

A new tool for the evaluation of stiffness vascular parameters in Clinical Practice: eTRACKING



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Introduction

In recent years, great attention has been paid to the role of arterial stiffness in the development of cardiovascular diseases. Indeed, the assessment of arterial stiffness is increasingly used in the clinical assessment of patients. Changes in the stiffness of the large arteries, such as the aorta and its major branches, largely account for the changes in SBP (Systolic Blood Pressure), DBP (Diastolic Blood Pressure) and PP (Pulse Pressure) that occur from 50 years of age onward. A large number of publications have reported the various pathophysiological conditions associated with increased arterial stiffness parameters. Apart from the dominant effect of aging⁽¹⁾, they include physiological conditions [i.e. menopausal status⁽²⁾, lack of physical activity⁽³⁾]; genetic background such as a parental history of hypertension⁽⁴⁾, diabetes or myocardial infarction⁽⁵⁾; traditional CV risk factors⁽⁶⁻¹²⁾; CV diseases such as coronary heart disease⁽¹³⁾, congestive heart failure⁽¹⁴⁾, fatal stroke⁽¹⁵⁾; primarily non-CV diseases⁽¹⁶⁻²⁰⁾ (i.e. moderate chronic kidney disease, systemic vasculitis, systemic lupus erythematosus, etc.). The contribution of these different factors to arterial stiffness parameters have been evaluated in different studies. The major parameters to be taken into account are: age and blood pressure and, to a lesser extent, gender and the other CV risk factors.

Until today it has not been possible to evaluate stiffness parameters by means of vascular machines, which required specific competence and organization. eTRACKING, developed by Aloka, overcomes these limitations because the soft-ware is implemented into the normal echo-equipment

and the parameters are obtained by a normal vascular transducer with a frequency of 10 Mhz. The technique is not time-consuming and the parameters can be obtained in a routine examination of the neck vessels.

In our clinical experience we have utilized eTRACKING to evaluate two different aspects:

- 1) The modifications of stiffness parameters related to age: the "Normal vascular aging"⁽²¹⁾
- 2) The physiopathological correlation between stiffness parameters and coronary blood flow.⁽²²⁾

• Normal vascular aging evaluated by eTRACKING.

The aim of our study was to assess how useful eTRACKING is in evaluating the stiffness vascular index at different ages and how it can be used as a common function in general-purpose ultrasonic diagnostic units. In this system a radio frequency signal is used to provide a high accuracy of 0.01 mm resolution at 10 MHz transmission/reception. Changes in the artery diameters are evaluated by measuring the distance between two tracking gates (fig.1). Measurements have been carried out at the level of the common carotid artery before the bifurcation. The following parameters have been calculated : Beta (stiffness parameter); Ep (pressure-strain elasticity modulus); AC (arterial compliance); AI (augmentation index); PWV (pulse wave velocity). The value of blood pressure (systolic and diastolic), measured in the left arm, have been included in the system for the evaluation of these parameters.

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Methods:

We studied 60 healthy patients (mean age 34.5 ± 12.9 , 29 men). Data were analyzed using SPSS 12, Chicago Ill (USA) software. In order to demonstrate the relationship between age and arterial stiffness, data were grouped according to decades of age. To evaluate the association of stiffness parameters according to age groups, we used a non parametric Kruskal-Wallis test. All calculations were significant at $p < 0.05$.

Results:

The results are reported in Table I. All parameters show an age-related increase, with the exception of AC which is reduced (Fig. 1a: young patient, Fig. 1b: old patient).

Table. I

Age groups (Years)		Beta	Ep	AC	AI	PWV
<30	Mean	5 ± 1.8	59.1 ± 20.5	1.3 ± 0.5	0.8 ± 8.9	4.5 ± 0.7
31-40	Mean	6.6 ± 2.5	78.8 ± 24.2	0.9 ± 0.2	3.5 ± 9.1	5.2 ± 0.7
41-50	Mean	7.3 ± 3.3	97.8 ± 48.4	0.9 ± 0.3	16.4 ± 15.1	5.9 ± 1.3
51-60	Mean	9.2 ± 2	115 ± 27.6	0.8 ± 0.09	24.2 ± 14.7	6.4 ± 0.6
>60	Mean	9.4 ± 1.7	129 ± 33.2	0.6 ± 0.09	26.6 ± 5.9	6.8 ± 0.9
	p	0.002	<0.001	0.004	<0.001	<0.001

Conclusions:

These results suggest that relevant age-related changes occur in the vascular system. Our data are similar to previous results obtained by other invasive or non-invasive tools. eTRACKING is a potentially useful, non-time-consuming tool for the clinical diagnostic routine evaluation of arterial stiffness parameters. Further research is necessary to validate the role of this technique in larger populations.

Fig. 1a: On the left, the gate tracking in 2D is shown with the optimal visualization of tracking in M-mode; below, three carotid waves are shown; On the right (top), the selected carotid waves are shown; below the carotid wave, resulting from the analysis of at least 5 selected waves is shown with a normal value of stiffness parameters.

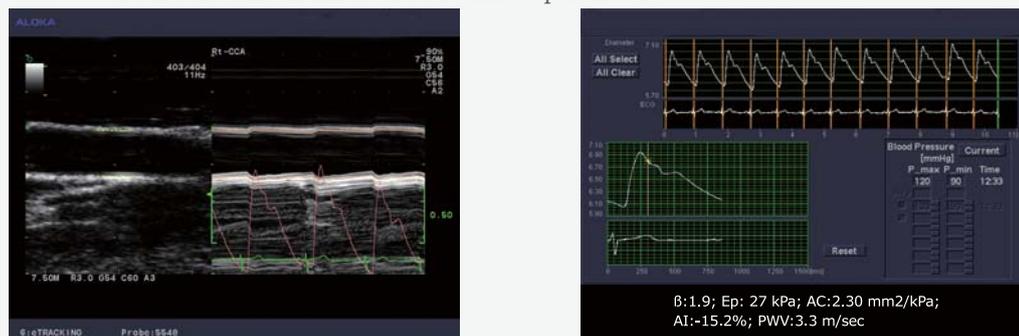
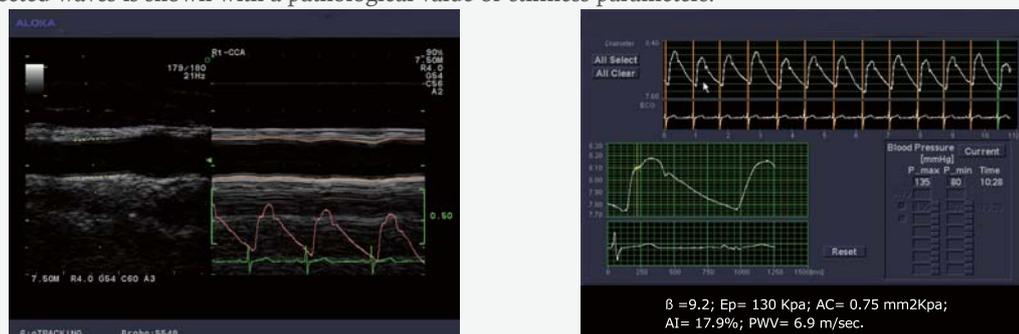


Fig. 1b: On the left, the gate tracking in 2D is shown with the optimal visualization of tracking in M-mode; below, four carotid waves are shown; On the right (top), the selected carotid waves are shown; below, the carotid wave, resulting from the analysis of at least 5 selected waves is shown with a pathological value of stiffness parameters.



Relationship between coronary flow velocity and vascular stiffness.

It has been hypothesized that an increase in stiffness of great vessels is associated with reduced coronary blood flow. Animal studies are conflicting and no human evidence particularly by non-invasive techniques, has been provided. The aim of our study has been to assess the relationship between arterial wall stiffness measured by *e*TRACKING and basal coronary blood flow evaluated in the left anterior descending artery (LAD) by transthoracic doppler echocardiography. We evaluated the correlation between coronary flow parameters and stiffness parameters calculating Spearman's Rho index. All calculations were significant at $p < 0.05$.

Methods:

We studied 34 patients with a mean age of 52.8 ± 15.1 , of which, 21 were men without a history of coronary artery disease and with negative echo-stress. We used an Aloka ProSound $\alpha 10$ echo-equipment. LAD doppler velocities were recorded at the distal segment of the vessel by a phased-array transducer. The following parameters were evaluated: the ratio between the diastolic peak velocity (D) and the systolic peak velocity (S), (D/S); the ratio between the velocity time integral of the diastolic component (VTI-D) and the velocity time integral of the total flow (VTI-tot), expressed as a percentage (VTI-D/VTI-Tot%). Parameters of vascular stiffness were evaluated at the level of the common carotid artery just before bifurcation. The following parameters were evaluated: Beta (stiffness parameter); AI (augmentation index); PWV (pulse wave velocity). The value of blood pressure (systolic and diastolic) evaluated in the left arm was included in the system for the evaluation of these parameters.



ALOKA ProSound $\alpha 10$

Results:

Our results showed an inverse correlation between vascular stiffness parameters and coronary blood flow velocities ($p < 0.01$), Table II.

Table. II

	Beta		AI		PWV	
	r	p	r	p	r	p
VTI-D/VTI-Tot %	-0.642	<0.001	-0.656	<0.001	-0.481	<0.004
D/S	-0.686	<0.001	-0.700	<0.001	-0.563	<0.001

Our data, obtained by non-invasive methods, show a negative correlation between vascular stiffness parameters and coronary blood flow velocity patterns. This preliminary data is very important for understanding some ischemic physiopathological mechanisms, but need further studies to be confirmed.

Final Considerations:

*e*TRACKING is a very important technique for the evaluation of patients' cardiovascular risk in daily practice. In perspective the greater advantages are:

- 1) To define the evolution of vascular aging in healthy patients without risk factors.
- 2) To define the burden of risk factors in vascular stiffness parameters.
- 3) To identify the modification of stiffness parameters very early, before the appearance of morphological alteration such IMT.
- 4) To evaluate, by means of follow-up the effects of medical therapy.
- 5) To study some physiopathological mechanisms, which until today was only possible in a highly specialized laboratory.
- 6) To be an easy technique without being time consuming.

References

- 1) McEniery CM, Yasmin, Hall IR, et al: Normal vascular aging: differential effects on wave reflection and aortic pulse wave velocity: the Anglo Cardiff Collaborative Trial (ACCT). *J Am Coll Cardiol* 2005; 46:1753-1760.
- 2) Tanaka H, DeSouza CA, Seals DR. Absence of age-related increase in central arterial stiffness in physically active women. *Arterioscler Thromb Vasc Biol* 1998; 18:127-132.
- 3) Kingwell BA, Berry KL, Cameron JD, et al.: Arterial compliance increases after moderate-intensity cycling. *Am J Physiol* 1997; 273: H2186-H2191.
- 4) Meaney E, Samaniego V, Alva F, et al.: Increased arterial stiffness in children with parental history of hypertension. *Pediatr Cardiol* 1999; 20:203-205.
- 5) Riley WA, Freedman DS, Higgs NA, et al.: Decreased arterial elasticity associated with cardiovascular disease risk factors in the young. Bogalusa Heart Study. *Arteriosclerosis* 1986; 6:378-386.
- 6) Ferrereira I, Henry RM, Twisk JW, et al.: The metabolic syndrome, cardiopulmonary fitness, and subcutaneous trunk fat as independent determinants of arterial stiffness: the Amsterdam Growth and Health Longitudinal Study. *Arch. Intern Med* 2005; 165:875-882.
- 7) Kool MJ, Hoeks Ap, Struijker-Boudier HA, et al: Short and long-term effects of smoking on arterial wall properties in habitual smokers. *J Am Coll Cardiol* 1993; 22:1881-1886.
- 8) Simon AC, Levenson J, Bouthier J, et al.: Evidence of early degenerative changes in large arteries in human essential hypertension. *Hypertension* 1985; 7:675-680.
- 9) Aggoun Y, Bonnet D, Sidi D, et al: Arterial mechanical changes in children with familial hypercholesterolemia. *Arterioscl Thromb Vasc Biol* 2000; 20:2070-2075.
- 10) Henry RM, Kostense PJ, Spijkerman AM, et al.: Hoom Study. Arterial stiffness increases with deteriorating glucose tolerance status: the Hoom study. *Circulation* 2003; 107:2089-2095.
- 11) Schram MT, Schalwijk CG, Bootsma AH, et al: Advanced glycation end products are associated with pulse pressure in type 1 diabetes: the EURODIAB Prospective Complications Study. *Hypertension* 2005; 46:232-237.
- 12) Bortolotto LA, Safar ME, Billaud E, et al: Plasma homocysteine, aortic stiffness, and renal function in hypertensive patients. *Hypertension* 1999; 34:837-842.
- 13) Boutouyrie P, TropeanoAI, Asmar R, et al: Aortic stiffness is an independent predictor of primary coronary events in hypertensive patients: a longitudinal study. *Hypertension* 2002; 39:10-15.
- 14) Giannattasio C, Failla M, Stella ML, et al: Angiotensin-converting enzyme inhibition and radial artery compliance in patients with congestive heart failure. *Hypertension* 1995;26:491-496.
- 15) Laurent S, Katsahian S, Fassot C, et al: Aortic stiffness is an independent predictor of fatal stroke in essential hypertension. *Stroke* 2003; 34:1203-1206.
- 16) Blacher J, Guerin AP, Pannier B, et al: Impact of aortic stiffness on survival in end-stage renal disease. *Circulation* 1999; 99:2434-2439.
- 17) Briet M, Bozec E, Laurent S, et al: Arterial stiffness and enlargement in mild to moderate chronic kidney disease. *Kidney Int* 2006;96:350-357.
- 18) Klocke R, Cockcroft J, Taylor GJ, et al.: Arterial stiffness and central blood pressure, as determined by pulse wave analysis, in rheumatoid arthritis. *Ann Rheum Dis* 2003;62:414-418.
- 19) Booth AD, Wallace S, McEniery CM, et al: Inflammation and arterial stiffness in systemic vasculitis: a model of vascular inflammation. *Arthritis Rheum* 2004; 50: 581-588.
- 20) Selzer F, Sutton-Tyrrel K, Fitzgerald S, et coll.: vascular stiffness in women with systemic lupus erythematosus. *Hypertension* 2001; 37:1075-1082.
- 21) Carerj S, Nipote C, Zimbalatti C., et al. : Normal vascular aging evaluated by a new tool : e-tracking. *Eur J Echocardiography* 2006; suppl : S49.
- 22) Carerj S, C. Zimbalatti C, Nipote C, et al: Relationship between coronary flow velocity and vascular stiffness. *Eur J Echocardiography* 2006;suppl.1: S185.



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