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Comparison of Regional Vs Local Arterial Parameters Using New Us Technology

Pedro Jose Forcada[1,2*], Kendy Che Cheung NG[3]

[1]Cardioarenales, Arenales 3028 PB "A" Buenos Aires Argentina

[2]DIM Prevención Cardiovascular Institute, Belgrano 139 Ramos Mejía, Provincia de Buenos Aires (1704), Argentina

[3]Hong Kong, China

ABSTRACT

Environment: It has been described that muscular arteries behaviour is different from aorta, and regional parameters like Intima Media Thickness (IMT) IMT, atherosclerotic plaques burden, c-f PWV and endothelial function are related with age and risk factors and are powerful prognostic markers but it is not the case of local parameters like wall shear stress (WSS), local Pulse Wave Velocity PWV or beta index in muscular arteries like common carotid artery, only just recently available in the clinical practice.

Objective: To analyze the relationship of regional and local arterial parameters with age and its potential use in the clinical practice.

Methods: We evaluated 100 consecutive patients from april 2019 to february 2020 with a Resona 7 (Mindray. Shenzhen. China) US device with tools to measure IMT, atherosclerotic load, PWV and endothelial function and by means of VFlow Doppler, an innovative multivectorial Doppler technology, we evaluated WSS and with radiofrequency edge detectors, stiffness parameters like PWV and beta index.

Results: IMT remodelling, plaques burden, PWV correlated tightly with age and endothelial function did but inverserly (regression p >0.05). Local carotid parameters like wall shear stress, PWV and beta index were grouped whithin a range, independently of age. (regression p NS).

Conclusion: The evaluation of local parameters has been proposed as markers of arterial disease and they are independent of age which makes easier to detect abnormal values out o frange, early markers of vascular disease, even before atherosclerosis is present. WSS is used for the first time in the current clinical practice.

***Corresponding author**

Pedro J Forcada, Cardioarenales, Arenales 3028 PB "A" Buenos Aires Argentina. Tel: +54 11 (15)44907315; E-mail: pforcada@gmail.com or pforcada@clinicadim.com.ar

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Abreviations
IMT: Intima Media Thickness
PWV: Pulse Wave Velocity
c-f PWV: Carotid Femoral Pulse Wave Velocity
WSS: Wall Shear Stress

Introduction

Atherosclerosis is the underlying cause of a cardiovascular disease epidemic worldwide. The understanding of normal artery structure and function and the initial disarrangements conducting to atherosclerosis is of key relevance to develop preventive interventions based on a rational study of arterial structural and functional parameters, their pathologic behaviour and response to therapeutic interventions [1].

New US approaches enable a precise understanding of the forces and stimuli acting on the arterial wall and measure its responses precisely in different clinical stages of the arterial atherosclerotic disease and a better understanding of the efficacy or not of different therapeutic interventions [2]. (Figure 1)

The ability to analyse WSS hemodynamically and to measure it accurately is an essential basis for the assessment of the atherosclerotic risk in the general population [3].

A new angle-independent technique, measuring and visualizing blood flow velocities in all directions, called Vector Flow Imaging (VFI), has been proposed [4]. Systems are equipped with VFI based on a multi-angle transmission plane waves method, which allows a very high frame rate and a detailed visualization of complex flow [5]. (Figure 2)

We evaluated, in a real-life study the feasibility of some clinical applications of this new technology for the evaluation of carotid flow patterns in comparison to the conventional US techniques and Vascular Mechanics determinations.

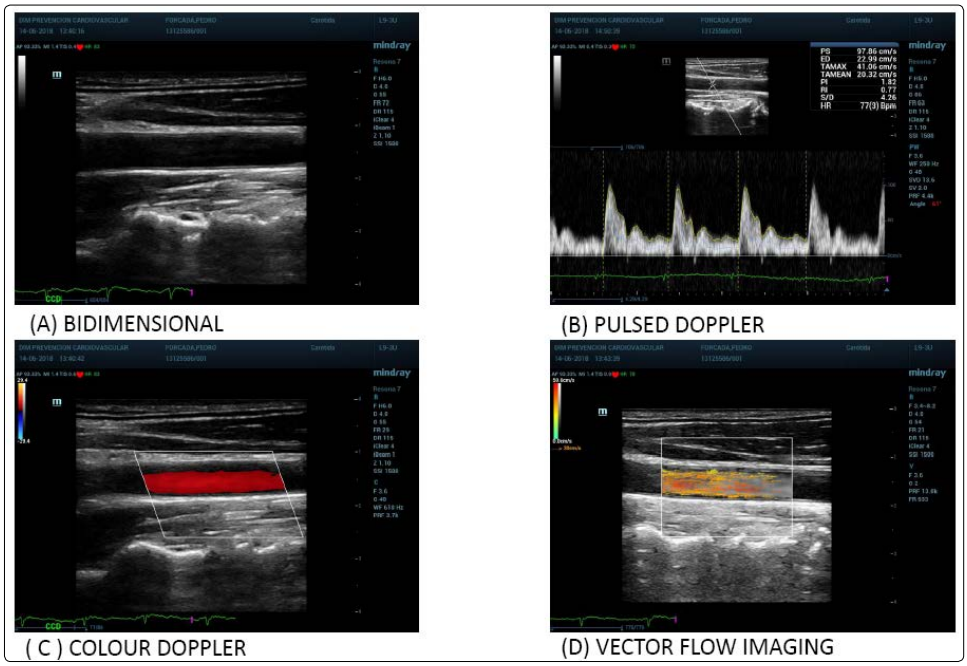

Figure 1: Different ultrasound approaches to study arteries structure and function

Figure 2: Vector Flow Imaging: vector's colour codes and different parameters available

Methods

Study Patients

This study enrolled 110 consecutive patients derived to perform a non-invasive vascular evaluation to refine the assessment of their cardiovascular risk. The mean age was 55.9 + 13 yo., fifty-seven were men (52%) and there were no significative differences of age between sexes (men 55 ± 12.5 and women 57 ± 12). factors, 35 did not receive CV medication and 51 (46%) were hypertensives, 46 (90,2%) under treatment with different degrees of blood pressure control (22 controlled, 28 not controlled and 5 without treatment at the moment of the evaluation). The distribution of the remaining risk factors is described in table 1.

Protocol

This is a single measurement, observational and descriptive study. We received the patients in the early morning, fasting and resting at least 15 minutes prior access to the vascular laboratory and the study was performed supine in a calm room climatized at 23o C. We explained the protocol, approved by the

local ethics committee and the patient then signed the informed consent. We measured height, weight and waist diameter then the blood pressure in the right arm standing and sitting according to Argentinean 2018 Guidelines for Hypertension Diagnosis and Treatment [6]. The echographic study was performed in supine position following, in the analysis of vessels of the neck and femoral groins, a clock wise order. We measured IMT using automatic edge detectors at end diastole using ECG. If any plaque were detected we obtained images in the two main axes and then we measured the surface of the plaque and sum up the total surface as plaque atherosclerotic burden [7]

Then, we measured the carotid femoral distance to calculate the Pulse Wave Velocity (PWV) using the transit time calculated substracting the time from ECG to the foot of the doppler signal in the femoral artery, the time from ECG to the foot of the carotid artery doppler wave. The PWV was calculated dividing the carotid femoral distance in meters over the transit time in seconds [8].

Finally, we performed the endothelial function test in the left arm according to the technique described in 1992 by Celermajer et al and clearly described in 2002 American Guidelines for Evaluation of Endothelial Function [9]. We added to the original vascular study of our laboratory determinations of IMT using radiofrequency, multidirectional doppler flow measurements and radiofrequency analysis of the distensibility of carotid arteries and left brachial artery during the endothelial test. As the analysis of results of these techniques was a post process procedure it didn´t increase significantly the duration of the study.

Equipment

We used the Resona 7 color Doppler ultrasound device (MINDRAY, Shenzhen, China) with a high-sensitive 4-13 MHz multi-frequency linear array probe transducer. The patient was in the supine position with his or her head 20° deviated to the opposite side. The device has built-in digital system processing software. A series of carotid artery parameters such as Vector Flow Imaging (VFI), Wall Shear Stress (WSS), RF quality intima-media thickness (RFQIMT), RF quality arterial stiffness (RFQAS), to determine local PWV and the hardness coefficient which were measured automatically.

Local arterial parameters

We measured in the left common carotid artery three different parameters and compared the values of the whole population according to age and the presence or not of hypertension: remodelling (IMT / carotid diameter ratio), wall shear stress in the mid common carotid trunk and the regional pulse wave velocity and hardness coefficient.

Regional parameters

We analysed two well-known parameters measured in peripheral arteries widely renown and supported by solid scientific evidence; Carotid femoral Pulse Wave Velocity and Postischemic dilatation of the brachial artery as index of endothelial function. Carotid femoral PWV was measured as described in guidelines and Endothelial function according guidelines and the results corrected according to age and brachial artery diameter [10].

Results

Population

The general population characteristics are described in table 1. We considered to split the sample according to the presence of hypertension as 90 % of these patients received cardiovascular drugs with hemodynamic effect and impact on the vascular parameters to be measured. Hypertensive patients were younger, presented higher values of blood pressure and cardiovascular drugs use. No significant differences in the proportion of dislypemia, diabetes, overweight or sedentarism was found. (Level of significance $p < .05$)

Table 1: Baseline characteristics of the study population (n=110)

PARAMETER	MEAN	SD (+/-)
AGE (years)	55,95	12.96
MALES (n,%)	57 (52%)	NA
WEIGHT (kg)	79,14	15,83
HEIGHT (cm)	168,93	8,98
BMI (kg/m^2)	27,74	4,85
BODY SURFACE (m^2)	1,89	0,22
SBP (mmHg)	131,42	15,94
DBP (mmHg)	77,27	9,47
HEART RATE (bpm)	67,05	11,33
HTN	51 (46%)	NA
DLP	69 (63%)	NA
DBT	13 (12%)	NA
SMKNG	10 (9%)	NA
OVERWEIGHT	51 (46%)	NA
SEDENTARISM	35 (32%)	NA
FAMILY HISTORY	38 (35%)	NA
CV EVENT	10 (9%)	NA
CV DRUGS	46 (42%)	NA

Regional parameters like IMT remodelling, plaques burden, PWV correlated tightly with age and endothelial function did, but inversely. (Figure 3)(Regression $p > 0.05$).

Local carotid parameters like wall shear stress (WSS), PWV and beta index did not correlate with age and the regional parameters but trended to be grouped whithin a range, independent of age and within the ranges of each local parameter. (regression p NS). (Figures 4,5).

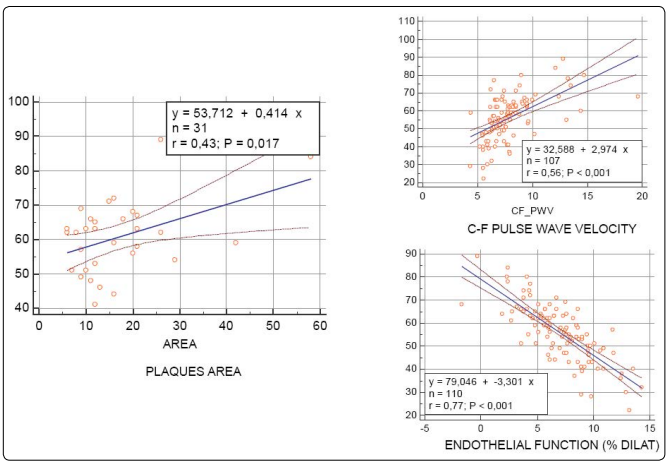

Figure 3: Regional parameters according to age: remodelling, plaques, cf-PWV and endothelial function

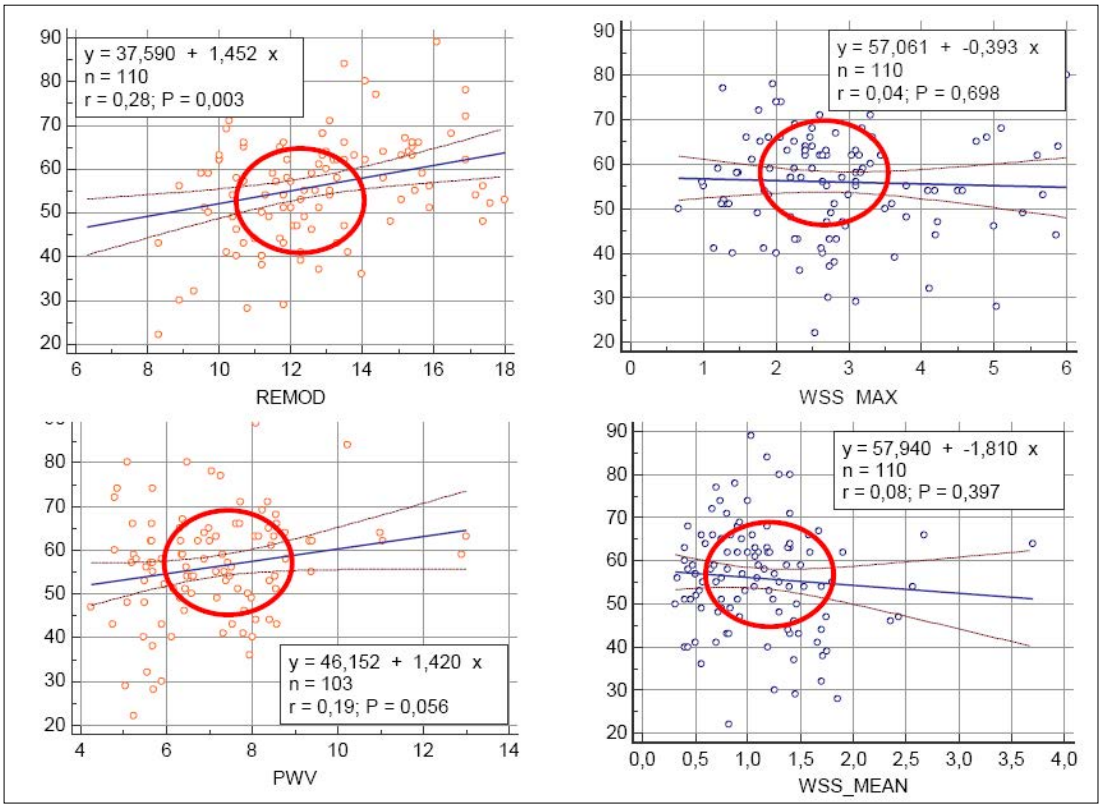

Figure 4: Local parameters according to age: remodelling, carotid PWV and wall shear stress (WSS)

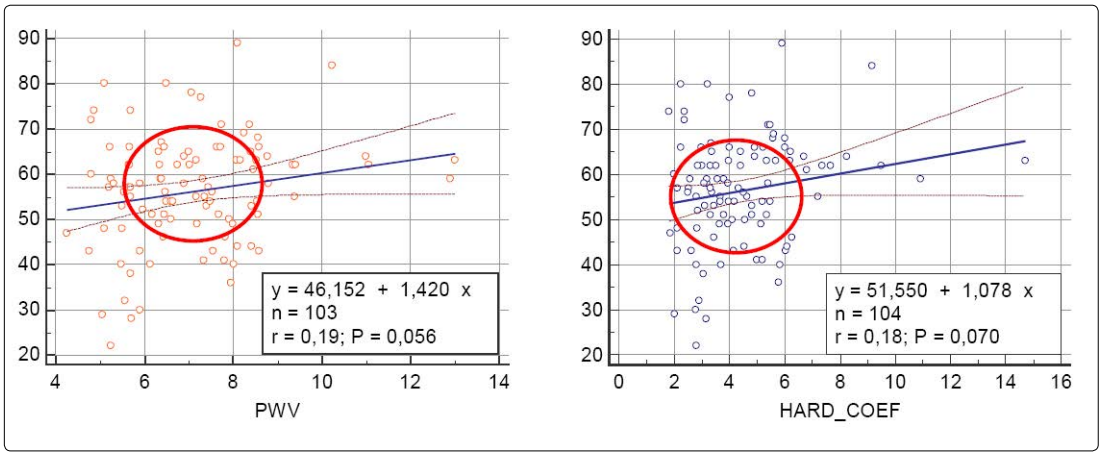

Figure 5: Local stiffness parameters according to age. (PWV and Hardness coefficient) Discussion

In a group of middle-aged patients, distributed a half hypertensive and a half normotensive, we evaluated new US doppler technology like VFI and radiofrequency to evaluate local arterial parameters like carotid IMT, remodelling, Wall Shear Stress, local Pulse Wave Velocity and arterial compliance.

In order to evaluate if these parameters reflect the effect of systemic conditions like hypertension, we measured also regional parameters like c-f Pulse Wave Velocity and Endothelial function by flow mediated vasodilation in the forearm. As described in classic literature there was no relation between regional and local parameters, but this time they were measured no invasively and by means of a single, reproducible method using US.

Regional parameters like plaques burden, PWV and Endothelial Function have been demostrated clearly as CV risk biomarkers. WSS is used for the first time in the current clinical practice.

The evaluation of local parameters has been proposed as markers of arterial disease and they are relatively independent of age which makes it easier to detect abnormal values out of range, as early markers of vascular disease, even before atherosclerosis is present.

The main difference of regional parameters and local parameters, although they are obtained by different methods is that the first ones depend on age, making necessary to settle boundaries according to age which is not the case of the local parameters. The other advantage is that the local parameters can be assessed in the same vessel, at the same time and during the examination using only a functions of the US machine.

The limitations of this study are the non-controlled and a "real life" design in a group of consecutive patients, derived for evaluation of Cardiovascular risk.

Other limitation is the sample size, in particular to determine boundaries for consideingr the parameters found as normal or not specially in the case that the differences found could be representative of what happens in greater samples.

Future Perspectives

The availability of this type of technology will allow a closer evaluation of the initial steps in the development of atherosclerosis and future studies should be designed with adequate samples to address questions about the initial abnormalities conducting to arteriosclerosis, (ie. Arterial stiffening) or Atherosclerosis (ie. Atherosclerotic plaques) in order to direct preventive and therapeutic decisions.

Conflicts of Interest: This investigation was conducted with an unrestricted grant of Mindray.

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