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NON-INVASIVE MEASUREMENT OF THE ARTERIAL STIFFNESS - IS THE ARTERIOGRAPH A RELIABLE METHOD?

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Abstract: *Arterial stiffness, measured as the aortic pulse wave velocity (PWV), is a predictor of cardiovascular events and all-cause mortality. The non-invasive methods for estimating PWV use oscillometry, ultrasound, applanation tonometry, piezoelectric mechanotransducers. The arteriograph is an oscillometric device that estimates PWV from the pressure waveform recorded in the brachial artery. We conducted a search of the PubMed database for studies that compared the arteriograph measurement of PWV with other non-invasive methods for estimating arterial stiffness in the adult population and found 11 relevant articles that included 1999 patients. Most of the articles reported good correlation for measuring PWV with various devices. No correlation between oscillometric and piezolectric methods was found in 2 studies of elderly and hemodialysis patients. There was a strong correlation between intima media thickness measured with carotid ultrasound and arteriograph measured PWV. The arteriograph is a reliable, less operator dependent method for estimating PWV.*

INTRODUCTION

Atherosclerotic cardiovascular disease is the leading cause of death worldwide.(1) Arterial stiffness has emerged as a measure of arterial health and its use has been encouraged for estimating cardiovascular risk, in addition to the traditional cardiovascular risk factors. The 2007 European Society of Hypertension/European Society of Cardiology guidelines mention increased arterial stiffness as a subclinical end-organ damage factor (alongside left ventricular hypertrophy, metabolic syndrome and carotid wall thickening), which places the subject in a high/very high-risk category.(2)

The gold standard for estimating arterial stiffness is the aortic pulse wave velocity (PWV).(3) A meta-analysis that included over 15000 patients has demonstrated that a high pulse wave velocity is associated with an increased risk of cardiovascular end all-cause mortality.(4) The PWV represents the speed at which the pressure wave, generated by the contraction of the heart, moves down the wall of the aorta, and it is mainly influenced by the elasticity of the aortic wall. The value of the aortic PWV is 5-15 m/s and it varies with age and blood pressure.(5) The proposed reference values range between 6-10.6 m/s for different age categories.(6) A higher PWV corresponds to a lower compliance of the artery, and to increased arterial stiffness.

The PWV can be measured non-invasively by tonometric, oscillometric, piezoelectric, ultrasound and magnetic resonance techniques.(7) The Arteriograph uses an oscillometric method for measuring arterial stiffness. The PWV is estimated indirectly from a single pressure waveform recorded in the brachial artery using a standard blood pressure cuff. The method is easy to use, reproducible but newer than other techniques.

The purpose of this review is to determine whether the arteriograph yields reliable results for the measurement of arterial stiffness in adults, as compared with other non-invasive methods.

MATERIALS AND METHODS

An advanced search of the PubMed database was conducted, using Boolean querying, of the following terms: (pulse wave velocity) AND ((arteriograph) AND (arterial stiffness measurement)). The search produced 84 results out of which 11 met the inclusion criteria. Those studies that compared the arteriograph measurement of PWV with other non-invasive methods for estimating arterial stiffness, in the adult population, were elected for analysis. We also included the studies that compared arterial stiffness measured with the arteriograph, with the intima-media thickness measured with carotid ultrasound.

The compared methods use applanation tonometry (SphygmoCor, PulsePen), oscillometry (Arteriograph, Mobil-O-Graph), piezoelectric mechanotransducers (Complior), ultrasound (Echo-tracking) for measuring PWV. Most of the studies used the Bland Altman plot and the coefficient of variation to analyse limits of agreement.

RESULTS

Of the 11 studies selected, 9 reported good or acceptable correlation with good limits of agreement between results for PWV measurement (as assessed using the Bland Altman plot). These included 1557 adult subjects, healthy or with known cardiovascular risk factors.

The coefficient of variation was wide. This indicates the fact that the methods are not interchangeable and that the reference values may need to be adapted to each of the devices used.

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Table no. 1. Arteriograph compared to other devices for measuring arterial stiffness

Cohort description	Devices used for measuring PWV	Correlation between methods	Coefficient of variation	Carotid Ultrasound (IMT)	*p* value
316 (age 55±14), with cardiovascular risk factors	Complior, Mobil-O-Graph	Acceptable correlation	Wide	Good correlation	<0,01
100 (age 51 ± 16), consecutive patients	Complior, Echo-tracking	Poor correlation	Wide		<0,05
63 (age 48±15), healthy subjects	SphygmoCor	Good correlation	Wide for values above median, in females		<0,01
64, with hypertension	Complior, SphygmoCor	Good correlation	Wide		<0,001
254 (age 48±14), with hypertension	Complior, SphygmoCor	Good correlation	Wide		<0,001
223 (age 58.5±7.8), with at least 2 risk factors for atherosclerosis				Good correlation	
98, on hemodialysis	PulsePen	No correlation			0,097
236 (age 47 ± 8 years), healthy subjects				Good correlation	
250 (age 62 ± 10 years), 125 with coronary artery disease, 125 healthy subjects	Echo-tracking	Strong correlation			<0,001
344 (mean age 73 years), elderly subjects	SphygmoCor	No correlation			0,92
51 adults	Complior, SphygmoCor	Good correlation			<0,001

Two studies comprising 442 patients (98 on hemodialysis, 344 elderly patients, mean age 73 years) reported no correlation between the results obtained for PWV measured with the Arteriograph, PulsePen and SphygmoCor.

All the studies that compared IMT and PWV demonstrated good correlation between these markers of arterial stiffness. These totalled 775 subjects (healthy or with known risk factors for atherosclerosis).

DISCUSSIONS

The most accurate non-invasive measurement of the PWV can be acquired by magnetic resonance imaging, however this is an expensive method, and not widely available. The gold standard for estimating PWV uses two pressure catheters (mechanotransducers) placed at the carotid and femoral arteries. The measured distance (travelled distance) divided by the time it takes the pressure wave to travel from the carotid to the femoral artery (transit time) provides the PWV. Techniques like Complior, SphygomCor and PulsePen, require the measuring of the travelled distance on the surface of the body.(8) This is dependent on the body habitus and it is a source of error.(9) The SphygomCor relies on applanation tonometry for acquiring the radial, carotid, and femoral blood pressure waveforms. This is time consuming and requires some operator skill. With the piezoelectric method (Complior), the quality of the measurement depends on placing the mechanotransducers precisely on the carotid and femoral arteries, which is challenging in obese patients. All these methods are strongly operator dependent.

The arteriograph uses a single pressure cuff applied on the upper arm to measure the pressure oscillations in the brachial artery. The information is transmitted via a wireless device to the computer software that analyses the time difference between the pressure waves and relates it to the length of the aorta (estimated by measuring the jugulum to symphysis distance).(10) It is an indirect regional method for estimating PWV, less operator dependent, requires less sophisticated technology and the training is simple. It can be applied to large populations, for screening, and it is useful in detecting subclinical atherosclerosis, which can lead to interventions for preventing cardiovascular morbidity and mortality.(11) It has a strong correlation with IMT, an established marker of atherosclerosis.(12) The limits of the method include the fact that it uses a single cuff, at the level of the brachial artery, and the stiffness of the arterial tree is not uniform, therefore the estimation of the aortic pulse wave velocity may not be accurate.

There is poor agreement between methods in patients with increased arterial stiffness (elderly or on haemodialysis), which suggests that the same method should be used to repeatedly assess PWV.

The limits of most of the non-invasive methods are the errors in appreciating the travelled distance, the difficulty in accessing the signal in obese patients, and the fact that the assessment is regional, but the arterial wall does not stiffen homogeneously.

CONCLUSIONS

Arterial stiffness estimated by PWV correlates with atherosclerotic cardiovascular disease and it should be considered as a more subtle measure of end-organ damage, especially in patients in which other signs of organ damage are not discovered. The estimation of arterial stiffness through non-invasive methods is valuable for screening of the population- in order to diagnose and establish risk of cardiovascular events- but also for assessing the therapeutic effect of different interventions. The detection of the subclinical presence of atherosclerosis can lead to the implementation of preventative measures and lifestyle changes for avoiding overt cardiovascular disease.

There is good agreement between the different non-invasive methods for measuring PWV. In patients with more pronounced arterial stiffness (PWV>12 m/s) there was insufficient agreement.

The arteriograph is a reliable, easy to use device for appreciating arterial stiffness, it correlates well with other non-invasive methods, the measurements have good reproducibility and low variability, however the values for PWV are not interchangeable between devices.

There is a need for more extensive studies in order to standardize the use of arterial stiffness measurement, adapted to different populations and settings. Comparison between non-invasive and invasive measurements would provide a more accurate assessment of the devices.

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