Assessment of Arterial Compression in Patients with Suspected Thoracic Outlet Syndrome: Comparison of Pressure Indices and Photoplethysmography

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ABSTRACT **We compared the results of photoplethysmographic (PPG) assessment to Doppler indices in the assessment of arterial compression during thoracic outlet maneuvers. Thirty-four limbs in 17 patients were studied in each of four maneuvers for a total of 136 assessments. There were 31 studies positive for arterial compression by Doppler (Doppler index < 0.8). PPG detected 17 of these giving a sensitivity of 55%, a specificity of 94% and an overall accuracy of 85%. Detection of arterial compression did not correlate with reproduction of symptoms. We recommend PPG as an efficient method of detecting arterial compression in selected patients with thoracic outlet syndrome.**

Introduction

Thoracic outlet syndrome is usually characterized by pain and parasthesia in the upper extremity and in some cases manifestations of arterial compression such as claudication, microemboli or Raynaud's phenomenon are present.[1] The diagnosis of this syndrome is elusive and many diagnostic tests have been advocated for these patients.[2,3,4] The diagnosis of arterial compression at the level of the thoracic outlet has traditionally been made with assessment of the distal circulation during various "thoracic outlet maneuvers."[5,6]

We have recently used the simple technique of photoplethysmography to detect arterial compression during these maneuvers. The purpose of this study is to compare the results of photoplethysmography to standard measurement of Doppler indices in the detection of arterial compression during thoracic outlet maneuvers.

Materials and Methods

All patients referred to the Vascular Laboratory of the Vancouver General Hospital for assessment of possible thoracic outlet syndrome between January 1, 1988 and June 30, 1988 were included in the study. Patients were referred with a variety of symptoms including: arm pain, parasthesia, and Raynaud's phenomenon. There were no patients with arm claudication or symptoms of arterial microemboli.

All patients had upper limb arterial assessment at rest and in the following positions:

1) Adsons maneuver: neck extended and head turned toward arm being studied with patient taking a deep breath;
2) costoclavicular maneuver (military maneuver): both shoulders positioned posteriorly and downwards;
3) hyperabduction maneuver at 90°: arm abducted to 90° with palm upwards;
4) hyperabduction maneuver 180°: arm abducted to 180° with external rotation.

Arterial assessment was carried out in each position using:

1) Doppler pressure index (DPI)—Brachial systolic blood pressure was recorded using continuous wave Doppler and a pressure index calculated by comparing the pressure with the arm in the stressed position to the pressure with the arm at rest. A pressure index of less than 0.8 was considered positive for arterial compression;
2) photoplethysmography (PPG)—photoplethysmographic tracings were obtained from the index finger at rest and in the stressed position and compared for evidence of dampening or obliteration of the arterial signal. Obliteration of the arterial signal in the stressed position was considered positive for arterial compression. (Figure 1)

Results of photoplethysmographic assessment were compared to Doppler pressure indices using a 2x2 table. The Doppler pressure index was used as the standard for comparison purposes.

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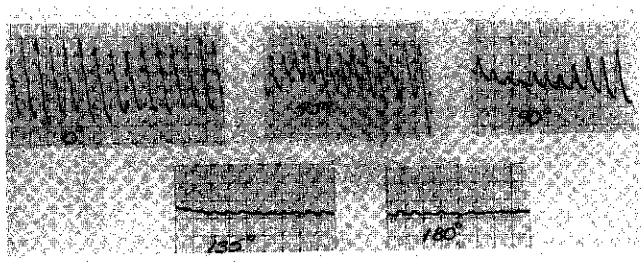

Figure 1.

Photoplethysmographic waveform recorded during the hyperabduction maneuver showing complete obliteration of the waveform with hyperabduction beyond 90° (positive test for arterial compression).

Results

During the period of study 34 limbs in 17 patients were assessed for possible thoracic outlet syndrome. Each limb was assessed using four maneuvers for a total of 136 assessments. Two studies were not interpretable.

There were 31 studies considered positive for arterial compression with stress using DPI (mean DPI .43 ± 0.33). Photoplethysmography detected 17 of these. The mean DPI for studies considered negative for arterial compression was 0.93 ± 0.07 (n = 103). Positive results during one maneuver did not correlate with the results of the other maneuvers in the same limb. As well there was poor correlation between positive results and reproduction of the patients' symptoms.

There were 23 studies which showed obliteration of the PPG waveform with stress. The mean DPI of these studies was 0.56 ± 0.37. Because the PPG waveform can show some variability, it is important to show complete or almost complete obliteration of the waveform in positive tests. The mean DPI of those studies with normal PPG waveforms was 0.87 ± 0.08 (n = 111). Using the standard of a DPI of less than 0.8 as indicative of arterial compression PPG had a sensitivity of 55%, a specificity of 94% and an overall accuracy of 85% in the detection of significant arterial compression (Kappa = 0.54). PPG had a positive predictive value of 74% and a negative predictive value of 87% (Table 1).

		Doppler Pressure Index ≥ 0.8	< 0.8	
Photoplethysmographic Waveform	present	97	14	111
	absent	6	17	23
		105	31	134

Table I

Comparison of photoplethysmography to Doppler index during thoracic outlet maneuvers.

Discussion

The majority of patients with thoracic outlet syndrome have neurologic rather than vascular impairment. There are however a number of patients who develop arterial symptoms related to compression of the subclavian artery as it passes over the first rib and behind the scalenus anticus muscle. This may present as claudication, peripheral microembolization or Raynaud's phenomenon.

Arterial compression can be documented during appropriate thoracic outlet maneuvers by non-invasive testing.[5,6] The simplest method is palpation of the pulse in the resting and stressed positions. This is a subjective assessment and not always reproducible. Assessment of the Doppler flow signal combined with Doppler pressure indices is a more objective and reproducible method. It is widely used in the assessment of arterial occlusive disease in the lower extremity.[7] Doppler indices have been the standard method of arterial assessment in patients with suspected thoracic outlet syndrome in our Vascular Laboratory.

In this study we have shown that obliteration of the photoplethysmographic arterial waveform in the stressed position during thoracic outlet maneuvers correlates (85% accuracy) with proximal arterial obstruction as measured by Doppler pressure indices. Both techniques use simple, readily available non-invasive vascular diagnostic equipment. Photoplethysmography does however offer advantages in the assessment of this condition. It is easier to perform, requiring only the placement of a fingertip probe while the patient goes through the thoracic outlet maneuvers. The technique using Doppler indices takes significantly more time. Also, because the photoplethysmographic technique is less cumbersome it allows more effective positioning of the patients' upper extremities and neck during the various maneuvers.

We noted a lack of correlation between the detection of arterial compression and reproduction of the patients symptoms in this study. This has been noted by others in the study of thoracic outlet syndrome and there are many patients who have never demonstrated arterial compression during thoracic outlet maneuvers but are cured of their symptoms by surgical decompression of their thoracic outlet.[8] Also, the phenomenon of arterial compression during thoracic outlet maneuvers, especially Adson's maneuver, is common in many normal individuals.[9,10] In spite of these concerns we nonetheless feel that it is important to detect arterial compression if it exists in selected patients with symptoms of thoracic outlet syndrome particularly those who have arterial symptoms.

Based on this study we feel photoplethysmography is a reliable method of detecting arterial compression in patients with suspected thoracic outlet syndrome and have adopted it for routine use in our Vascular Laboratory.

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