The Journal for Vascular Ultrasound 41(2):71–73, 2017

Upper Extremity Arterial Testing: The Diagnostic Criteria for the Physiologic Examination

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ABSTRACT **Upper extremity arterial disease is relatively uncommon compared with lower extremity disease, but presents a unique diagnostic challenge for physicians and technologists. It affects approximately 5–10% of the population. The most common causes of upper extremity arterial disease are atherosclerosis and embolic disease. Some common symptoms of upper arterial disease include dysesthesia, paresthesia, pallor, cold intolerance, ulceration, pain, or weakness in one or both extremities. The vascular system plays a vital role in the delivering of nutrients and clearing metabolic waste products from the peripheral tissues and also helps maintain an individual's systemic core temperature. In a majority of patients, the deep and superficial palmar arches provide the dominant blood supply to the hand. The arches are a continuation of the radial and ulnar arteries. These arches are typically connected in approximately 80% of patients. In order to accurately diagnose upper extremity arterial disease, a noninvasive upper extremity physiologic examination is of importance to determine treatment options for patients. The physiologic examination includes upper extremity segmental pressures known as wrist-brachial index, Doppler waveforms; digital evaluations include photoplethysmography and pressures of the digits known as the digital-brachial index. Physiologic tests are indirect examinations. The upper extremity arterial physiologic examination is always completed bilaterally in order to determine if the disease is present in one or both extremities and also assists in the diagnosis of disease severity. The vascular physiologic examination should focus on the symptoms presented by the patient during the history. However, a complete vascular examination is appropriate given the diffuse nature of the atherosclerotic disease process.**

Background

Diagnosing peripheral arterial disease (PAD) can be an intimidating and confusing task since each is unique. There are few disease processes as variable in location, presentation, and severity as those seen in the vasculopath.[1] There are many etiologies to be considered simultaneously.[1] Ironically, it is the variability of PAD that provides an opportunity to extract a comprehensive and tightly integrated history and physical examination that is nearly unparalleled in medicine.[1] Even though the pathophysiology, risk factors, location, and eventual treatment options for a patient often prove routine, the manner in which the patient presents is anything but predictable.[1] Ischemic digital ulceration or gangrene may develop in patients with severe upper extremity ischemia.[2] Although large artery atherosclerosis is the most common cause of lower extremity ischemia, small artery occlusive disease of the palmar and digital arteries of diverse causes is a frequent cause of upper extremity ischemia.[2] Upper extremity ischemia caused by small artery occlusive disease occurs with sufficient infrequency that little has been published describing its evaluation and treatment.[2] The underlying small artery etiology in a patient with ischemic digital ulceration is often considered only after extensive evaluation fails to reveal proximal arterial obstruction or a cardiac or proximal arterial embolic source.[2] Long-term limb salvage and patency rates after arterial repair in upper extremity injuries are favorable, but functional impairment is a significant problem.[3]

Methods

Upper arterial Doppler physiologic examinations were performed more than 170 extremities from January 2014 to January 2017. The records of these patients who had undergone these arterial tests were reviewed and the results were also compared with angiography and/or operative findings when available. An upper extremity arterial Doppler is a noninvasive physiological test comparing the systolic pressure at the level of the brachial artery to the systolic pressure at the wrist and/or forearm. Doppler-derived measurements of blood pressure helped identify the location of a significant obstruction in an upper extremity arterial segment and

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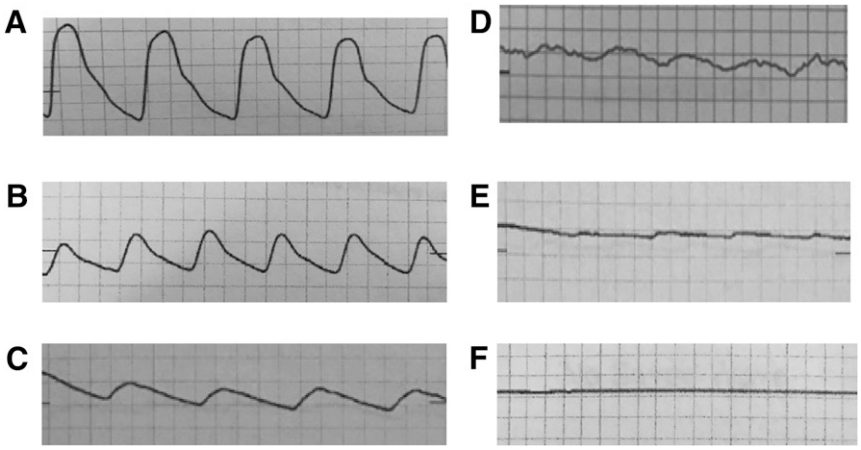

Figure 1

Normal and Abnormal PPG Tracings - Arterial Disease (A) No Disease (B) Mild Disease (C) Moderate Disease (D) Severe disease (E) severe to critical disease (F) Critical disease.

also defined the resulting decrease in terms of pressure. The physiologic examinations performed included the following in the results: upper extremity segmental pressures and Doppler waveforms; digital evaluations included photoplethysmography (PPG) and digital pressures (Figure 1). The upper extremity arterial physiologic

Table 1

Upper Extremity Arterial Physiologic Examination Criteria

Severity	WBI	Upper Extremity Doppler Waveform Characteristics	DBI	Digital PPG Waveform Characteristics
Normal	≥0.90	Triphasic signal; sharp upstroke, followed by flow reversal in early diastole; late diastolic component	≥0.86	Dicrotic notch present in downslope; downslope bows toward baseline; short onset to peak (subjective)
Mild	0.75–0.89	Triphasic or biphasic signal; sharp upstroke, followed by flow reversal in early diastole and late diastolic component may or may not be absent	0.70–0.85	Dicrotic notch not as prominent and/or may not be present in downslope; mildly diminished waveform; prolonged onset to peak (subjective)
Moderate	0.60–0.75	Biphasic signal; sharp upstroke, followed by flow reversal in early diastole and late diastolic component is absent	0.50–0.69	Dicrotic notch is not present in downslope; moderately diminished waveform (reduced pulsatility); prolonged onset to peak (subjective); rounded peak; downslope bows away from the baseline
Severe	0.40–0.59	Biphasic signal; sharp upstroke, followed by flow reversal in early diastole and late diastolic component is absent *OR* monophasic signal; slow upstroke; low amplitude; and broad peak with no evidence of the reversed flow component in late systole (typically present distal to a high-grade stenosis or complete occlusion)	0.30–0.49	Dicrotic notch is not present in downslope; dampened waveform (reduced pulsatility); prolonged onset to peak (subjective); rounded peak; downslope bows away from the baseline
Critical	≤0.39	Monophasic signal; slow upstroke; low amplitude; and broad peak with no evidence of the reversed flow component in late systole (typically present distal to a high-grade stenosis or complete occlusion) *OR* absent/no signal	≤0.29	Dicrotic notch is not present in downslope; dampened waveform; prolonged onset to peak (subjective); rounded peak; downslope bows away from the baseline; "absent" or nonpulsatile waveform is reported when the PPG tracing reflects a flat line

DBI, digital-brachial index; PPG, photoplethysmography; WBI, wrist-brachial index.

examination is always completed bilaterally in order to determine if the disease is present in one or both extremities and also assists in the diagnosis of disease severity. Combining the upper extremities and digital arterial examinations will differentiate between large and small vessel disease. The wrist-brachial index will only provide a result on the presence and severity of obstructive disease. The limitations of the upper arterial Doppler examinations were calcified vessels and functionally significant lesions with good collateral circulation. The equipment used for these upper extremity arterial examinations was the FLO-LAB 2100-SX (Parks Medical Electronics, Inc.). Examinations were compared with computed tomography angiogram as well as operative findings in order to confirm disease presence. With these data that were obtained from these examinations, we were able to determine the degree of arterial disease present and also create an accurate arterial physiologic diagnostic criterion for the upper extremities.

Results

A total of 175 extremities were examined for upper extremity arterial disease. All of these patients examined were noted to be symptomatic. Indications for the examinations included at least one of the following: claudication, limb pain at rest, absent peripheral pulses, extremity ulcer, gangrene, bruit, digital cyanosis, or trauma. The patients' risk factors were also assessed prior to the upper extremity arterial Doppler examinations. After reviewing these cases, it was noted that more than half of these patients who presented for upper arterial examinations were noted to have at least one of the following risk factors; hypertension, hyperlipidemia, and/or diabetes mellitus. After reviewing each upper extremity arterial examination, and then comparing those findings to operative and/or angiograms, we were able to determine and create a criterion for the severity of upper extremity arterial disease. The following results were observed in patients that presented with symptoms of upper arterial disease: 45% of the extremities had no evidence of disease, 23% were positive for mild disease, 14% were positive for moderate disease, 6% were positive for severe disease, and 12% were positive for critical disease. The upper extremity arterial criterion provided in Table 1 is what was used for severity diagnosis on these patients.

Conclusions

Bilateral upper extremity arterial physiologic examinations to rule out disease were performed on symptomatic patients who presented at least one of the following risk factors: hypertension, hyperlipidemia, and/or diabetes. The physiologic examinations performed included the following in the results: upper extremity segmental pressures and Doppler waveforms; digital evaluations included PPG and digital pressures. With the results of the examinations performed, we were able to create and use a criterion that accurately diagnoses upper extremity arterial disease based on physiologic (indirect) testing.

References

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