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

O. Stivalet, L. Omarjee, S. Chaudru, C. Hoffmann, L. Bressollette, K.P.
Cohoon, V. Jaquinandi, Guillaume Mahé

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1 Title: **Non-invasive Peripheral artery disease screening tools: A deficient**
2 **knowledge among French vascular residents from four medical schools**

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6 Authors list:

7 STIVALET O¹, OMARJEE L², CHAUDRU S³, HOFFMANN C⁴, BRESSOLLETTE L⁴,
8 COHOON KP⁵, JAQUINANDI V^{1,2}, MAHE G^{1,2}.

9 Affiliations:

10 1 Vascular Medicine, University Hospital of Rennes, France.

11 2 Vascular Medicine, University Hospital of Rennes, France.

12 3 Univ Rennes 1, France ; INSERM CIC 1414.

13 4 Vascular Medicine, University Hospital of Brest, France.

14 5 University of Wisconsin, WI, USA

15

16 Corresponding author:

17 Guillaume MAHE.

18 Pôle imagerie médicale et explorations fonctionnelles. Hôpital Pontchaillou, 2 rue Henri Le
19 Guilloux. Rennes, F-35033. France. Tel: +33 (0)2 9928 4321. Fax: +33 (0)2 9928 4364

20 E-mail: maheguillaume@yahoo.fr

21 Twitter : @GMahe_

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27 **Abstract**

28 Background

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

33 Patients and methods

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

37 Results

38 All residents accepted to fill three questionnaires.

39 None of the residents correctly knows how to perform all pressure measurements (ABI, Post-exercise
40 ABI, and TBI). Two residents had the knowledge to perform the whole ABI at rest procedure whereas no
41 resident had the knowledge to perform neither the Post-exercise ABI ($p=0.48$), nor the TBI ($p=0.48$).

42 Twelve residents correctly completed the question regarding the interpretation of ABI at rest, while two
43 correctly completed the Post-exercise ABI question ($p=0.001$) and four the TBI question ($p = 0.02$).

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

47 Conclusion

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

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

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53 **Keywords**

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

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75 1. Introduction

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

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

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

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

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

100 vascular medicine at a university hospital, in addition to completing a general medicine training period
101 that lasts a minimum of eight years (general practitioner). There is a paucity of studies evaluating
102 whether vascular medicine residents in France are aware of all the different types of pressure
103 measurements and how to calculate and interpret them to diagnose individuals with PAD.

104 Therefore, our study sought to assess the theoretical knowledge on whether a sample of vascular
105 medicine residents in France could correctly measure and calculate the resting ABI, Post-exercise ABI
106 and the TBI.

107 **2. Materials and methods**

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

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

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

123 **3. Results**

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

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

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

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

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

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

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

147 **4. Discussion**

148 The importance of pressures measurement has been strongly highlighted as the first step for
149 diagnosing individuals with PAD in the recently updated PAD guidelines released by AHA in November
150 2016.[8] This study demonstrates that the theoretical procedure of knowing how to measure and
151 interpret all the three main non-invasive tools used for diagnosing PAD is limited among French
152 vascular medicine residents from four medical schools. Furthermore, this study underscores our clinical
153 impression that a significant lack of knowledge exists among French vascular medicine residents from
154 these four medical schools regarding not only the ABI procedure, but also the TBI and ABI Post-
155 exercise procedures.[14,17]

156 Our study is similar to those found previously in France and in different countries, where the
157 knowledge of measuring and interpreting the ABI at rest among residents in vascular medicine is poor.
158 [13–16] One of the reasons may be the style of teaching as some authors have highlighted that the
159 current academic training method may not have enough experiential (“hands-on”) learning. This may
160 have contributed to a poor level of competency with regard to the ABI procedure among residents.[13–
161 16] ABI measurement teaching generally takes the form of lectures and in very few cases practical
162 training.[18] However, it has been suggested that practical teaching would improve this competency.[19]
163 Another reason may be the lack of coaching of this ABI measurement training. Residents are often left
164 to themselves without real feedback of the senior vascular physician. A lack of reading can also be
165 suggested since only four residents (21%) were aware of the AHA recommendations.[8]

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

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

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

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

198 quickly as possible.[23] If there is only one examiner, the solution may be to assess arm pressure with
199 an automatic blood pressure monitor and measure the ankle pressure with a hand held continuous
200 Doppler. Gardner and Montgomery have shown at rest, that brachial systolic blood pressure was not
201 significantly different ($p=0.954$) among the Doppler (128.5 ± 18.4 mmHg), auscultatory (128.4 ± 17.4
202 mmHg), and oscillometric (128.2 ± 17.1 mmHg) methods.[24] However, this should be assessed in a
203 dedicated study to assess this procedure for post-exercise ABI. Third, the number of residents assessed
204 in this study is limited, but represents all the vascular residents trained in four different medical schools
205 with different vascular teachers. Therefore, these results cannot be generalizable to all training
206 institutions in France and reflects only the residents at these four institutions.
207 Fourth, we couldn't compare answer between first and second year residents because the two groups
208 were too small to show a difference statistically significant. Fifth, we didn't use validated questionnaires
209 to assess the level of knowledge of the residents. Indeed, it is possible that there isn't a good correlation
210 between the residents' result in each questionnaire, and the capacity to perform the three pressures
211 measurement tests correctly or to perform a test better than another.

212 **5. Conclusion**

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

221 **Acknowledgment**

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223 **Conflict of interest**

224 The authors declare no conflict of interest.

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- 322 Figure I. Questionnaire about the knowledge on pressures measurement for ABI at rest
- 323 Figure II. Questionnaire about the knowledge on pressures measurement for Post-exercise ABI and TBI
- 324 Figure III. Number of measurements performed by vascular medicine residents
- 325 Figure IV. Flow of the residents that gave cumulative right answers throughout the entire questionnaire
326 on ABI at rest
- 327 Figure V. Flow of the residents that gave cumulative right answers throughout the entire questionnaire
328 on Post-exercise ABI
- 329 Figure VI. Flow of the residents that gave cumulative right answers throughout the entire questionnaire
330 on TBI
- 331 Figure VII. Numbers of right answers for each question of the 3 questionnaires

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

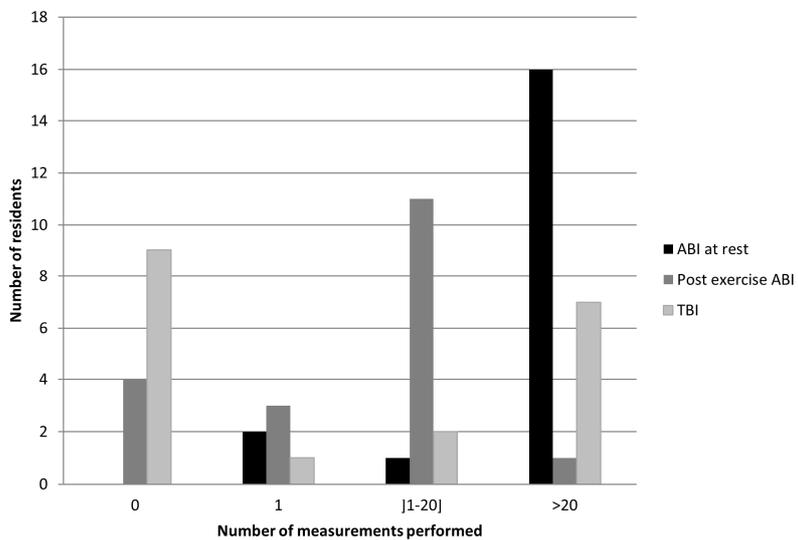
Corrects answers are written in bold and highlighted.

- 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.

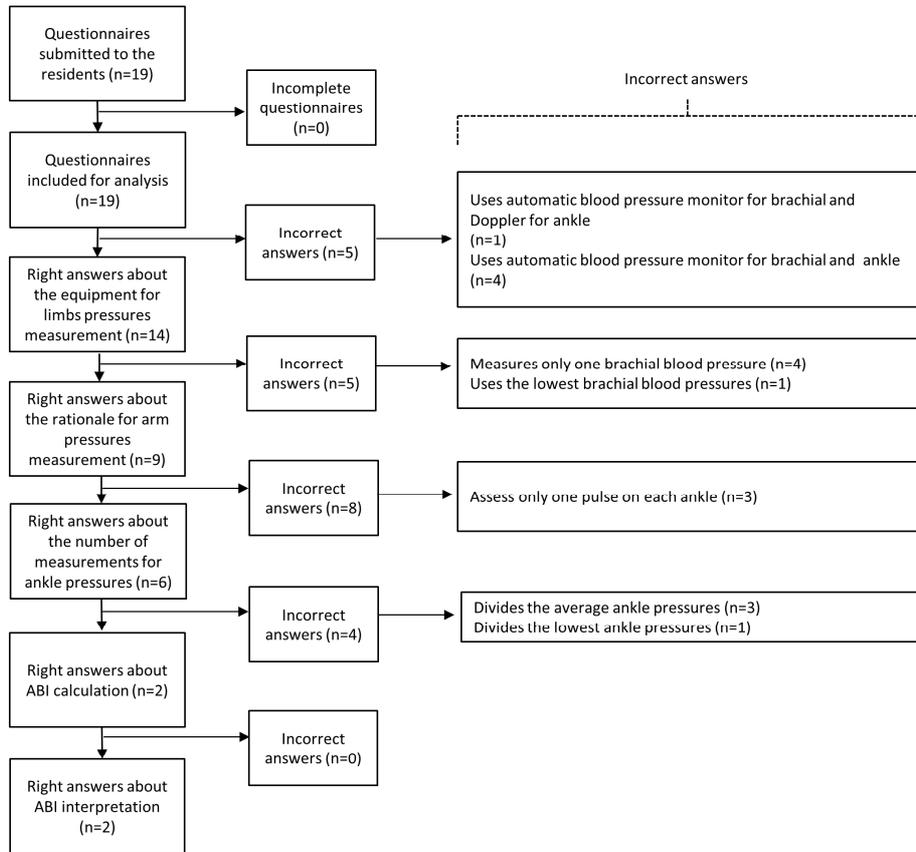
Previous learning

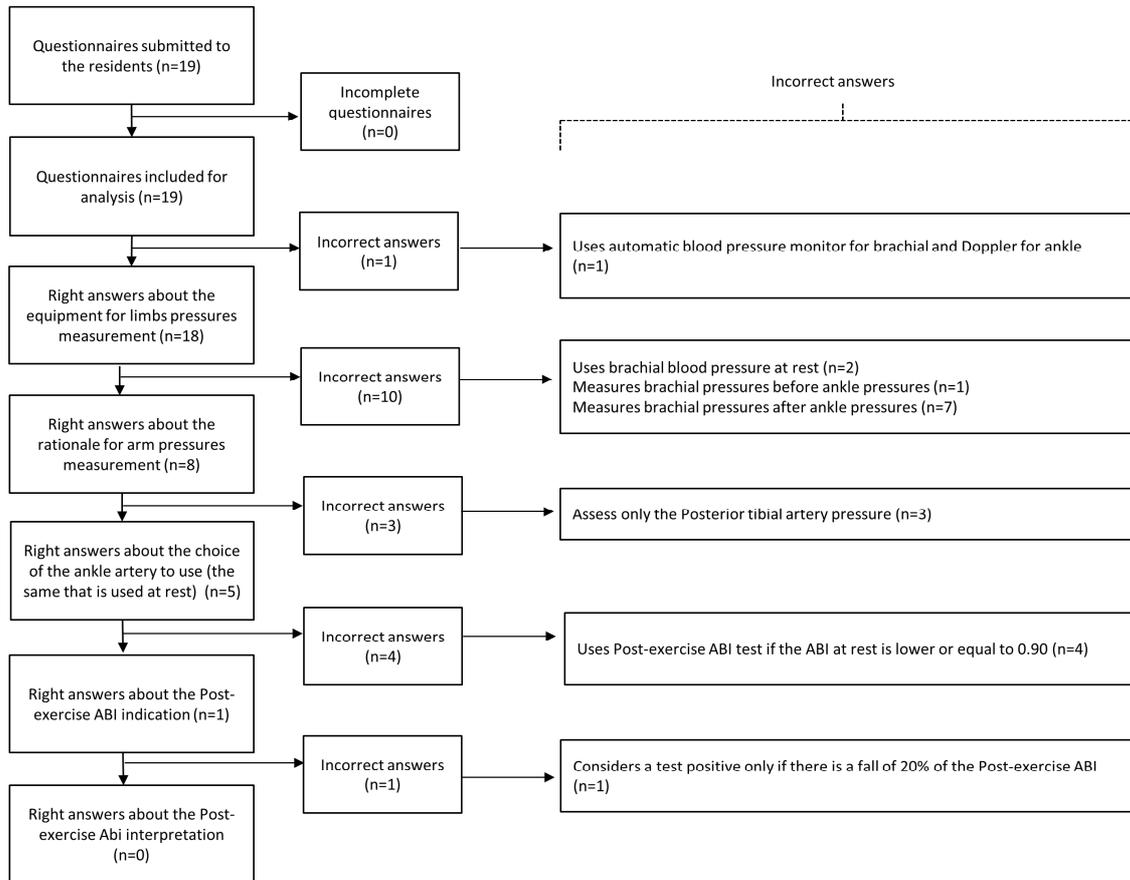
- 1) Do you have a previous experiential learning in pressures measurement procedure (ABI at rest or Post-exercise ABI or TBI) during your medical school ?
- Yes
 - No

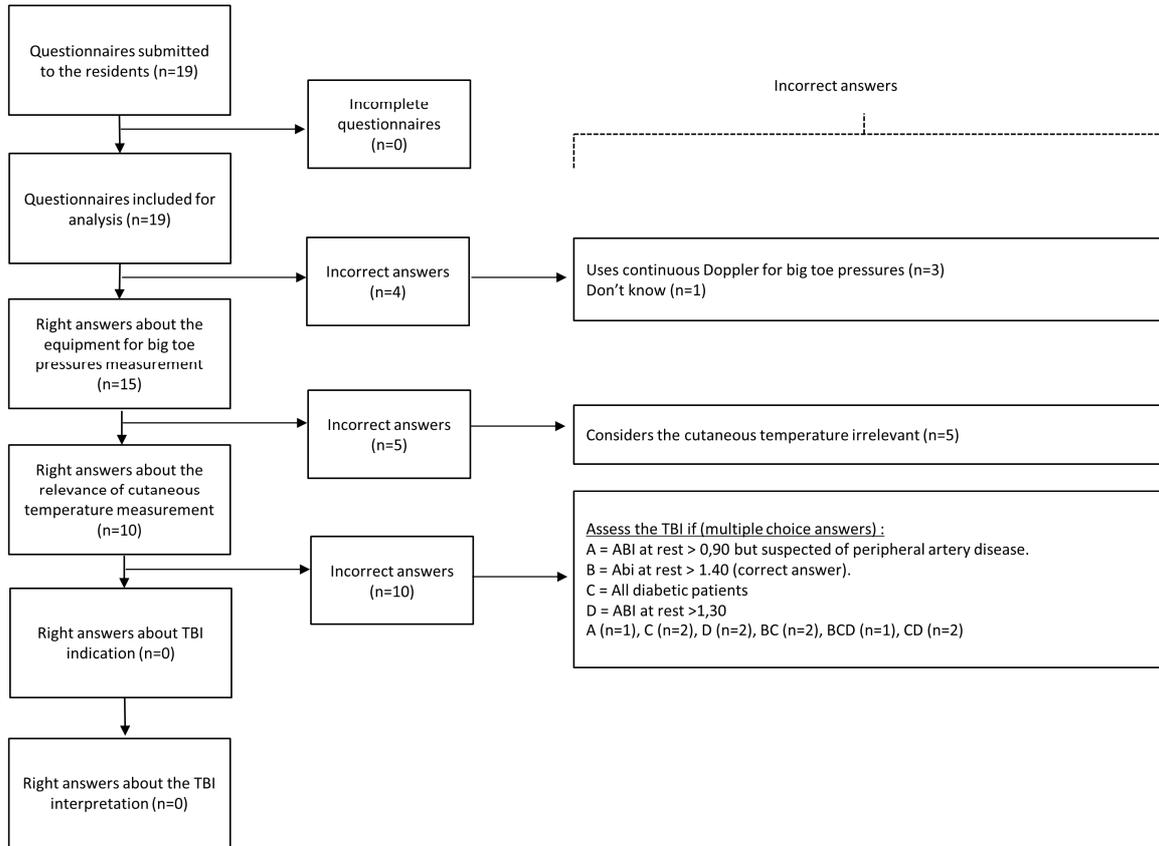
ACCEPTED TEL

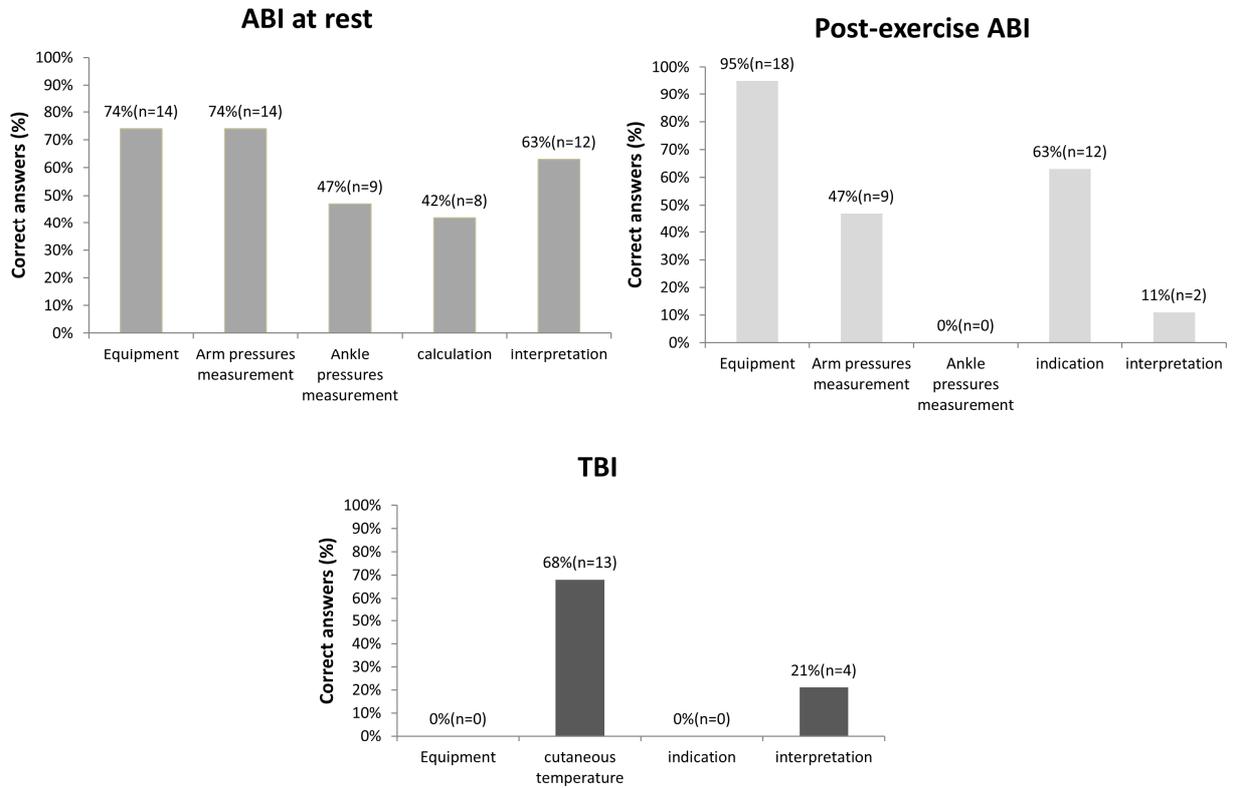


ACCEPTED









ACCEPTED TEL