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Age-related distensibility and histology of the ascending aorta in elderly patients with acute aortic dissection

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ABSTRACT

Degradation and fragmentation of elastic fibers in the media dilate the aortic wall excessively in patients with acute Stanford type A aortic dissection (AD). Such dilatation occurs not via aortic stiffening, which is diagnosed using imaging under physiological loading, but due to the abovementioned intrinsic changes in elastic fibers, which can be detected at the low-stress region of the stress–strain relationship. Our objective is to determine an age-related correlation between distensibility and histology. We conducted uniaxial stretching tests and a histological evaluation of the ascending aorta (AA) using AD samples obtained at surgery from 9 elderly patients (aged 52–85 yr), with no heritable connective tissue disorders, and control (CN) samples from 10 subjects at autopsy (aged 56–86 yr). We compared the distensibility, or an increase in strain for the uniaxial tensile stress of 0–50 kPa, between the AD and CN groups, and correlated it with age and histology. Distensibility was significantly greater in the AD than that in the CN group ($p=0.030$), but elastin content was significantly lower ($p=0.0025$). The positive correlation between distensibility and elastin content in CN samples suggests that the distensibility increases with elastic fiber histological abnormalities. The age-matched collagen content decreased with the age of the patients, and did not differ between the AD and CN groups. The age-matched distensibility in the AD and CN groups decreased and became closer with aging. Such intrinsic properties should be considered during imaging to assess distensibility in patients with AD.

1. Introduction

Emergency surgery is conducted frequently in patients over 50 years of age with acute Stanford type A aortic dissection (AD), which usually accompanies a wall rupture. The aorta is subjected to longitudinal tension and repeated intraluminal pressure, and rupture or excess dilatation in patients with AD is caused by degradation and fragmentation of medial elastic fibers (Nakashima et al. 1990a; Tsai et al. 2005).

Nakashima et al. (1990b) observed an AA with a Stanford type A AD by electron microscopy and reported that the interlaminar fibers between the elastic laminae were arranged irregularly and had decreased in number, particularly in the outer media in 6 of 10 cases. Fritze et al. (2012) reported that the proximal AA in patients (40–86 yr of age) undergoing coronary artery bypass grafting exhibited a dramatic decrease in the number of interlaminar fibers and an increase in laminae distance with aging. A review by Tsamis et al. (2013) showed that collagen content increases with age both in the normal AA and in cases of AD.

Aging results in dilation of the aortic wall in people 20–94 years of age (Sawabe et al., 2011) and stiffens in those over 50 (Hayashi, 1993). Aging also decreases AA distensibility (Redheuil et al. 2010; Martin et al. 2013), which has been studied for the AA with heritable connective tissue disorders such as Marfan syndrome under physiological loading (Okamoto et al., 2003; Baumgartner et al., 2006), as well as for the AA with dilated bicuspid aortic valve under low strain (Choudhury et al., 2009). Here we focus on the effects of aging on the mechanical properties of the AA in patients with AD and without connective tissue disorders.

The intrinsic mechanical properties of the aorta can be described by the stress–strain relationship. Changes in the intrinsic mechanical properties of the AA with histologic abnormalities and aging cannot be obtained by clinical imaging under physiological loading conditions. Rather than the pressure–diameter relationship between diastolic and systolic pressures, we

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Table 1
Clinicopathological characteristics of the subjects and attributes of the specimens.

Subject ID	Age (yr)	Sex	De Bakey classification	Max. dia. of ascending aorta (mm)	Store (days)	Thickness of specimen (mm)
AD-1	52	M	I	48	1[a]	2.1
AD-2	58	M	I	55	24	1.7[b]
AD-3	78	F	II	40	4	2.1
AD-4	77	F	I	39	85	1.2
AD-5	79	M	I	46	46	1.7
AD-6	85	F	II	52	68	1.2
AD-7	79	M	I	51	7	1.1
AD-8	62	M	I	44	123	1.8
AD-9	67	M	I	67	3	1.9
Mean	70.8			49.1	40.1	1.66
(SD)	(11.4)			(8.6)	(43.7)	(0.38)

Subject ID	Age (yr)	Sex	Pathological diagnosis	Store (days)	Thickness of specimen (mm)
CN-1	86	F	Acute interstitial pneumonia	6	1.3
CN-2	75	M	Bronchopneumoia	32	1.7
CN-3	68	M	Acute myeloid leukemia	5	1.5
CN-4	63	F	Polycystic kidney disease	68	1.3
CN-5	78	F	Nephrotic syndrome	0[a]	1.4
CN-6	59	M	Idiopathic interstitial pneumonia	84	1.8
CN-7	58	M	Chronic myocardial infarction	59	1.5
CN-8	56	M	Alcoholic liver cirrhosis	6	1.5
CN-9	61	F	Breast cancer	1	1.5
CN-10	75	F	Acute pancreatitis	1	1.3
Mean	67.9			26.2	1.46
(SD)	(10.1)			(32.4)	(0.17)

AD: aortic dissection, CN: control, M: male, F: female.

[a] Refrigerated at 5 °C.

[b] A thin surface tissue of false lumen was removed to prepare the specimen.