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Provider ankle brachial index and wound classification teaching as part of a comprehensive limb preservation outreach program

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Abstract

Objective: Utilization of evidence-based specialty guidelines is low in primary care settings. Early use of ankle-brachial index (ABI) testing and a validated wound classification system allows prompt referral of patients for specialty care. We implemented a program to teach providers ABI testing and the use of the Wound, Ischemia, and foot Infection (WIfI) classification tool. Here, we report program outcomes and provider perceptions.

Methods: Physicians and non-physicians from wound care centers, nursing and physician education programs, primary care offices, and federally qualified health centers were invited to participate in the educational program teaching ABI testing and the use of the WIfI tool. Pretest and posttest responses and intention to use content in the future were assessed with descriptive statistics.

Results: A total of 101 subjects completed the ABI module, and 84 indicated their occupation (59 physicians, 25 non-physicians). Seventy-nine subjects completed the WIfI module, and 89% indicated their occupation (50 physicians, 20 non-physicians). Physicians had lower pre-test knowledge scores for the ABI module than non-physicians (mean scores of 7.9 and 8.2, respectively). Both groups had improved knowledge scores on the post-test (physicians, 13.4; non-

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AUTHOR CONTRIBUTIONS

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Analysis and interpretation: KD, GR, MN, MH

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physicians, 13.8; $P < .001$). Non-physicians in practice longer than 10 years at wound care centers had the lowest base-line knowledge scores, whereas physicians in practice for over 10 years had the highest. In the ABI module, the largest knowledge gap included accurately calculating the ABI, followed by the correct use of the Doppler, and management of incompressible vessels. For the WIfI module, providers struggled to accurately score patients based on wound classification. The greatest barriers to the implementation of ABI testing were the availability of trained personnel, followed by limited time for testing. Barriers to the use of the WIfI tool for physicians included lack of time and national guideline support. For non-physicians, the most notable barrier was a lack of training.

Conclusions: Provider understanding of ABI and WIfI tools are limited in wound care centers, primary care offices, and federally qualified health centers. Further barriers include a lack of training in the use of tools, limited potential for point-of-care testing reimbursement, and insufficient dissemination of WIfI guidelines. Such barriers discourage widespread adoption and result in delayed diagnosis of arterial insufficiency.

Keywords

Ankle-brachial index; Peripheral arterial disease; Wound Infection foot Ischemia Score

Each year in the United States, more than 185,000 patients with peripheral artery disease (PAD), diabetes mellitus, or combined PAD/ diabetes mellitus undergo a lower extremity amputation.[1] Even for experienced specialists, determining the underlying pathology and coor-dinating revascularization and other care for patients with lower extremity ulcers remains a challenge.[2] Primary care providers (PCPs) have limited understanding of the assessment and classification of ulcers. In addition, guidelines from primacy care societies such as the American Academy of Family Physicians and the American College of Physicians guidelines are confusing and often contradictory to those published by specialty societies, such as the Society for Vascular Surgery (SVS).[3,4] These recommendations prioritize use of broad-spectrum antibiotics and endorse the Wagner assessment tool, though the Wagner tool is flawed, providing no assessment of the depth and extent of the ulcer and no consideration for degree of ischemia.[5] The SVS recommends the use of the Wound Ischemia Foot infection (WIfI) tool, a validated tool able to predict amputation risk and the potential benefit of revascularization.[6] The challenge of course, is that the Centers for Medicare and Medicaid Services bases reimbursement on the Wagner Assessment.

Training of providers in wound care is very limited. The Accreditation Council for Graduate Medical Education does not require family medicine or internal medicine residencies to teach about management of wounds.[7] A survey of over 200 general providers found a lack of evidence-based care and continued use of outdated, harmful wound principles.[8] The use of early ankle-brachial index (ABI) testing has been shown to decrease the risk of amputation.[9] It is also known that with appropriate training, this evaluation can be completed in less than 5 minutes.[10] Despite the ease of use, assessment of arterial perfusion with the ABI measurement is only performed by 13% of providers in patients with high risk for PAD in primary care clinics.[11]

In an attempt to actively implement widespread use of the SVS WIfI tool and increase use of ABI testing in wounds arising from arterial insufficiency, our institution developed a limb salvage educational program for health care providers. The goal of this work was to test those modules in a targeted limb salvage program and garner data concerning provider knowledge of ABI and WIfI testing, provider intention to use the tools in practice, and the perceived barriers to use.

METHODS

The study was conducted as part of the development process for a comprehensive limb salvage program. Institutional review board approval was obtained prior to conduction of the study.

Participants.

Training modules were open enrollment, available to providers from local wound care centers, educational programs for nurses and physicians, primary care offices, federally qualified health centers, and safety net hospitals. None of the subjects were currently using the WIfI scoring tool or completing ABI testing in clinical practice. All subjects were given access to an online portal and courses free of charge.

Training modules.

Providers were asked to participate in an educational curriculum for limb salvage. The modules were designed as part of a remote telehealth outreach program to provide necessary knowledge and tools to providers when developing new care and referral pathways. The curriculum consisted of two online educational modules and a virtual or in-person lecture. One module was designed to teach about ABI measurement testing, and the second module was designed to demonstrate use of the SVS WIfI classification tool. Each module consisted of a pretest, the educational curriculum with a video-based learning module, a post-test, and a completion survey. Providers were given a month to complete modules before participating in a hands-on session to demonstrate the tools. Supplemental written material was also provided for each module. Participants were offered continuous medical education credit upon completion of the survey for each online module.

Pre-/post-test development.

The tests were developed with the help of the University of California Continuous Medical Education Team using a backwards design.[12] Backward design starts with the final concepts the educator desires learners to understand and then develops assessment questions around those concepts. For the ABI assessment, a vascular surgeon, vascular trainees, a nurse practitioner, and a vascular lab technician all participated in the development of the assessment. For the WIfI assessment, a podiatrist replaced the vascular lab technician as the final member of the team. The assessments were created in an iterative fashion with discussion regarding the principle that was being taught, possible choices that are obvious to confuse novices, and then straightforward correct answers that would be clear to learners. The content of the module was then reviewed, and the test was taken by other vascular

surgeons, trainees, nurse practitioners, vascular technicians, and podiatrists to ensure the clarity of the questions and make changes as needed.

Analysis.

Mean and standard deviation were used to describe normally distributed continuous variables. For nonparametric data, median and interquartile range were reported. Frequencies and percentages were used for categorical variables. Continuous variables were compared using the Wilcoxon rank sum test for nonparametric data or the Student *t* test for normally distributed data. Categorical values were evaluated using the Fisher exact test, with a *P*-value of .05 conferring statistical significance. All statistics were performed using SAS software. (Cary, NC).

RESULTS

A total of 135 providers participated in the ABI training module over a 12-month period. Of these, 101 took both the pre-test and post-test associated with the module. Eighty-four participants (62%) indicated their occupation in the completion survey. Physicians accounted for 59 (70%) of the 84 participants, and the remaining 25 participants (30%) were non-physician personnel, which consisted of nurse practitioners, registered nurses, licensed vocational nurses, or wound care technicians. The WIfI training module was begun by 105 providers, with 79 (75%) completing the entire module. Physicians represented 71% (n = 50), and non-physicians represented 29% (n = 20) of the participants with occupation specified.

Baseline knowledge.

The maximum score for the ABI pre-test and post-test was 15. The mean ABI pretest score for all participants was 8.02 (standard deviation [SD], 2.77), scored one point per question answered correctly of 15 points, with a mean post test score of 13.16 (SD, 1.78). Physicians had a slightly lower mean pretest score of 7.92 (SD, 2.69) compared with non-physicians (8.12; SD, 2.85). Both physicians and non-physicians significantly increased their understanding of ABI testing after completion of the education module, with an increase of more than 5 points between the pre and post-test scores (Table I).

Time in practice and baseline ABI knowledge.

The mean ABI pretest score for non-physicians varied by years in practice. For non-physicians, providers who had been in practice for longer had a lower ABI pretest score (Table II). Non-physician providers who were in practice for more than 10 years had the lowest pretest score at 6.67 (SD, 3.06). Non-physician providers who had been in practice for only 1 to 3 years had the highest baseline pretest score of 7.8 (SD, 3.26). Physicians who had been in practice for more than 10 years had the highest ABI pretest score at 9.44 (SD, 1.59), whereas those that had been in practice for 4 to 6 years had the lowest score at 7 (SD, 5).

Type of practice and knowledge.

Non-physician providers at academic medical centers and physicians in hospital-based practice had the highest ABI pretest scores (Table III). Non-physician providers at wound care centers had the lowest pre-test ABI scores, followed by physicians at academic medical centers. All providers performed similarly on the ABI post-test and had a statistically significant increase from the pre-test to the post-test, with non-physician wound care providers scoring the highest.

Areas of knowledge deficit.

Within the ABI module, three questions had >60% wrong responses on the pre-test compared with the post-test (Table IV). The most common question answered incorrectly asked the learner to calculate the ABI based on provided values. Learners were more likely to choose a brachial artery pressure that was ipsilateral to lower extremity symptoms rather than use the highest brachial pressure measured to calculate the ABI. The second most common question answered incorrectly asked the learner to describe the correct angle to hold the Doppler probe when obtaining an ABI. Participants were more likely to point the probe at a 90-degree angle to the artery. The final question asked learners how to manage a patient with incompressible vessels found on ABI testing. Learners were unfamiliar with the concept of calcified vessels, the need for specialist evaluation, and the role of toe pressure measurements to determine extremity perfusion when the tibial arteries could not be compressed due to calcific vascular disease. With regard to the WIfI module, participants were unfamiliar with when to employ the tool, correctly scoring the wound stage in accordance with the criteria, and interpreting the resulting score after using the tool.

Willingness to use after training.

On the final module evaluation, subjects were surveyed to identify barriers to use of ABI testing in their practice. Pre-participation utilization of the WIfI score was absent, and many providers were unfamiliar with the tool. Although some providers ordered ABI testing in the outpatient facility, no providers were completing ABI testing within the primary care setting. On the survey, 53% of physicians indicated that they would be unlikely to perform the ABI test as part of their practice in the future. When asked to describe specific barriers, 33% of physicians reported the main reason they would not use ABI testing in the future was a lack of trained personnel to complete the test. Alternatively, 52% of non-physicians felt they were likely or extremely likely to use the ABI test in the future. The most common reason non-physicians felt they would not be able to incorporate ABI testing into their practice was limited time to perform the test within their day (23%). Other significant barriers included a lack of financial reimbursement for point-of-care testing (16%). Physician and non-physician respondents on the WIfI module noted a similar barrier with limited time for patient evaluation (40%), as well as a lack of guideline knowledge and non-vascular society support for use of the tool (16%). Overall, 52% of non-physician participants and 41% of physician participants indicated that they would be likely or extremely likely to use the WIfI tool in practice after completing the module.

DISCUSSION

Early use of vascular screening tools supports prompt referral to a specialist for dedicated evaluation and appropriate intervention to promote limb salvage. Delays in diagnosis of underlying vascular disease increases the risk of adverse outcomes and limb loss for patients with chronic limb-threatening ischemia (CLTI). In our study, physicians and non-physicians had differing levels of knowledge and experience with these tools. We noted specific knowledge gaps in physician and non-physician groups, ultimately impacting correct utilization of both tools, limiting their application as part of a diagnostic and treatment algorithm. Significant knowledge gaps combined with perceived barriers to use represent areas for improvement within the primary care community to positively impact outcomes in CLTI with tissue loss.

Analysis of baseline knowledge for physicians and non-physicians revealed that physicians had a lower overall pre-test mean score for both the ABI and WIfI modules. When the groups were stratified by years in practice, however, physicians in practice greater than a decade had the highest mean ABI pre-test scores, whereas the lowest was among non-physicians in practice longer than a decade. Regardless of type or length of practice, all providers, physician and non-physician alike, experienced a significant increase in mean pre-test to post-test scores for both the ABI and WIfI modules. Any further sub-cohort analysis by practice type was some-what limited by the small sample size. Despite these limitations, we concluded that regardless of provider type, practice style, or years in practice, implementation of the two online educational modules resulted in significant improvement in knowledge of correct use of both screening tools as part of a diagnostic algorithm for management of patients with CLTI and associated tissue loss. To determine the efficacy of the educational modules, providers completed a pre and post-test for each module, revealing that there were some consistent knowledge gaps among participants. We noted providers were unfamiliar with performing ABI testing correctly, and upon completion, were uncertain about correct management of patients with abnormal ABIs, especially in the setting of calcified vessels. When attempting to use WIfI criteria, providers frequently struggled with correct evaluation of extremity wounds. Such knowledge gaps can impact successful screening and early referral of patients with CLTI. Post-test results suggest the training modules employed were successful in bridging the identified knowledge gaps. Widespread efforts directed towards primary care provider education in correct use of screening tools for PAD, such as through use of similar online education modules, are needed.

Advocacy remains a vital component for optimal patient care, both on the part of the patient and their provider. PCPs are the gatekeepers to crucial multidisciplinary specialty care, and the screening and referral process for specialty care represents the advocacy employed by PCPs on behalf of their patients. Barriers to use of the available screening tools limit the ability of PCPs to appropriately refer patients for care. The barriers identified by providers included a lack of familiarity in using one or both tools, a lack of reimbursement for ABI point-of-care testing, and a lack of society support. Although education and training can bridge gaps for providers who are unfamiliar with the nuances of using these tools effectively, other barriers are more complex. There are current national

initiatives to encourage PCPs to employ screening of patients with risk factors for PAD and ongoing efforts to support reimbursement for point-of-care testing. Surgeon support for such initiatives is imperative to improve PCP adoption of ideal screening practices. Finally, collaboration across societies offers an opportunity to inform providers of the benefits of early screening and referral on overall limb salvage and survival.

Our study had some limitations. Although the gold standard for diagnosis of PAD remains arteriogram, ABI testing has a role in screening, although even this has limitations. When used correctly, specificity can be up to 99%, though sensitivity can be as low as 15%; furthermore, use in peri- and inframalleolar disease is limited.[13] Although results demonstrated a significant improvement in knowledge for all providers after completion of the education modules, our results are limited due to the small cohort of participants. Additionally, we did not evaluate the impact of improved PCP knowledge on referral practices, aside from select facilities with whom a pathway for care exists. Although the completion survey inquired into provider intention to use screening tools, there is a lack of discreet data to allow for evaluation of the impact on outcomes in CLTI. Future efforts should be directed towards evaluating the role of PCP education in improving referral rates and overall outcomes for patients with CLTI.

CONCLUSION

Early screening for vascular disease in patients with CLTI and tissue loss promotes prompt referral for specialist evaluation and appropriate intervention. PCP understanding and utilization of ABI testing and the WIfI tool is limited in wound care centers, primary care offices, and federally qualified health centers. Further barriers to use include lack of training with these tools, limited potential for point-of-care testing reimbursement, and insufficient society support of WIfI guidelines to PCPs. Such barriers discourage widespread adoption in primary care settings, leading to delayed diagnosis of arterial insufficiency and ultimately worse outcomes in patients with CLTI.

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ARTICLE HIGHLIGHTS

- **Type of Research:** Single-center retrospective review of a non-randomized cohort
- **Key Findings:** After completing the education modules, all 180 participating providers had significant improvement in their understanding of ankle-brachial index testing and the Wound, Ischemia, and foot Infection tool based upon pre-test and post-test scores (8.02-13.16 of 15 points, and 3.36-6.95 of 8 points, respectively; $P < .0001$).
- **Take Home Message:** Limited provider understanding of screening tools in chronic limb-threatening ischemia can be improved with targeted educational modules; however, provider employment of tools may still be limited by other barriers to use.

Table I.

Pre- and post-test scores for physicians and non-physicians participating in the ankle-brachial index (*ABI*) and Wound, Ischemia, and foot Infection (*WIfI*) modules

	No.	Pre-test mean (SD)	Post-test mean (SD)	*P*-value (paired Wilcoxon signed rank test)
ABI module (score of 15)				
Physician	59	7.92 (2.69)	13.38 (1.05)	<.0001
Non-physician	25	8.12 (2.85)	13.84 (1.07)	<.0001
All providers	101	8.02 (2.77)	12.16 (1.78)	<.0001
WIfI module (score of 8)				
Physician	50	3.35 (1.80)	7.11 (0.80)	<.0001
Non-physician	20	3.79 (1.17)	7.00 (0.93)	<.0001
All providers	79	3.36 (1.61)	6.95 (0.96)	<.0001

SD, Standard deviation.

Table II.

Baseline ankle-brachial index (ABI) knowledge based on years in practice and type of provider

Scenario	Years in practice	Participants, %	Pre-test mean (SD)
Non-physician	1-3	59	7.80 (3.26)
	4-10	24	7.25 (2.06)
	>10	17	6.67 (3.06)
Physician	1-3	70	8.00 (2.23)
	4-10	8	7.00 (5.00)
	>10	22	9.44 (1.59)
All providers		100 (N = 101)	8.02 (2.77)

SD, Standard deviation.

Table III.

Ankle-brachial index (ABI) pre- and post-test score based on type of provider and type of practice

Provider type	Practice type	Participants, %	Pre-test mean (SD)	Post-test mean (SD)	*P*-value (paired Wilcoxon signed rank test)
Non-physician	Wound care/community clinic	47	7.25 (2.49)	14.25 (1.04)	.02
	Hospital-based practice	24	8.50 (2.65)	13.50 (1.00)	.13
	Academic medical center	29	9.29 (2.63)	13.29 (1.11)	.06
Physician	Wound care/community clinic	29	9.02 (3.08)	13.64 (0.92)	.002
	Hospital-based practice	18	9.29 (2.63)	13.29 (1.11)	.03
	Academic medical center	53	7.60 (1.93)	13.40 (1.05)	<.0001

SD, Standard deviation.

Table IV.

Questions with >60% incorrect answers on the ankle-brachial index (ABI) pre-test

Question	Answer choices (correct response italicized)		Incorrect, %
A 62-year-old man is being seen to evaluate leg pain associated with walking. You obtain the following brachial and tibial vessel pressures (mmHg): right brachial = 128, left brachial = 134, right dorsalis pedal = 120, right posterior tibial = 122, left dorsalis pedal = 110, left posterior tibial = 119. What is the ankle brachial index for the right lower extremity?	**a.**	120/134 = 0.90	79
	b.	120/128 = 0.94	
	c.	122/128 = 0.95	
	d.	122/134 = 0.91	
Which of these is the suggested Doppler angle for obtaining arterial Doppler signals?	**a.**	15 degrees to the skin	64
	b.	45 degrees to the skin	
	c.	70 degrees to the skin	
	d.	90 degrees to the skin	
While performing the ankle brachial index test, a patient's highest arm pressure is 134, but the tibial pressure is raised to over 220 and the Doppler signal can still be heard. Given the high ankle pressure, which is the most appropriate next step?	**a.**	This patient should get a CT angiogram to evaluate the arteries	61
	b.	This patient should be referred for toe pressure measurements and to see a vascular specialist	
	c.	This patient should have exercise ankle brachial index measurements performed to accurately diagnose a blockage	
	d.	This patient should have a full duplex ultrasound of the lower extremity arteries	

CT, Computed tomography.