

# Ankle-Brachial Index as a Predictor of Significant Coronary Artery Disease in Patients Undergoing Coronary Angiography

Marcelo Sabedotti<sup>1</sup>, Rogerio Sarmiento-Leite<sup>2</sup>, Alexandre Schaan de Quadros<sup>2</sup>

## ABSTRACT

**Background:** The ankle-brachial index is a simple and effective tool for diagnosing peripheral artery disease, but has not been validated for the diagnosis of coronary artery disease. The aim of this study was to evaluate the ability of the ankle-brachial index to predict coronary artery disease in patients undergoing coronary angiography. **Methods:** Patients with clinical suspicion of coronary artery disease and indication for coronary angiography were prospectively evaluated. Significant coronary artery disease was defined as the presence of stenosis > 70% of at least one major epicardial coronary artery or any of their major branches. A ROC curve was developed to define the ankle-brachial index cutoff that best predicts coronary artery disease. **Results:** A total of 312 patients were evaluated: mean age was  $57 \pm 11$  years and 50% were male. One hundred and sixteen (37.2%) patients had significant coronary disease. Ankle-brachial index measurement in these patients was significantly lower than in those without coronary artery disease ( $0.88 \pm 0.14$  vs.  $0.96 \pm 0.87$ ;  $p < 0.01$ ). Ankle-brachial index  $< 0.87$  showed a sensitivity of 31%, specificity of 95.4%, positive predictive value of 75.9% and negative predictive value of 71.6%. The area under the ROC curve was 0.73 (95% confidence interval of 0.67-0.79). **Conclusions:** Ankle-brachial index  $< 0.87$  had a high specificity to predict significant coronary disease. Considering its low cost and ease of use, measurement of ankle-brachial index may be incorporated to daily clinical practice to help diagnose significant coronary artery disease.

**DESCRIPTORS:** Atherosclerosis. Cardiovascular diseases. Ankle brachial index. Risk factors. Coronary angiography.

## RESUMO

### Índice Tornozelo-Braquial como Preditor de Doença Coronariana Significativa em Pacientes Submetidos à Angiografia Coronária

**Introdução:** O índice tornozelo-braquial é uma ferramenta simples e efetiva para diagnosticar doença arterial periférica, porém não foi ainda validado para o diagnóstico de doença arterial coronariana. O objetivo deste estudo foi avaliar o desempenho do índice tornozelo-braquial em prever doença arterial coronariana em pacientes submetidos à angiografia coronária. **Métodos:** Pacientes com suspeita clínica de doença arterial coronariana e indicação de angiografia coronária foram avaliados prospectivamente. Doença arterial coronariana significativa foi definida como estenose  $\geq 70\%$  em pelo menos uma coronária epicárdica maior ou ramo principal. Uma curva ROC foi construída para definir o ponto de corte do índice tornozelo-braquial que melhor predizia doença arterial coronariana. **Resultados:** Foram estudados 312 pacientes, cuja média de idades foi  $57 \pm 11$  anos e 50% eram do sexo masculino. Tinham doença coronariana significativa 116 pacientes (37,2%). A medida do índice tornozelo-braquial nestes pacientes foi significativamente menor do que naqueles sem doença arterial coronariana ( $0,88 \pm 0,14$  vs.  $0,96 \pm 0,87$ ;  $p < 0,01$ ). Índice tornozelo-braquial  $\leq 0,87$  mostrou sensibilidade de 31%, especificidade de 95,4%, valor preditivo positivo de 75,9% e valor preditivo negativo de 71,6%. A área da curva ROC foi 0,73 (intervalo de confiança de 95% 0,67-0,79). **Conclusões:** Índice tornozelo-braquial  $\leq 0,87$  teve alta especificidade para prever doença arterial coronariana significativa. Considerando o baixo custo e a fácil utilização, a medida do índice tornozelo-braquial pode ser adicionada na prática clínica para auxiliar no diagnóstico de doença arterial coronariana significativa.

**DESCRIPTORES:** Aterosclerose. Doenças cardiovasculares. Índice tornozelo-braço. Fatores de risco. Angiografia coronária.

<sup>1</sup> Universidade de Caxias do Sul, Caxias do Sul, RS, Brazil.

<sup>2</sup> Instituto de Cardiologia do Rio Grande do Sul, Porto Alegre, RS, Brazil.

**Correspondence to:** Marcelo Sabedotti. Rua Francisco Getúlio Vargas, 1.130 – Petrópolis – CEP: 95070-560 – Caxias do Sul, RS, Brazil  
E-mail: msabedotti@me.com

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**A**therosclerosis is a systemic disease, which is not restricted only to a vascular territory. Coronary artery disease (CAD) and peripheral arterial disease (PAD) are commonly found in the same patient,<sup>1</sup> and this condition is associated with high risk of cardiovascular events.<sup>2,3</sup>

In clinical practice, preventive actions are recommended in cardiology,<sup>4-7</sup> and risk stratification and early treatment are very important strategies to reduce cardiovascular disease and its consequences.<sup>8</sup>

The ankle-brachial index (ABI) is a simple and effective tool for PAD screening.<sup>9</sup> ABI < 0.90 is considered as altered, and has a 95% sensitivity for predicting peripheral vascular disease with significant stenosis on angiography.<sup>10</sup> In addition, ABI < 0.90 is associated with a worse cardiovascular prognosis and increased all-cause mortality.<sup>11-15</sup> Although ABI is useful for detecting PAD, its validity in predicting CAD is not well established.

This study aimed to evaluate the performance of ABI as a predictor of CAD in patients undergoing coronary angiography.

## METHODS

This protocol was approved by the ethics committee and met all clinical research criteria in Brazil. All patients received information about the study and signed an informed consent.

This was a cross-sectional study, for which consecutive patients referred for coronary angiography for suspected CAD were selected. Patients with previous coronary angiography, ABI > 1.0, severe valve disease, acute coronary syndrome, and those who did not agree to sign the informed consent were excluded from this analysis.

### Clinical evaluation and measurement of ankle-brachial index

Patients were clinically evaluated before their coronary angiography through physical examination and medical history; information on the classic risk factors for ischemic heart disease was collected.

ABI was measured as recommended by current guidelines.<sup>9</sup> Systolic pressure was measured in upper and lower limbs with a portable vascular Doppler device DV610® (Medmega – Franca, São Paulo, Brazil). In the ABI calculation, the ratio between anterior and/or posterior tibial artery pressure (the highest value was considered) and brachial systolic pressure was used. In the case of differing values between left and right side, the lowest value was used in this analysis.

### Coronary angiography

Quantitative coronary angiography was the parameter used for diagnosis of coronary stenosis. After

clinical evaluation, the patients underwent coronary angiography (Judkins technique) through the femoral artery. Quantitative coronary angiography was performed by an independent investigator. Coronary disease was considered significant in the presence of a stenosis ≥ 70% in at least one coronary segment.

## Statistical analysis

Quantitative variables were expressed as means ± standard deviations and compared using Student's *t*-test. Qualitative variables were presented as absolute numbers and percentages and compared using the chi-squared test or Fisher's exact test, as appropriate. The determination of the cutoff for ABI was performed by receiver operating characteristic (ROC) curve. This statistical analysis was performed with SPSS version 15.0 (Chicago, Illinois, United States).

## RESULTS

From March to December of 2013, 312 patients were included in this study. The mean age was 57 ± 11 years, 50% were male, and 24.4% were diabetic (Table 1). One hundred and sixteen patients (37.2%) were diagnosed with significant CAD. In these individuals, ABI was significantly lower than in those patients without significant CAD (0.88 ± 0.14 vs. 0.96 ± 0.87; *p* < 0.01).

The specificity of ABI for predicting significant CAD in patients with ABI ≤ 0.87 was 95.4% (95% confidence interval – 95% CI, 91.7-97.7), with a sensitivity of 31% (95% CI, 23.1-39.9) (Figure); the positive predictive value was 75.9% and the negative predictive value was 71.6%.

**TABLE 1**  
Patients' characteristics and risk factors for coronary arterial disease (CAD)

Characteristics	Without significant CAD* (n = 196)	With significant CAD (n = 116)	<i>p</i> -value
Age, years	56 ± 11	61 ± 11	< 0.01
Male gender, n (%)	76 (38.8)	80 (69.0)	< 0.01
Risk factors for CAD, n (%)			
Hypertension	141 (71.9)	99 (85.3)	< 0.01
Diabetes	29 (14.8)	47 (40.5)	< 0.01
Hyperlipidemia	73 (37.2)	78 (67.2)	< 0.01
Current smoking	69 (35.2)	74 (63.8)	< 0.01
Family history of CAD	78 (39.8)	50 (43.1)	0.63
ABI ≤ 0.87, n (%)	13 (6.6)	44 (37.9)	< 0.01

\*Presence of stenosis ≥ 70% in a coronary artery or main coronary branch.  
ABI: ankle-brachial index.

The probability of a significant coronary lesion presentation for patients undergoing coronary angiography can also be predicted by ABI. With an ABI  $\leq 0.87$ , the probability of significant CAD was 77.2%. As shown in Table 2, it was observed that the lower the ABI, the greater the likelihood of a significant CAD.

A model was created to predict the occurrence of significant CAD associated with risk factors for this disease with ABI. For example, patients with ABI  $\leq 0.87$  and four risk factors had a 90.5% probability of significant CAD (Table 3).

## DISCUSSION

This study evaluated the sensitivity and specificity of ABI for predicting significant CAD in patients undergoing coronary angiography. CAD and PAD are two major problems of modern medicine, due to the mortality, reduced life expectancy, and social and economic impacts associated with these conditions.<sup>16</sup>

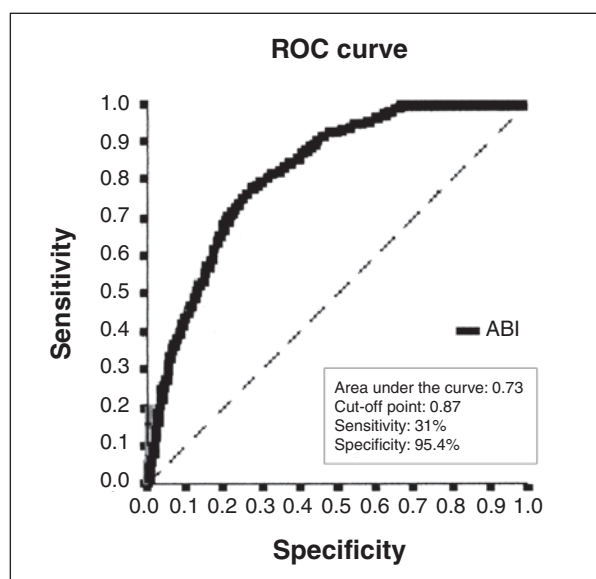


Figure – Receiver operating characteristic curve of ankle-brachial index (ABI) determination, related to the presence of stenosis  $\geq 70\%$  in a coronary artery or in a main coronary branch in angiography.

CAD may be present in 58% of patients with PAD,<sup>17</sup> and such an association is related to a worse prognosis. The diagnosis and early treatment are critical in order to minimize cardiovascular events.

ABI is a useful tool for diagnosing PAD, and ABI  $< 0.5$  is associated with claudication when walking 100 m.<sup>18</sup> Lee et al.<sup>19</sup> have previously proved an association between low ABI with high risk of cardiovascular and cerebrovascular events and death. Patients with ABI  $< 0.90$  present an increased risk of cardiovascular events, and low ABI was an independent predictor of risk of fatal myocardial infarction, even after adjustment for traditional risk factors for CAD. Additionally, ABI increased significantly ( $p < 0.01$ ) the predictive value for fatal myocardial infarction, when compared with a model considering only risk factors for CAD. However, ABI is not fully validated for detecting CAD. The present study demonstrated the usefulness of this index in predicting significant coronary lesions.

When used as a single diagnostic method, ABI does not have good sensitivity for predicting CAD. However, when indexes  $\leq 0.87$  were considered, the specificity was 95.4%. Otah et al.<sup>20</sup> demonstrated that three-vessel arterial disease or left main coronary artery disease can be predicted by the ITB, with sensitivity and specificity of 85% and 77%, respectively. In the present study, the sensitivity was low, but with higher specificity. Probably the main reason for this finding was the criterion used for CAD. In the present study, only cases of CAD with  $\geq 70\%$  stenosis were considered as significant, while Otah et al.<sup>20</sup> considered all coronary injuries that were diagnosed. Perhaps these different criteria have contributed to these differences in results.

Although ABI *per se* does not have a high sensitivity to detect CAD, with an index  $\leq 0.87$  the probability of the patient having a significant CAD is estimated in 77.2%. When associating ABI with risk factors for CAD, the probability of lesions  $\geq 70\%$  in coronary angiography increases. Considering patients with four or more risk factors and an ABI  $\leq 0.87$ , approximately 90% have a significant CAD. This suggests that ABI is most useful when combined with clinical assessment data. Thus, the combination of these elements allows for a reasonable probability of predicting significant CAD.

TABLE 2  
Probability of significant coronary artery disease (CAD) in relation to the ankle-brachial index (ABI)

ABI	Without significant CAD (n = 196)	Chance of significant CAD* (%)	Odds Ratio
$\leq 0.87$	13	77.2	5.66
0.88-0.92	32	48.4	1.58
0.93-0.96	10	33.3	0.84
$\leq 0.97$	141	20.9	0.44

\*Presence of stenosis  $\geq 70\%$  in a coronary or main coronary branch.

**TABLE 3**  
**Probability of significant coronary artery disease (CAD) in relation to ankle-brachial index (ABI) and coronary risk factors\***

Number of risk factors	ABI			
	≤ 0.87	0.88-0.92	0.93-0.96	≥ 0.97
≤ 1	50% (n = 4)	0% (n = 12)	0% (n = 0)	3.6% (n = 55)
2-3	70.6% (n = 34)	47.1% (n = 34)	36.4% (n = 11)	22.2% (n = 99)
≥ 4	90.5% (n = 21)	87.5% (n = 16)	25% (n = 4)	56.5% (n = 22)

\*Presence of stenosis ≥ 70% in a coronary artery or main coronary branch; coronary risk factors were hypertension, current smoking, dyslipidemia, diabetes mellitus, and family history of coronary artery disease.

### Study limitations

The present study had some limitations that should be mentioned. This was a cross-sectional study with a small number of patients. In addition, most patients had established risk factors for ischemic heart disease and were referred for coronary angiography for suspected CAD. Perhaps this sample represents a high-risk population with a high prevalence of CAD, and may have overestimated the predictive values of ABI.

### CONCLUSIONS

ABI values ≤ 0.87 showed high specificity to predict significant coronary artery disease. Considering its low cost and ease of use, ABI should be added to the physical examination, as a useful method to stratify the risk of coronary artery disease.

### CONFLICT OF INTERESTS

The authors declare no conflicts of interest.

### FUNDING SOURCE

None.

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