Screening for preclinical athero- and arterio-sclerosis, clinical relevance?

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Why Vascular Evaluation is Important?
Vascular Pathology

- Atherosclerosis: inflammatory process that selectively affects arteries
- Senescence of the arterial tree: a biologic process that follows a natural course that can be accelerated by the combined injury of multiple risk factors
Atherosclerosis

- Aorta
  - Abdominal
  - Thoracic
- Coronary artery and carotid artery
- Lower extremity arteries
- Upper extremity arteries

Early

Late
60 year-old man with abdominal pain and claudication

- DM for 6 years
- HTN for 8 years
- Colon polyp and diverticulosis
- Blood sugar: 178 mg/dl
- BUN/Cr: 30.6/3.0
- T-Chol/HDL/LDL: 163/29/88
ECG
Patient Clinical Course

- We recommended the aortic arch replacement surgery but patient refused
- Anticoagulation was started
- 2 months later, patient had a fatal massive cerebral infarction
Lesson from this patient

Role of Vascular Imaging in Decision Making
Morphology  Function

?
Normal vs Stiff aorta

Normal

Stiff
Assessment of Elastic Properties of the Descending Thoracic Aorta By Transesophageal Echocardiography with Acoustic Quantification in Patients with a Stroke

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Previous studies have described the use of transesophageal echocardiography (TEE) with acoustic quantification (AQ) in assessing aortic elastic properties. We hypothesized that patients with a prior history of stroke (ST) may have a higher risk of atherosclerotic change in great vessels compared to nonstroke subjects (NST) and thus have decreased elastic properties. We assessed the elastic properties of the descending thoracic aorta (DTA) by TEE in ST patients and compared them with data in NST patients. Subjects included 31 with ST without any evidence of emboli originating from the heart (age $51 \pm 10$ years, M:F = 20:11) and 25 age-matched NST (M:F = 8:17). Patients with significant valvular heart disease including aortic or mitral regurgitation, left ventricular dysfunction (ejection fraction < 55%), and congenital heart disease were excluded. Compliance (C), distensibility (D), and stiffness index (SI) were measured using AQ and M-mode measurement at a level of the left atrium. We scored atherosclerotic risk factors (ARF) such as a history of diabetes, hypertension, smoking, hypercholesterolemia, and the presence of atheroma of DTA. There was no evidence of atheroma of DTA in NST. There were no significant differences in heart rate and systolic and diastolic blood pressure between ST and NST patients. Fractional area change (FAC) of DTA was significantly lower in ST than in NST patients ($3.2 \pm 1.6$ vs $5.4 \pm 2.5\%$, $P = 0.000$). ST patients had significantly lower $C (1.2 \pm 0.4$ vs $1.5 \pm 0.7 \times 10^{-3} \text{cm}^2 \text{mmHg}^{-1}$, $P = 0.039$), lower $D (0.8 \pm 0.3$ vs $1.5 \pm 0.8 \times 10^{-3} \text{mmHg}^{-1}$, $P = 0.000$), and higher SI ($10.3 \pm 8.8$ vs $5.3 \pm 2.9$, $P = 0.006$) than NST patients. ST patients without atheroma of DTA ($n = 21$) also had significantly lower $C (1.1 \pm 0.4$ vs $1.5 \pm 0.7 \times 10^{-3} \text{cm}^2 \text{mmHg}^{-1}$, $P = 0.038$) and lower $D (3.5 \pm 1.4$ vs $4.8 \pm 2.4 \times 10^{-3} \text{mmHg}^{-1}$, $P = 0.021$) than NST patients. There was a significant positive correlation between SI and the score of ARF ($r = 0.51$, $P = 0.000$). The regional elastic properties of DTA measured by TEE with AQ and M-mode method were abnormal in ST. Therefore, TEE with AQ technique may have a possible clinical application for the detection of early atherosclerotic changes such as alteration of elastic properties in morphological normal DTA. (ECHOCARDIOGRAPHY, Volume 17, November 2000)
Comparison of Elastic Properties of DTA Between Patients with Stroke and Non-stroke

Kang SM et al. Echocardiography 2000
Comparison of Elastic Properties of DTA Between Patients with Stroke and Non-stroke

- The regional elastic properties of DTA measured by TEE with AQ and M-mode method were abnormal in stroke.
- TEE with AQ technique may have a possible clinical application for the detection of early atherosclerotic changes such as alteration of elastic properties in morphological normal DTA.
Comparison of Elastic Properties of DTA Between Patients with Stroke and Non-stroke

- Stroke patients without atheroma of DTA (n = 21) also had significantly lower $C$ (1.1 +/- 0.4 vs 1.5 +/- 0.7 x 10(-3) cm$^2$ mmHg(-1), $P = 0.038$) and lower $D$ (3.5 +/- 1.4 vs 4.8 +/- 2.4 x 10(-3) mmHg(-1), $P = 0.021$) than non-stroke patients.
• Structural (or functional) alterations precedes morphological changes
Cardiac Cycle-Dependent Changes in Aortic Area and Distensibility Are Reduced in Older Patients With Isolated Diastolic Heart Failure and Correlate With Exercise Intolerance

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OBJECTIVES The goal of this study was to determine if cardiac cycle-dependent changes in proximal thoracic aortic area and distensibility are associated with exercise intolerance in elderly patients with diastolic heart failure (DHF).

BACKGROUND Aortic compliance declines substantially with age. We hypothesized that a reduction in cardiac cycle-dependent changes in thoracic aortic area and distensibility (above that which occurs with aging) could be associated with the exercise intolerance that is prominent in elderly diastolic heart failure patients.

METHODS Thirty subjects (20 healthy individuals [10 < 30 years of age and 10 ≥ 60 years of age] and 10 individuals > the age of 60 years with DHF) underwent a magnetic resonance imaging (MRI) study of the heart and proximal thoracic aorta followed within 48 h by maximal exercise ergometry with expired gas analysis.

RESULTS The patients with DHF had higher resting brachial pulse and systolic blood pressure, left ventricular mass, aortic wall thickness and mean aortic flow velocity, and, compared with healthy older subjects, they had a significant reduction in MRI-assessed cardiac cycle-dependent change in aortic area and distensibility (p < 0.0001) that correlated with diminished peak exercise oxygen consumption (r = 0.79). After controlling for age and gender in a multivariate analysis, thoracic aortic distensibility was a significant predictor of peak exercise oxygen consumption (p < 0.04).

CONCLUSIONS Older patients with isolated DHF have reduced cardiac cycle-dependent changes in proximal thoracic aortic area and distensibility (beyond that which occurs with normal aging), and this correlates with and may contribute to their severe exercise intolerance. (J Am Coll Cardiol 2001;38:796–802) © 2001 by the American College of Cardiology
Aortic stiffening was not inevitable in older persons.
Carotid Artery Ultrasound

1982 James et al

First description of ultrasound appearance of the carotid arterial wall

“Thin inner – thick outer lines”
Intima + Media Thickness Measurement

IMT = distance between the bright lines
CCA IMT < 1.0 mm
Carotid IMT

Early Studies

CCA IMT correlates with disease in the coronary arteries

- Salonen et al, 1993: Each 0.1 mm IMT increase = 11% ↑ in AMI risk

- IMT proposed as potential marker for coronary artery disease
Correlation between CV disease and carotid artery wall thickness

Burke et al, 1995
Carotid Artery Imaging
Two different TR signals
Simplified Bernoulli Equation

\[ \Delta P = 4V^2 \]
Two different TR signals
Two different LVOT signals
20 year-old man

Rest  25W  50W  75W
M/ 20

**At Rest**
- SBP/ DBP 103/ 75 mmHg
- PP 28 mmHg
- HR = 58 bpm
- Aortic AIx 18 %
- Aortic AIx (HR 75) 10 %

**Peak Exercise (100 W)**
- SBP/ DBP 115/ 71 mmHg
- PP 44 mmHg
- HR = 94 bpm
- Aortic AIx -1 %
- Aortic AIx (HR 75) 8 %
74 year-old man

Rest  25 W  50 W
M/ 74

At Rest

SBP/ DBP 130/ 77 mmHg
PP 53 mmHg
HR = 51 bpm
Aortic Alx 45 %
Aortic Alx (HR 75) 33 %

Peak Exercise (50 W)

SBP/ DBP 200/ 127 mmHg
PP 73 mmHg
HR = 57 bpm
Aortic Alx 37 %
Aortic Alx (HR 75) 28 %
The Parameters of LVOT Doppler

1. LVOT Ejection time
2. LVOT Acceleration time (Time to peak velocity)
3. LVOT Deceleration time
4. Peak aortic flow velocity

\[
\begin{align*}
\text{Acceleration time/ Ejection time} & = \frac{2}{1} \\
\text{Deceleration time/ Ejection time} & = \frac{3}{1} \\
\text{Deceleration time/ Acceleration time} & = \frac{3}{2}
\end{align*}
\]
Deceleration time/ Ejection time

P = 0.027

P = 0.158

P = 0.791

20-29  30-39  40-49  50-59  60-69

Rest     25 Watt     50 Watt
Change of DT/AT During Exercise

- Rest to 25 Watt
- Rest to 50 Watt

* $p < 0.05$
US for Vascular Imaging

- Excellent imaging tool for the evaluation of arteries
- Gives morphologic and functional information
- Detect preceding functional changes of arterial tree before overt atherosclerosis
- New techniques for analysis