Figure 2: Exercise-induced zero TBI sing (e-ZETS).

In 31.1% of outpatients undergoing HD, the e-ZETS was observed [7]. Furthermore, the "zero TBI sign", which reflects severe perfusion disorder, was present in approximately 9.6% [7]. This suggests that, in a 3-fold number of HD patients with severe perfusion disorder of the toes in HD, e-ZETS is latently present.

In our study [7], the TBI at rest in HD patients with the e-ZETS was slightly lower than the normal value [15,16] and there were no findings, such as cyanosis, ischemic pain at rest, ulcers, or gangrene. However, the results of a 36-month follow-up showed that the e-ZETS progressed to the zero TBI sign, involving CLI, in 36.4% of the patients (Figure 3). This suggests that the e-ZETS in HD patients reflects mild perfusion disorder, whereas the condition may become severe in the future.

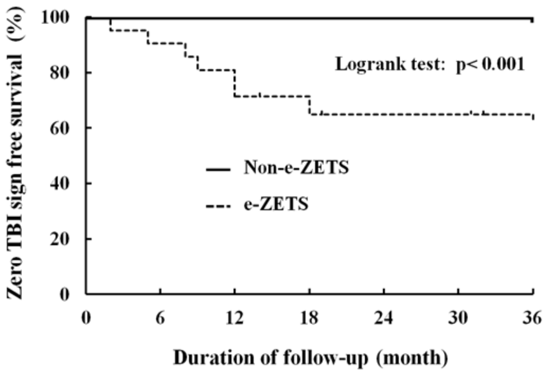

Figure 3: Comparison of resting zero TBI sing (r-ZETS) free survival between the e-ZETS and non-e-ZETS group in HD patients.

In clinical practice, it is necessary to predict the risk of severe perfusion disorder by measuring the TBI regularly. However, no area of the TBI suggestive of "progression to severe perfusion disorder" has been reported. From this viewpoint, the e-ZETS progressed to the zero TBI sign at a high rate; it may indicate "progression to severe perfusion disorder". Therefore, e-ZETS assessment by Ex-TBI measurement is useful for the early detection of severe perfusion disorder of the toes and prognostic assessment.

Conclusion

In HD patients, the incidence of PAD is high. PAD is asymptomatic, and rapidly progresses, leading to a severe condition in many patients. Therefore, it is important to detect latent PAD in the early stage before the appearance of clinical symptoms and perform treatment. The ABI and TBI measured immediately after walking indicate the presence of latent PAD; they are useful for the early detection of PAD.

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