# Noninvasive Peripheral Artery Disease Screening Tools A Deficient Knowledge among French Vascular Residents from 4 Medical Schools

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## Abstract

Background

Ankle-brachial index (ABI) at rest, Post-exercise ABI and Toe-Brachial Index (TBI) are essential diagnostic tools recommended for peripheral artery disease (PAD) diagnosis. Our study investigates the level of knowledge on these three tests among vascular medicine residents from four French medical schools in France.

Patients and methods

We included nineteen vascular medicine residents in a cross-sectional study. During an annual obligatory seminar, all residents accepted to fill three questionnaires concerning knowledge about these three tests.

Results

All residents accepted to fill three questionnaires.

None of the residents correctly knows how to perform all pressure measurements (ABI, Post-exercise ABI, and TBI). Two residents had the knowledge to perform the whole ABI at rest procedure whereas no resident had the knowledge to perform neither the Post-exercise ABI (p=0.48), nor the TBI (p=0.48). Twelve residents correctly completed the question regarding the interpretation of ABI at rest, while two correctly completed the Post-exercise ABI question (p=0.001) and four the TBI question (p = 0.02). The number of residents who have performed more than twenty measurements is higher regarding ABI at rest than Post-exercise ABI and TBI (84%, 5%, 37% respectively; p<0.001 and p= 0.006 respectively) and significantly less often in Post-exercise ABI than TBI (5% versus 37%; p=0.04).

Conclusion

This study shows for the first time that residents 'knowledge of pressure measurements (resting ABI, Post-exercise ABI and TBI) of four French medical school, are insufficient even though the importance

of pressure measurement has been strongly highlighted by the new released PAD guidelines (2016) for PAD diagnosis.

## Keywords

Peripheral artery disease; Ankle-brachial index; Post-exercise ankle-brachial index; Toe-brachial index; Residents; Exercise.

## 1. Introduction

Lower extremity peripheral artery disease (PAD) is a highly prevalent atherosclerotic condition that affects approximately 202 million individuals worldwide.[1] Early diagnosis of PAD is essential as it is associated with considerable morbidity that includes impaired functional capacity, frailty, poor quality of life, as well as high medical care costs.[2] The prevalence of PAD is expected to increase due to the aging population, increasing prevalence of diabetes, and rise in obesity.(3–5)

Different non- invasive complementary tests using pressure measurements are recommended to diagnose PAD. [6–8]

According to intersociety consensus guidelines, PAD can be diagnosed using segmental blood pressure measurements by obtaining a resting ankle-brachial index (ABI).[8] An ABI<0.90 is considered abnormal and predictive of PAD.[8] Unfortunately, there are clinical conditions (i.e., diabetes, renal insufficiency, and advanced age) when the resting-ABI measurement can be falsely within the normal range.[8] In these cases, the American Heart Association (AHA) recommends the use of post-exercise ABI or the toe-brachial index (TBI).[8] In addition, patients with exertional non–joint-related leg symptoms and with a normal or borderline resting ABI (>0.90 and ≤1.40) should undergo exercise treadmill ABI testing to evaluate for PAD. [8] Diagnostic criteria for PAD is a post exercise pressure decrease of >30mm Hg or a post exercise ABI decrease of >20% from the resting values.[9–11] A TBI value ≤0.70 is often used as the threshold value to diagnose the presence of PAD.[8]

All of these pressure measurements (ABI at rest, Post-exercise ABI and TBI) are key elements in the clinical practice of vascular medicine for identifying PAD patients. Therefore, the method for measuring, calculating and interpreting ABIs have been standardized and published in 2012 by the American Heart Association (AHA).[12]

Yet, several studies have highlighted the lack of theoretical and practical training in measuring ABI at rest among students in medicine, residents, cardiology residents and young general physicians or surgeons .(13–16) In France, a vascular medicine physician must complete a two-year residency in

vascular medicine at a university hospital, in addition to completing a general medicine training period that lasts a minimum of eight years (general practitioner). There is a paucity of studies evaluating whether vascular medicine residents in France are aware of all the different types of pressure measurements and how to calculate and interpret them to diagnose individuals with PAD. Therefore, our study sought to assess the theoretical knowledge on whether a sample of vascular medicine residents in France could correctly measure and calculate the resting ABI, Post-exercise ABI and the TBI.

## 2. Materials and methods

This study was conducted according to the French Health Research Authority guidance. All vascular medicine residents who volunteered to participate were present at an annual obligatory vascular medicine seminar from four French medical schools (Rennes, Brest, Nantes, Angers). All vascular medicine residents completed a French multiple-choice questionnaire (Figure I,II) (translated to English for this manuscript), specifically developed to evaluate each residents prior experience and knowledge about the three main noninvasive tools for PAD screening (Resting-ABI, Post-exercise ABI and TBI; Figure I; inspired on the Wyatt questionnaire).[15]

The multiple-choice questionnaire (18 questions) was divided into three distinct sections: i) Resting-ABI procedure (Figure I); ii) Post-exercise ABI procedure (Figure II); and iii) TBI procedure (Figure II). Each section included questions designed to assess whether the four fundamental tasks of each procedure: indication, measurement, calculation and interpretation were assimilated by each vascular medicine residents. (Figure I, II)

Statistical analysis: A proportion comparison test, the Fisher Exact Probability Test (MedCalc 12.6.1.0 Software) was used to compare the number of vascular medicine residents knowing each task according to the procedure. A two-tailed p value $<0.05$ was considered as statistically significant.

## 3. Results

All nineteen vascular medicine residents participated in this study. Eleven first-year (i.e. six months after beginning their vascular training) residents and eight second-year residents (i.e. eighteen months after beginning their vascular training) completed the evaluation. A minority of participants (37%, 7 of 19) reported previous experiential learning in ABI procedure during their medical school training (Figure II). The number of measurements performed by the vascular medicine residents are shown in the Figure III. Four participants (21%) have never performed a Post-exercise ABI and nine participants (47%) have never performed a TBI.

The number of residents who have performed more than twenty measurements is higher regarding ABI at rest than Post-exercise ABI and TBI (84%, 5%, 37% respectively; $p<0.001$ and $p= 0.006$ respectively) and significantly less often in Post-exercise ABI than TBI (5% versus 37%; $p=0.04$).

Figure IV, V, VI presented the flow of the residents that gave cumulative right answers throughout each section of the multiple-choice questionnaire, and figure VII presented the numbers of right answers for each question of the 3 questionnaires.

Four (21%) vascular residents reported knowing the current American Heart Association (AHA) guidelines concerning ABI procedure.

Two residents (11%) had the knowledge to perform the whole ABI at rest procedure whereas no resident has the knowledge to perform neither the Post-exercise ABI ($p=0.48$) nor the TBI ($p = 0.48$). (Figure IV, V, VI)

Twelve (63%) residents correctly completed the question regarding the interpretation of ABI at rest, while two (11%) correctly completed the Post-exercise ABI (in comparison with interpretation of ABI at rest, $p = 0.001$) and four the TBI (21%) (in comparison with interpretation of ABI at rest, $p = 0.02$). There was no significant difference concerning result interpretation between Post-exercise and TBI ($p=0.65$).

No (0%) resident correctly completed the question about indications for the TBI.

## 4. Discussion

The importance of pressures measurement has been strongly highlighted as the first step for diagnosing individuals with PAD in the recently updated PAD guidelines released by AHA in November 2016.[8] This study demonstrates that the theoretical procedure of knowing how to measure and interpret all the three main non-invasive tools used for diagnosing PAD is limited among French vascular medicine residents from four medical schools. Furthermore, this study underscores our clinical impression that a significant lack of knowledge exists among French vascular medicine residents from these four medical schools regarding not only the ABI procedure, but also the TBI and ABI Post-exercise procedures.[14,17]

Our study is similar to those found previously in France and in different countries, where the knowledge of measuring and interpreting the ABI at rest among residents in vascular medicine is poor. [13–16] One of the reasons may be the style of teaching as some authors have highlighted that the current academic training method may not have enough experiential ("hands-on") learning. This may have contributed to a poor level of competency with regard to the ABI procedure among residents.[13–16] ABI measurement teaching generally takes the form of lectures and in very few cases practical training.[18] However, it has been suggested that practical teaching would improve this competency.[19] Another reason may be the lack of coaching of this ABI measurement training. Residents are often left to themselves without real feedback of the senior vascular physician. A lack of reading can also be suggested since only four residents (21%) were aware of the AHA recommendations.[8]

This study also demonstrated that the Post-exercise and TBI procedures were similarly problematic or even more poorly understood among the vascular medicine residents than the measurement and interpretation of the resting ABI. Our result showed that none of the residents correctly answered all the questions concerning the fundamental knowledge needed to perform these two procedures and a majority were not aware of the indication for when to use these clinical tools. Moreover, our results were not restricted to residents only at one medical school, but were more generalized throughout the four different medical schools. The lack of didactic and/or experiential

learning, especially of the TBI and Post-exercise ABI, could be explained in part, by the lack of abundant high-level evidence based literature. The thresholds for Post-exercise ABI and TBI are discussed.[20] For Post-exercise ABI, two diagnostic thresholds are recommended by the AHA, but a recent study shows that these two criteria are discordant in 20% of the patients evaluated.[20] For TBI, studies have shown that normal threshold have demonstrated wide ranges from 0.49 and 0.74.[21] Currently, a TBI cutoff < 0.70 is suggested as diagnostic for PAD.[21]

There is a lack of studies about teaching methods. According to the literature, we suggest bedside teaching instead of theoretical teaching in order to enable students to know the technical aspects of the different procedures. The results of our systematic review about ABI teaching methods have suggested that bedside teaching should be performed. However, literature is sparse and no randomized controlled trial has been already performed neither for ABI nor for TBI and Post-exercise teaching.[19] A randomized controlled trial among French medical students to determine the best learning intervention to become proficient in ABI procedure is ongoing. Concerning the TBI and the post-exercise ABI procedures, to our knowledge no study has been yet conducted to determine how to improve current modalities of teaching. We suggest to know first basis about ABI at rest and then to learn the technical aspects of TBI and post-exercise ABI. The interest of online video demonstrating the different procedures should be addressed.

Limitations: This study had several limitations. First, we assessed the vascular medicine residents' knowledge through a multiple-choice questionnaire without assessing "hands-on" measurements and interpretation with real practice on an individual. However, it seems accurate to say that a resident who says taking the pressure with an automatic pressure monitor will take the pressures in real practice with this automatic monitor. Second, for the post-exercise ABI procedure, we have considered as a correct answer "to perform the procedure with at least two examiners". Indeed, the AHA recommends measuring post-exercise ABI on both ankles with hand help Doppler.[22] In that case, it is impossible to measure the post-exercise ABI with only one operator since measurement should be performed as

quickly as possible.[23] If there is only one examiner, the solution may be to assess arm pressure with an automatic blood pressure monitor and measure the ankle pressure with a hand held continuous Doppler. Gardner and Montgomery have shown at rest, that brachial systolic blood pressure was not significantly different (p=0.954) among the Doppler (128.5 +/- 18.4 mmHg), auscultatory (128.4 +/- 17.4 mmHg), and oscillometric (128.2 +/- 17.1 mmHg) methods.[24] However, this should be assessed in a dedicated study to assess this procedure for post-exercise ABI. Third, the number of residents assessed in this study is limited, but represents all the vascular residents trained in four different medical schools with different vascular teachers. Therefore, these results cannot be generalizable to all training institutions in France and reflects only the residents at these four institutions.

Fourth, we couldn't compare answer between first and second year residents because the two groups were too small to show a difference statistically significant. Fifth, we didn't use validated questionnaires to assess the level of knowledge of the residents. Indeed, it is possible that there isn't a good correlation between the residents' result in each questionnaire, and the capacity to perform the three pressures measurement tests correctly or to perform a test better than another.

## 5. Conclusion

We found a remarkably poor level of competency with regard to the three main PAD screening non-invasive complementary tools among vascular medicine residents from four French medical schools. Our studies may suggest the need of an evaluation of the vascular residents' knowledge in other French medical schools. At a minimum, residents should have didactic and experiential learning under the supervision of a qualified and experienced health vascular specialist; and that residents should be proficient in performing the technique as determined by quality control measures. Futures randomized studies should be completed to determine the optimal learning and evaluation of these three procedures.

## Acknowledgment

S. Chaudru has received a grant from the region "Bretagne" (Bourse ARED).

## Conflict of interest

The authors declare no conflict of interest.

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# Ankle-brachial index at rest

***Corrects answers are written in bold and highlighted.***

1) To measure blood pressure, indicate the equipment which you would use. (please tick) ***(equipment for limb pressures measurement)***

- ❑ Automatic blood pressure monitor (ex: Dynamap) for brachial and ankle blood pressures.
- ❑ Automatic blood pressure monitor for brachial, and hand-held Doppler for ankle blood pressure.
- ❑ **Hand-held Doppler for ankle and brachial blood pressures.**
- ❑ I don't know.

2) To calculate ABI, you use: (please tick) ***(rationale for arm pressures measurement)***

- ❑ **The highest of the two brachial pressures.**
- ❑ The lowest of the two brachial pressures.
- ❑ The average of the two brachial pressures.
- ❑ Only one brachial pressure.
- ❑ I don't know.

3) To measure ABI, you assess in each foot/ankle: (please tick) ***(number of measurements for ankle pressures)***

- ❑ Three ankle pressures.
- ❑ **Two ankle pressures.**
- ❑ Only one ankle pressure.
- ❑ I don't know.

4) You decide to perform an ABI measurement. The blood pressure measurements and ABIs are shown below. Which ABI do you use to define the patient diagnosis? (please tick) ***(ABI calculation)***

| Arteries | Systolic blood pressure (mmHg) | ABI |
|---|---|---|
| Dorsal pedis | 100 | 1.00 |
| Posterior tibial | 75 | 0.75 |
| Fibular | 80 | 0.80 |

- ❑ Average of the three ABIs.
- ❑ Average of the two ABIs.
- ❑ Lowest ABI.
- ❑ **Highest ABI.**
- ❑ I don't know.

5) Match the ankle-brachial index (ABI) value in the left column with the correct diagnosis listed in the right column. Each diagnosis selection may be used more than once.

| | |
|---|---|
| ❑ ABI=1.50 ..... | |
| ❑ ABI=1.20 ..... | A. Normal. |
| ❑ ABI=1.00 ..... | B. Mild to moderate peripheral artery disease. |
| ❑ ABI=0.80 ..... | C. Severe peripheral artery disease. |
| ❑ ABI=0.60 ..... | D. Non-compressible arteries. |
| ❑ ABI=0.30 ..... | |

**Correct answer : DAABBC**

6) How many times do you have performed ABI at rest ?

- ❑ None.
- ❑ One time.
- ❑ Between 2 to 20.
- ❑ More than 20.

## Post-exercise ankle-brachial index

***Corrects answers are written in bold and highlighted.***

1) To measure Post-exercise ABI, indicate the equipment which you would use (please tick) ***(equipment for limb pressures measurement)***

- ❑ Automatic blood pressure monitor
- ❑ **Continuous hand-held Doppler**
- ❑ Pulsed Doppler

2) Do you measure arm pressures after exercise ? ***(rationale for arm pressures measurement)***

- ❑ No, I use arm pressure at rest.
- ❑ Yes, I assess the two brachial pressures before ankle pressures.
- ❑ Yes, I assess the two brachial pressures after ankle pressures.
- ❑ **Yes, I assess simultaneously arm and ankle pressures, because we are many examiners.**

3) To measure ABI, you assess in each foot/ankle: (please tick) ***(choice of the ankle artery to use)***

- ❑ Almost systematically posterior tibial artery pressure.
- ❑ Almost systematically posterior dorsal pedis artery pressure.
- ❑ Two ankle pressures systematically.
- ❑ **I begin by the artery with the highest pressure at rest.**

4) If a patient has an ABI at rest lower than or equal to 0,90, does a post-exercise ABI must be performed ? ***(Post-exercise ABI indication)***

- ❑ Yes
- ❑ **No**

5) Which criteria is used to say that a patient is affected by a PAD ( multiple answers question) ***(Post-exercise ABI interpretation)***

- ❑ A Post-exercise ABI lower or equal to 0,90.
- ❑ **A fall of Post-exercise ABI higher than 20 %.**
- ❑ **A fall of ankle pressure higher than 30 mmHg.**
- ❑ Post-exercise ABI lower than 0,50.

6) How many times do you have performed post-exercise ABI ?

- ❑ None.
- ❑ One time.
- ❑ Between 2 to 20.
- ❑ More than 20.

## Toe-brachial index

***Corrects answers are written in bold and highlighted.***

1) To measure big toe pressures, indicate the equipment which you would use (please tick) ***(equipment for big toe pressures measurement)***

- ❑ **Laser Doppler**
- ❑ **Photoplethysmography**
- ❑ Continuous hand-help Doppler
- ❑ Pulsed Doppler

2) Does cutaneous skin temperature have a major role in TBI measurement ? ***(relevance of cutaneous temperature measurement)***

- ❑ **Yes**
- ❑ No

3) When a TBI must be performed ? ***(TBI indication)***

- ❑ If the ankle ABI at rest > 0,90 and the patient suspected of PAD.
- ❑ **If the ankle ABI at rest > 1,40.**
- ❑ On diabetic patients regardless their ABI at rest.
- ❑ ABI at rest >1,30.

5) Which criteria is used to say that a patient is affected by a PAD ( multiple answers question) ***(TBI interpretation)***

- ❑ TBI lower or equal to 0,90.
- ❑ **TBI lower to 0,70.**
- ❑ TBI lower to 0,30.
- ❑ Other, precise … .

6) How many times do you have performed TBI ?

- ❑ None.
- ❑ One time.
- ❑ Between 2 to 20.
- ❑ More than 20.

## Previous learning

1) Do you have a previous experiential learning in pressures measurement procedure (ABI at rest or Post-exercise ABI or TBI) during your medical school ?

- ❑ Yes
- ❑ No