VASCUPEDIA

TIPS AND TRICKS FOR FACILITATING TEACHING OF DOPPLER WAVEFORMS AND ANKLE-BRACHIAL-INDEX IN UNDERGRADUATE LEVEL: A PRACTICAL GUIDE

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Introduction

- Measurement of Ankle-Brachial Index (ABI) is considered a basic skill for the diagnosis and assessment of peripheral arterial disease and a predictive tool for cardiovascular events.

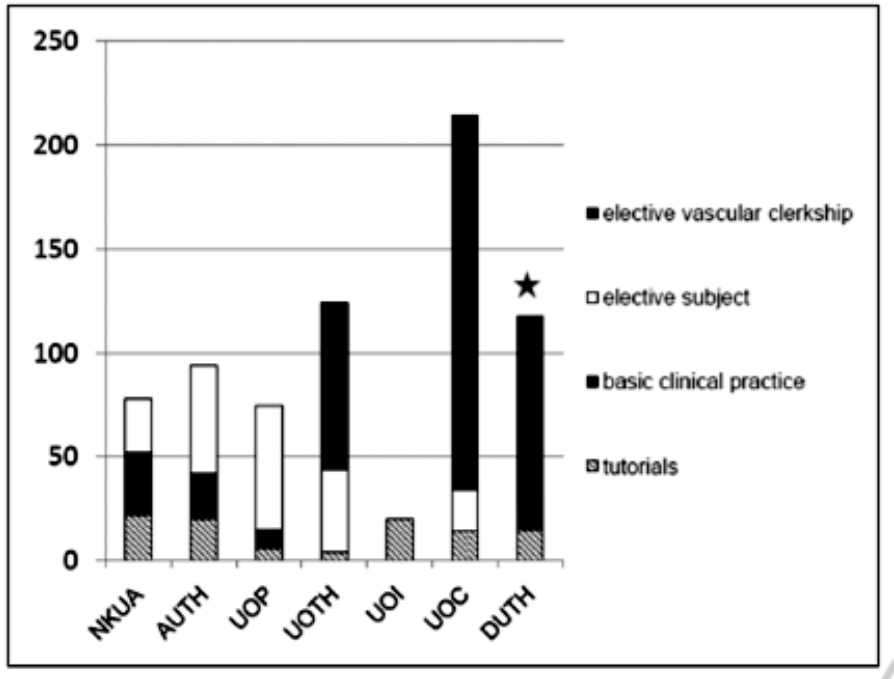
- However, real-world practice shows that current teaching and practice is far from ideal.

- Moreover, the value of ABI is undeappreciated if ist measurement is restricted only to physicians working in the vascular field

- Deficiencies of education have led to the placement of ABI among the "Top-10 forgotten diagnostic procedures,, (Vasa 2016; 45:5-6)

ABI measurement and vascular teaching are underappreciated in undergraduate medical curricula

- *There is marked discrepancy in the teaching of Angiology and ABI skills among the Greek medical schools…*



Bafitis et al, Int Angiol 2017; 36:386-391

- *…while practical training in ABI was reported to be implemented during the 2nd and 3rd cycle of 20% and 60% of French Medical Schools, respectively.*

Mahé G, J Mal Vasc 2015; 40:165-72

ABI measurement and vascular teaching are underappreciated in undergraduate medical curricula

- *Wyatt et al. documented a poor level of knowledge of ABI calculation and interpretation among internal medicine residents irrespective of the year of residency*

Table I. Errors in ankle–brachial index (ABI) measurement at baseline

Measurement error	N [%]	
	Baseline (n = 29)	Post-education (n = 24)
Failure to use Doppler to assess brachial pressures	25 [86]	1 [4]
Failure to assess both pedal vessels (i.e. DP and PT)	24 [83]	0 [0]
Failure to assess both brachial pressures	23 [79]	0 [0]
Failure to accurately record Doppler signal from brachial or pedal artery	12 [60][a]	12 [50]
Use of small arm cuff to assess pedal pressures	15 [52]	1 [4]
Incorrect placement of ankle cuff over body of calf muscles	14 [48]	2 [8]
Failure to use Doppler to assess pedal pressures	9 [31]	0 [0]
Use of large leg cuff to assess brachial pressures	4 [14]	1 [4]
Assessment of radial artery pressure instead of brachial pressure	1 [4]	0 [0]

DP, dorsalis pedis; PT, posterior tibial.

Wyatt et al, Vasc Med; 2010:15:99-105

- *Chaudru et al. showed that experienced residents perform better than inexperienced ones, but not faultlessly*

Chaudru et al, Vasa 2016; 45:37-41

ABI training: a challenging task for dedicated tutors

Internal Medicine Interns Have a Poor Knowledge of Peripheral Artery Disease

Aron I. Schwarcz, MD[1], Aimee Quijano, MD[1], Jeffrey W. Olin, DO[2], and Robert J. Ostfeld, MD, MSc[1]

Table 1. Results of Questionnaire by Category

Category	Percentage Correct	Range (%)
Prevalence	48.9	0-100
Screening	33.8	0-80
Treatment	45.0	0-87.5
Outcomes	42.5	0-100
Overall	41.7	10.5-73.7

Schwartz et al, Angiology; 2012:63:597-602

Knowledge about ankle-brachial index procedure among residents: being experienced is beneficial but is not enough

Summary: *Background:* Ankle-brachial index (ABI) at rest is the main clinical tool to diagnose the presence of lower extremity peripheral artery disease (PAD). The method for ABI procedure (i.e., measurement, calculation and interpretation) is standardised and guidelines were published in 2012. This study sought to: i) assess knowledge about the three major steps of the ABI procedure (i.e., measurement, calculation and interpretation) among residents from different medical schools, ii) compare the ABI knowledge of experienced residents (i.e., who have already performed ABI procedure more than 20 times) with the knowledge of inexperienced residents, and iii) describe the most common errors by residents. *Methods:* Residents from six medical schools were invited to complete a questionnaire about the ABI procedure. *Results:* Sixty-eight residents completed the questionnaire. None of them knew how to perform the entire ABI procedure. Overall, 22%, 13% and 41% of residents correctly answered questions about ABI measurement, ABI calculation and ABI interpretation, respectively. Score comparisons underlined the fact that experienced residents (n = 26) answered ABI measurement questions to a significantly better level and had a significantly higher total score than inexperienced residents (n = 42) (P = 0.0485 and P = 0.0332, respectively). Errors were similar for most of the residents. *Conclusions:* Our study confirms that experienced residents have significantly better ABI procedure knowledge than inexperienced residents. However, none of them are able to perform the entire ABI procedure without any mistake with regard to current guidelines. It is important that training be given to residents in medical schools in order to improve their ABI procedure knowledge.

Chaudru et al, Vasa 2016; 45:37-41

Training of students in ABI measurement requires time-commitment to achieve comparable results with professionals

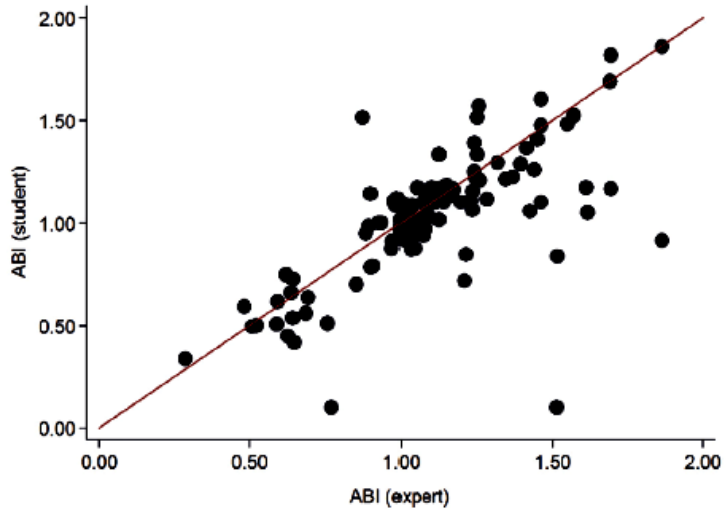
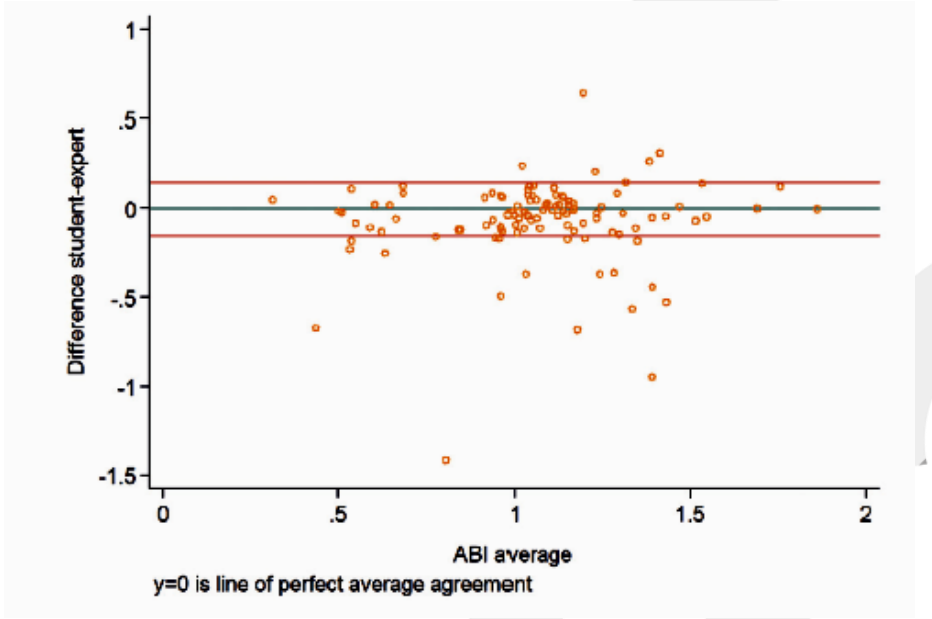


Figure 2. Correlation between students› and expert›s ABI measures.



Summary: *Background:* Ankle brachial index (ABI) is a first line non-invasive screening tool for peripheral arterial disease (PAD) in at risk populations. The need to extend ABI use in large population screening has urged its use by professionals other than vascular physicians. As advocated by the American Heart Association, ABI teaching is part of medical curriculum in several countries. We determine accuracy in ABI measurement by trained medical students compared with an experienced angiologist. *Methods:* Twelve 6th year medical students underwent 9 days of training at Lausanne University Hospital. Students and an experienced angiologist, blinded to students' results, screened consecutive hospitalised patients aged ≥65 or ≥50 with at least one cardiovascular risk factor during a 6-week period. *Results:* A total of 249 patients were screened of whom 59 (23.7%) met the inclusion criteria. Median age was 80, 45.8% were women, and 6.8% were symptomatic. In total, 116 ABIs were available for analysis. Agreement between students and angiologist was moderate with a k-value of 0.498 (95% confidence interval: 0.389–0.606). Overall accuracy and precision of PAD screening performed by students showed sensitivity of 73.2% and specificity of 88.0%. Positive and negative predictive values were 76.9% and 85.7%, respectively; positive and negative likelihood ratios were 6.3 and 3, respectively. *Conclusions:* A nine day training program on ABI measurement is not sufficient for inexperienced medical students to achieve an acceptable diagnostic accuracy in detecting PAD in at risk populations.

Monti et al, Vasa 2016; 45:43-48

- Aim of this presentation is to present certain tips that facilitate the estimation and interpretation of ankle brachial index
- The following tips reflect our experience from ABI bed-side teaching in our University Hospital, Medical School, Democritus University of Thrace (DUTH), where "Vascular Surgery" is core subject

Medical School	Year	Estimated hours of lectures*	Estimated hours of clinical practice
NKUA	4th (2 semesters)	15 (5+10)	10 (5+5)
	6th	7	20
AUTH	3rd	10	7
	4th	12	12
	6th	2	2
UOP	5th	6	9
UOI	4th	20	–
UTH	4th (2 semesters)	4 (2+2)	–
UOC	4th	14	–
DUTH	4th	13	13

NKUA: National and Kapodistrial University of Athens; AUTH: Aristotle University of Thessaloniki; UOP: University of Patras; UOI: University of Ioannina; UTH: University of Thessaly; UOC: University of Crete; DUTH: Democritus University of Thrace.
*The teaching hours refer to vascular surgery either as a core subject or as part of other core subjects (mainly general surgery).

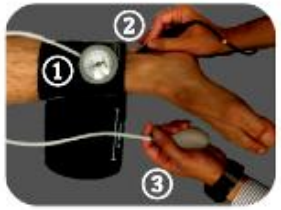
Bafitis et al, Int Angiol 2017; 36:386-391

How to measure ABI

MEASUREMENT

Conditions:

- Room with comfortable temperature (19°C–22°C).
- Patient at rest for 5 to 10 min in supine position, relaxed, head and heels supported.



① Sphygmomanometer (the cuff should have a width at least 40 % of the limb circumference). Ankle cuff is placed just above the malleoli.

② 8 to 10 MHz Doppler probe with Doppler gel applied over the probe. Probe is placed in the area of the pulse at 45° to 60° angle to the surface of the skin.

③ Inflate the cuff up to 20 mmHg above flow signal disappearance and then deflate slowly to detect the pressure level of flow signal reappearance.

⚠ The cuff should not be applied over a distal bypass or over ulcers.

Sequence of pressure measurements (from 1 to 7):

Right brachial artery

Right posterior tibial (PT) artery

Right dorsalis pedis (DP) artery

Left posterior tibial (PT) artery

Left dorsalis pedis (DP) artery

Left brachial artery

Right brachial artery

CALCULATION

For peripheral artery disease (PAD) diagnosis :

$$ABI_{right} = \frac{\text{Higher of the PT or DP systolic pressure in right ankle}}{\text{Higher of the left or right brachial systolic pressure*}}$$

$$ABI_{left} = \frac{\text{Higher of the PT or DP systolic pressure in left ankle}}{\text{Higher of the left or right brachial systolic pressure*}}$$

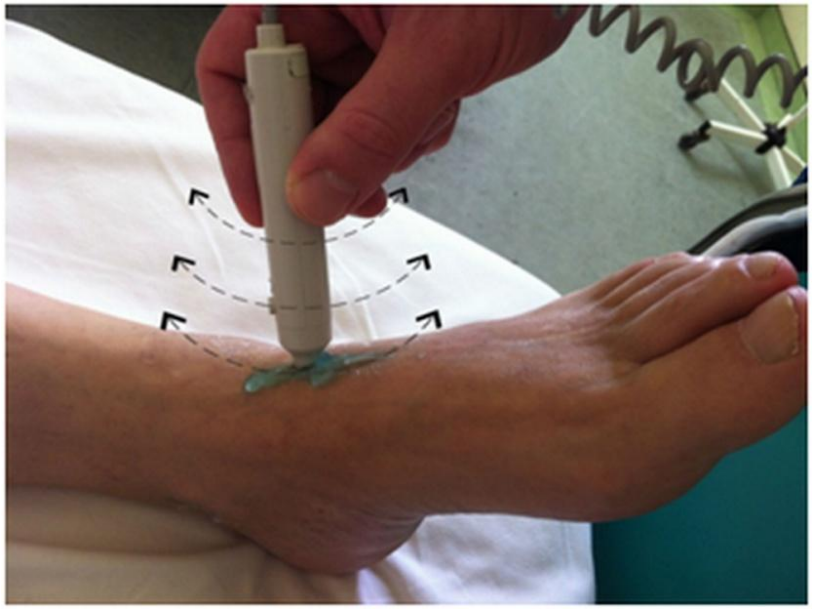
For cardiovascular risk assessment:

The lower of the ABIs of the left and right leg should be used.

INTERPRETATION

≤ 0.40	Severe PAD
0.41 – 0.90	Mild to moderate PAD
0.91 – 1.00	Borderline
1.01 – 1.40	Normal
>1.40	Incompressible artery

Chaudru et al, EJVES 2016; 51:240-247



1. Hold hand steady over patient's dorsal foot to estimate dorsalis pedis artery
2. Support your hand on the firm surface of the dorsal foot to avoid subtle trembling movements (pendulum)
3. Pendulum movements are exacerbated once the sphygmomanometer is inflated leading to loss of arterial signal and underestimation of the segmental pressure

4. Likewise, support the examiner's hand against the bed surface to estimate posterior tibial artery

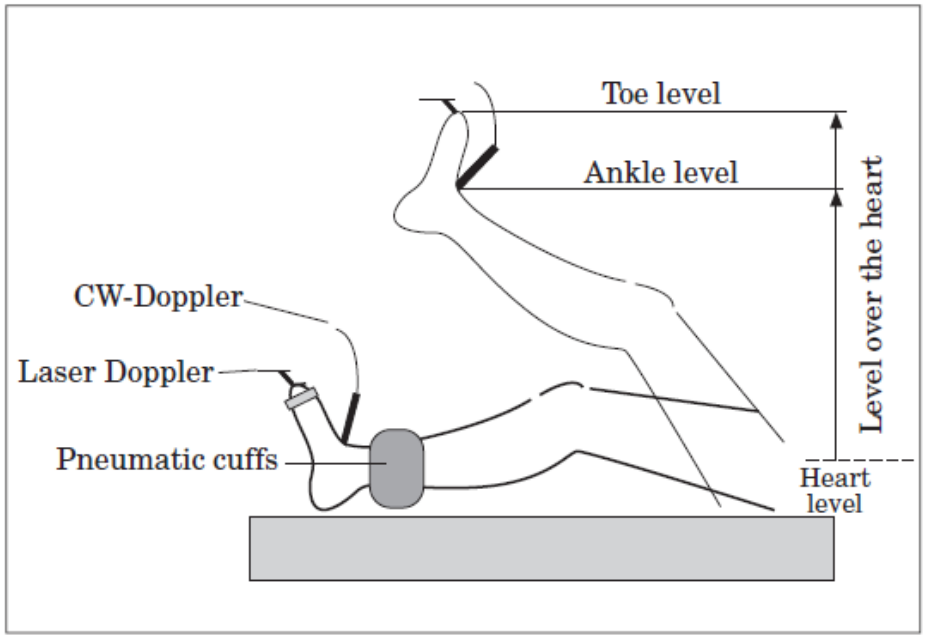
5. Avoid venous interference when estimating arterial sign often perceived as attenutated, barely audible arterial sign.

6. Apply gentle squizing maneuvers distally to the examined area to augment venous return and delineate non-arterial origin

‘Pole Test’ Measurements in Critical Leg Ischaemia

N. Paraskevas,[1*] R. Ayari,[1] S. Malikov,[1] M. Mollo,[1] P. Branchereau,[1]
F. Hut[2] and A. Branchereau[1]

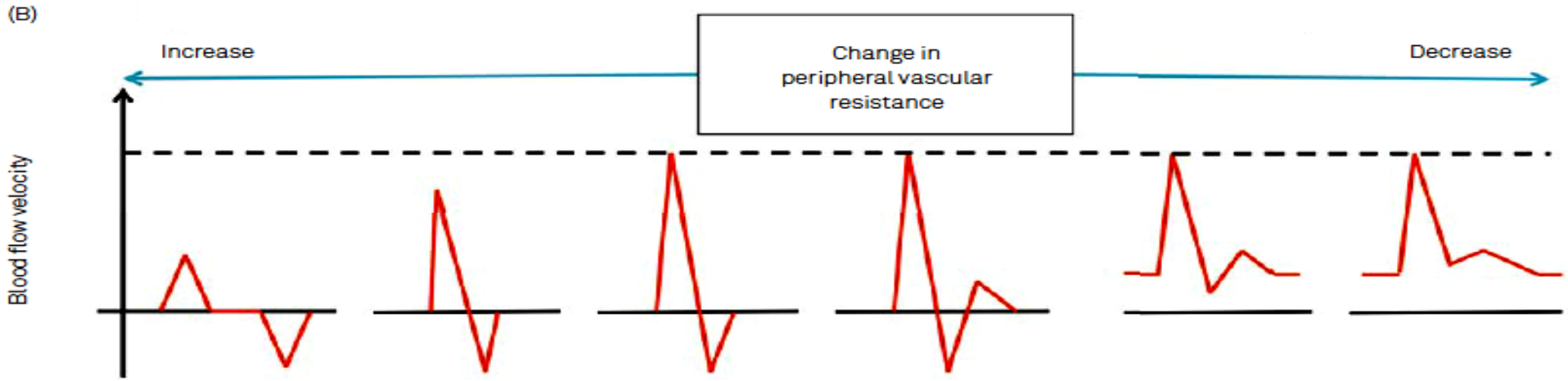
7. Recruit the Pole test to assess ischemia and evaluate “high” ABI



Results. *Measurements obtained by cuff-manometry were significantly higher to those obtained by pole test (mean pressure difference: 40 mmHg, $p<0.001$). The difference between the two methods remained statistically significant for both diabetics (50.73, $p<0.001$) and non-diabetics (31.46, $p<0.001$). Mean $TcPO_2$ value was 15.51 mmHg and there was no important difference between patients with and without diabetes. Overall, there was a correlation between sphygmomanometry and pole test ($r=0.481$). The correlation persisted for patients without diabetes ($r=0.581$), but was not evident in patients with diabetes. Correlation between pole test and $TcPO_2$ was observed only for patients with diabetes ($r=0.444$). There was no correlation between cuff-manometry and $TcPO_2$. The pole test offered an accuracy of 88% for the detection of CLI. The sensitivity of this test was 95% and the specificity 73%.*

Eur J Vasc Endovasc Surg 31, 253–257 (2006)

Getting familiar with the arterial waveforms

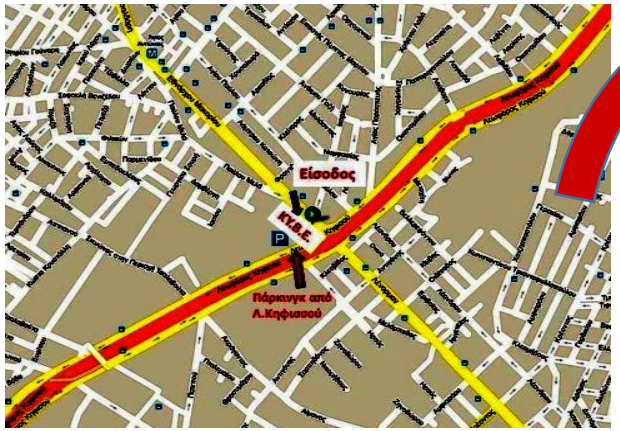


Review

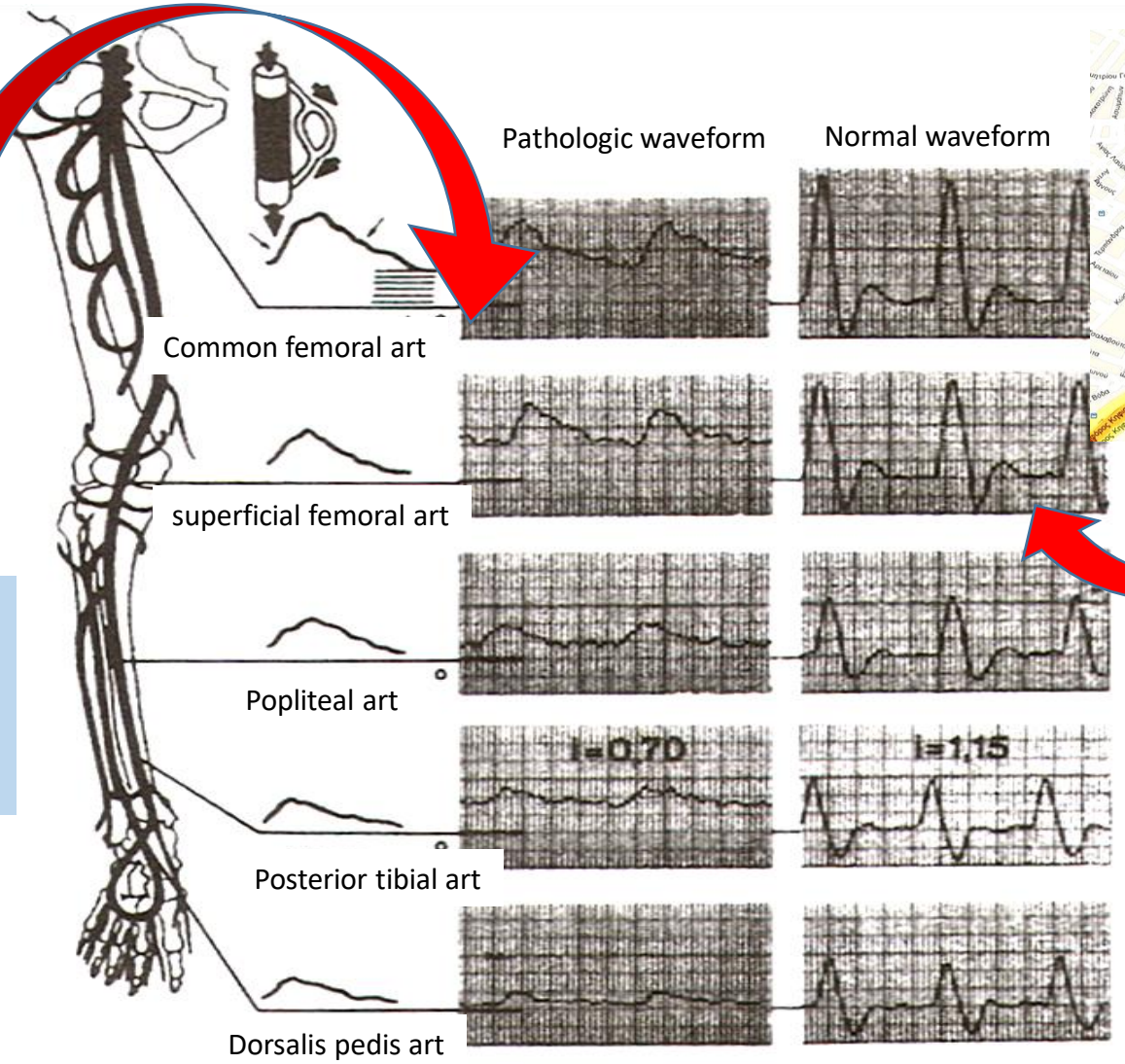
Statement for Doppler waveforms analysis

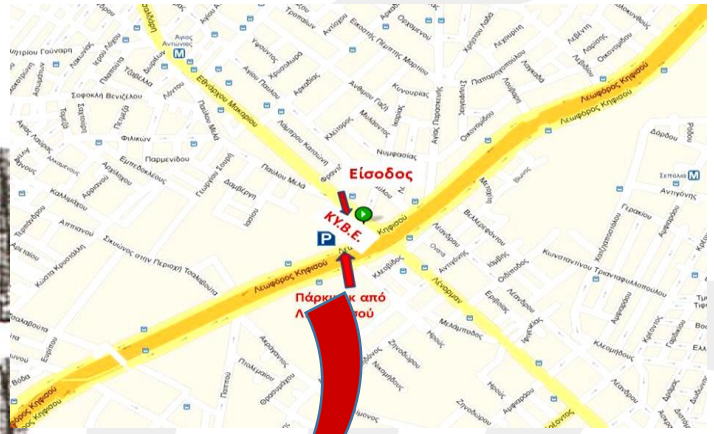
Guillaume Mahé[1], Carine Boulon[2], Ileana Desormais[3], Philippe Lacroix[3], Luc Bressollette[4], Jean-Louis Guilmot[5], Claire Le Hello[6], Marie-Antoinette Sevestre[7], Gilles Pernod[8], Joel Constans[2], Christian Boissier[6], and Alessandra Bura-Rivière[9]

Vasa (2017), *46* (5), 337–345



Flow through multiple &smaller collaterals (when main road is closed) results in monophasic, slow, attenuated waveforms





Flow through open unobstructed "highway" results in triphasic waveforms

High ABI with monophasic Doppler sign: questionable

VASCUPEDIA

Discriminate the normal- from the monophasic post-obstructive arterial signals

8. Getting familiar with the triphasic signal

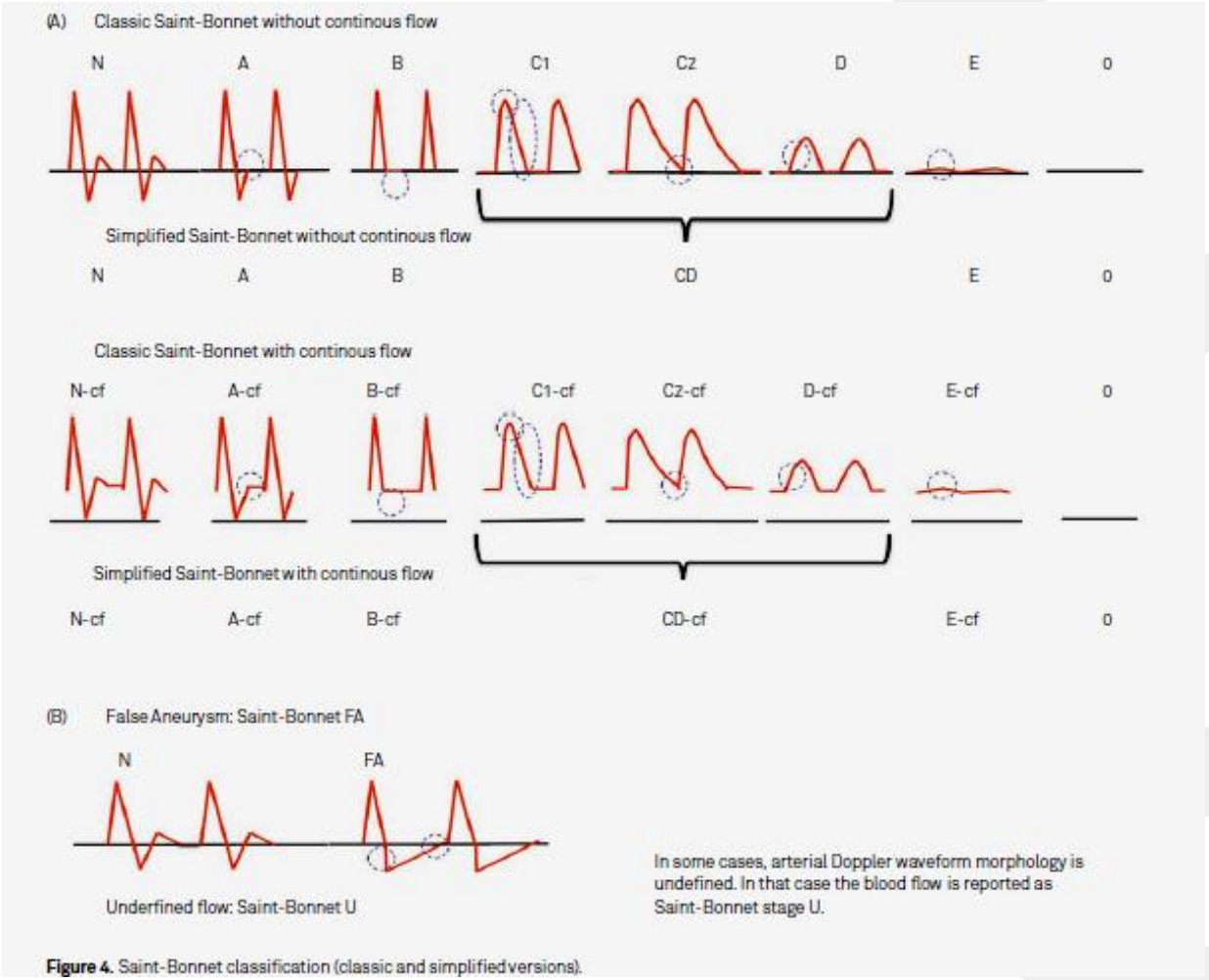
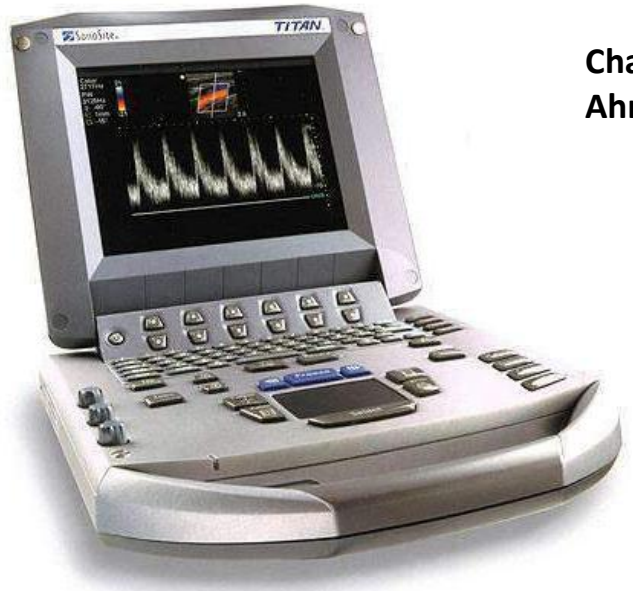
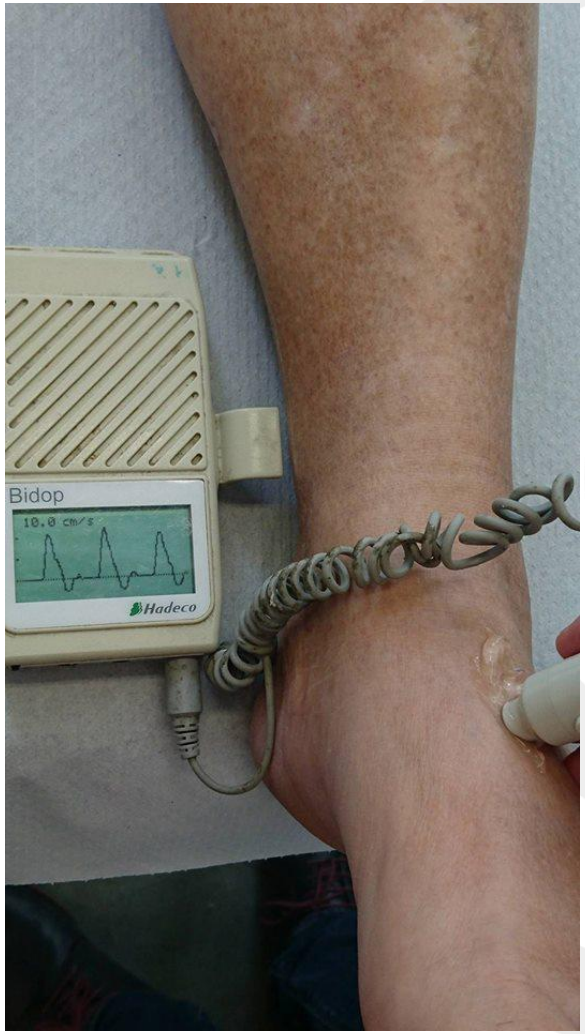


Figure 4. Saint-Bonnet classification (classic and simplified versions).

Combining audible signs with visual recordings



Chaudru et al, Int J Cardiol, 2015
Ahn et al, J Ultrasound Med, 2015



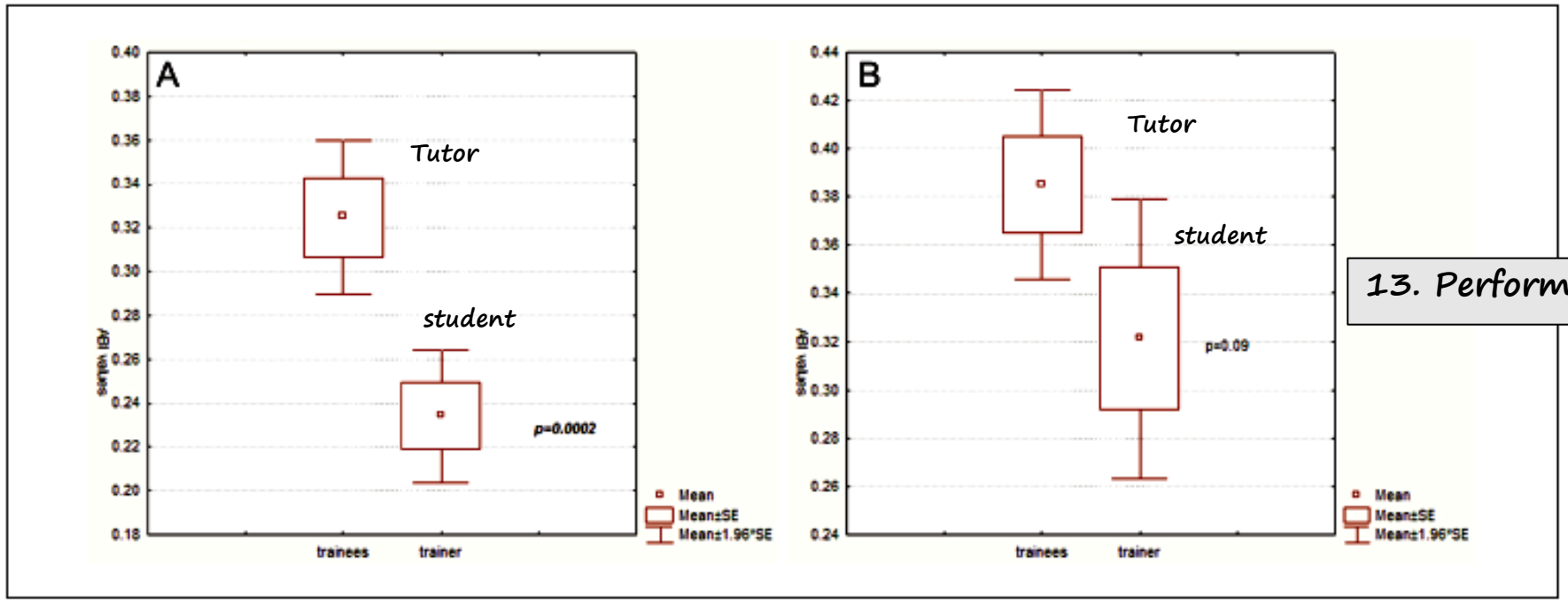
Use portable color Duplex in the bedside teaching

9. Comprehension of bi- and triphasic flow
10. Discriminate from venous continuous flow
11. Check ABI in cases of incompressible crural vessels
12. Ultrasound stimulates students' attention and enhances skills

Underline the significance of ABI presentation with practical examples

- ✓ Trauma in Lower limb
- ✓ External fixation
- ✓ Inability to apply sphygmomanomener to estimate ABI
- ✓ A triphasic Doppler signal can remote serious arterial damage although ABI >0.9 remains the task

Repetition is the mother of learning and the father of action!



13. Perform at least 20 measurements of ABI

Improvement of students' performance in ABI after practice even for critical limb ischemia

Georgakarakos et al, Int J lower Extrem Wounds 2013; 12:167-171

Take home messages

- Teaching basic principles of vascular examination can be an intriguing task
- Acquaintance of ABI-practical skills is a demanding process and needs commitment, repetition and combination of theory and practice
- Understanding of Doppler waveforms completes ABI interpretation and helps avoiding misinterpretations in vascular examinations

Questions to Vascupedians

- How often do you perform ABI estimation pre- and post-operatively in your patients?
- How do you perform peripheral vascular evaluation in patients with incompressible crural vessels (e.g., diabetics and dialysis patients)?
- Is ABI measurement considered a basic practical skill in your medical school?
- What is the commonest difficulty you encounter when measuring ABI?
- Do referral letters from general practitioners or family doctors in your country report an ABI estimation?
- Are you familiar with basic arterial waveforms?
- Would you consider the basic knowledge of arterial waveforms as necessary when estimating ABI and/or differentiating "arterial" symptoms?