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Computed tomographic quantification of periaortic adipose tissue volume as a correlate of cardiovascular disease

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The accumulation of adipose tissue has long been thought of as a risk factor for cardiovascular disease (CVD) [1]. However, the dynamic effects in metabolic homeostasis and pathology are still being discovered [2]. The complexity of factors associated with obesity including adipokines associated with various adipose tissue depots is frequently overlooked [3]. Intuitively, one of these depots, perivascular adipose tissue (PVAT), is likely contributing to the development and/or progression of CVD given its proximity to arterial vasculature. A subset of PVAT that surrounds the coronary arteries, epicardial fat, has been well studied in the development of coronary artery disease [4]. Another subset of PVAT, periaortic adipose tissue has also been implicated in CVD, however, previous studies have limited their investigation to a specific population, unique depots, or a single CVD [5–7]. Herein, the current study describes the quantification of periaortic adipose tissue volume in both the thoracic and abdominal regions in a unique population and correlates this value to specific measures of CVD.

Once the study protocol and procedures were approved by the University of Cincinnati Institutional Review Board (IRB#2013-8286), An electronic medical record was queried for patients who obtained non-contrasted computed tomography (CT) scans of their chest and/or abdomen over a 2-year period. These deidentified records were reviewed to verify subjects met inclusion/exclusion criteria which were broad, allowing for a diverse patient population. Inclusion criteria included 18 years of age or older and non-contrasted CT scan of chest and/or abdomen. Exclusion criteria where limited to variables that would compromise the measurement of the periaortic tissue volume including previous aortic surgery, gross anatomical anomalies (including trauma) or the use of contrast as the increased attenuation within the lumen would alter the radiodensity of the surrounding tissue.

After appropriate subjects were identified, abdominal and thoracic periaortic adipose tissue volume was quantified in a similar manner as previously conducted [5]. The segment of thoracic aorta that was measured started at the level of the pulmonary artery bifurcation and extended 70 mm inferiorly. The abdominal aortic segment was measured starting at the level of the aortic bifurcation and extended superiorly 40 mm. Adipose tissue was selectively gated using a window width of –195 to –45 Hounsfield units (HU) with a center of –120 HU [5]. The region of interest was encircled with a diameter being 10 mm larger than the anteroposterior aortic diameter and then adipose tissue was selectively gated [6]. The degree of aortic calcification was determined by the volume of hyperattenuation with a minimum of three connected pixels with attenuation over 130 HU [5].

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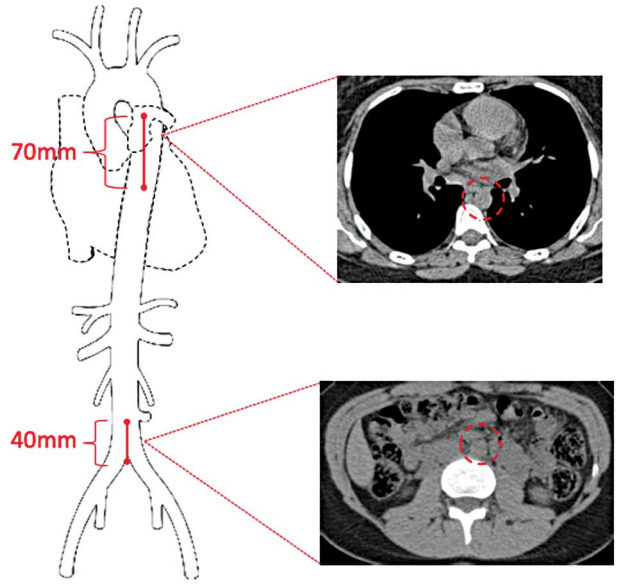
	Total (n=200)	
Age - mean (SD)	52	(15)
Race		
Caucasian	106	53.0%
African American	87	43.5%
Hispanic	4	2.0%
Other	2	1.0%
Asian	1	0.5%
Male	128	64.0%
Past Medical History and Medications		
Diabetes mellitus	47	23.5%
Hypertension	89	44.5%
Hyperlipidemia	38	19.0%
Coronary Artery Disease	28	14.0%
Congestive Heart Failure	32	16.0%
Renal Failure	31	15.5%
Anti-hypertensive Medication	90	45.0%
Lipid Lowering Agents	42	21.0%
Aspirin	46	23.0%
Plavix	6	3.0%
Anticoagulants	18	9.0%
Insulin	16	8.0%
Tobacco Use	100	50.0%
Alcohol Use	51	25.5%
Cocaine Use	8	4.0%



		Thoracic Periaortic Adipose Volume	Thoracic Aortic Dimension	Thoracic Aortic Calcification	Abdominal Periaortic Adipose Volume	Abdominal Aortic Dimension	Abdominal Aortic Calcification
Total							
Thoracic Periaortic Adipose Volume	Pearson Correlation	1	0.480	0.117	0.683	0.348	0.097
	Sig. (2-tailed)		0.000	0.114	0.000	0.009	0.478
	N	184	184	184	56	56	56
Thoracic Aortic Dimension	Pearson Correlation	0.480	1	0.156	0.501	0.693	0.123
	Sig. (2-tailed)	0.000		0.034	0.000	0.000	0.366
	N	184	184	184	56	56	56
Thoracic Aortic Calcification	Pearson Correlation	0.117	0.156	1	0.000	0.021	0.489
	Sig. (2-tailed)	0.114	0.034		0.999	0.875	0.000
	N	184	184	184	56	56	56
Abdominal Periaortic Adipose Volume	Pearson Correlation	0.683	0.501	0.000	1	0.581	-0.028
	Sig. (2-tailed)	0.000	0.000	0.999		0.000	0.817
	N	56	56	56	72	72	72
Abdominal Aortic Dimension	Pearson Correlation	0.348	0.693	0.021	0.581	1	0.103
	Sig. (2-tailed)	0.009	0.000	0.875	0.000		0.392
	N	56	56	56	72	72	72
Abdominal Aortic Calcification	Pearson Correlation	0.097	0.123	0.489	-0.028	0.103	1
	Sig. (2-tailed)	0.478	0.366	0.000	0.817	0.392	
	N	56	56	56	72	72	72

Figure 1. Summary of patient demographics, methods and results. **Top left**: Demographic information of the study population; **Top right**: Representative diagram of computed tomographic methods and periaortic adipose tissue volume quantification; **Bottom**: Summary of the Pearson correlations and significance of periaortic adipose tissue volume in the thoracic and abdominal regions to aortic dimension and aortic calcification in the same regions.

The aortic dimension was calculated as the mean of the anteroposterior and transverse diameter of the aorta from the outer edge to the outer edge at the level of the right pulmonary artery for the thoracic aorta and 5 cm above the aortoiliac bifurcation for the mid-abdominal aorta. A representation of the regions can be seen in Figure 1 (top right). All scans were performed on a Siemens SOMATOM scanner. Study data were collected and managed using Research Electronic Data Capture (REDCap) electronic data capture tools [8]. All statistical analyses were conducted using SPSS 24.0 (IBM Corporation, Armonk, NY). Data is as the median with minimum and maximum reported. Pearson correlation was calculated between periaortic adipose tissue volume in the thoracic and abdominal regions with aortic dimension and calcification in the same regions.

Two hundred cases were reviewed, 184 non-contrast chest CTs and 72 non-contrast abdominal CTs. A detailed list of this demographic information is shown in Figure 1 (top left). Thoracic perivascular adipose tissue volume (PVAT) correlated the best with abdominal PVAT with an r statistic of 0.683 ($p < 0.000$). Thoracic PVAT also correlated well with thoracic aortic dimension ($r = 0.480$; $p < 0.000$). Similarly, abdominal PVAT also correlated with thoracic and abdominal aortic dimension ($r = 0.501$; $p < 0.000$ and $r = 0.581$; $p < 0.000$, respectively). A summary of the data can be seen in the table at the bottom of Figure 1.

In the current study, two distinct regions of the aorta, thoracic and abdominal, were analyzed to quantify PVAT volume via selective gating for adipose tissue. These values were correlated with surrogates of CVD including aortic dimension and aortic calcification. It was found that PVAT volume correlated well with the aortic dimension in both thoracic and abdominal regions. This data is congruent with previously publish studies investigating similar endpoints including CVD risk factors and abdominal aortic aneurysms [5–7].

In conclusion, periaortic adipose tissue volume was higher in individuals with CVD in both the thoracic and abdominal regions, albeit more so around the thoracic aorta. While this association is significant, the direct clinical relevance of these specific depot volumes is still to be determined; therefore, further work needs to be conducted to investigate the association of periaortic adipose volume with cardiovascular outcomes.

Conflict of interest: None declared

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