A prospective study of growth and rupture risk of small-to-moderate size ascending aortic aneurysms

Sarah Geisbüsch, MD,[a] Angelina Stefanovic,[a] Deborah Schray,[a] Irina Oyfe,[b] Hung-Mo Lin, ScD,[c] Gabriele Di Luozzo, MD,[a] and Randall B. Griepp, MD[a]

Objective: The natural history of small-to-moderate size ascending aortic aneurysms is poorly understood. To follow these patients better, we have developed a method to objectively and reproducibly measure ascending aortic volume on the basis of gated contrast computed tomography scans.

Methods: From 2009 to 2011, 507 patients were referred for management of ascending aortic aneurysms. A total of 232 patients (46%) with small-to-moderate size aneurysms who did not have compelling indications for operation had measurement(s) of ascending aortic and total aortic volume; 166 patients had more than 1 scan, allowing measurement of growth. A total of 66 patients admitted to the emergency department without ascending aortic pathology served as a reference group.

Results: None of the patients experienced rupture, dissection, or death; 3 patients ultimately underwent operation. Ascending aortic volume and volume/total aortic volume differed for the surveillance and reference groups: 132.8 ± 39.4 mL versus 78.0 ± 24.5 mL; 38.3% ± 7.4% versus 29.1% ± 3.9%, respectively (both $P < .001$). Diameters at the sinotubular junction and mid-ascending aortic were 4.1 ± 0.6 cm and 4.4 ± 0.6 cm, respectively, for the surveillance group and 3.0 ± 0.4 cm and 3.2 ± 0.4 cm, respectively, for controls. The increase in ascending aortic volume was 0.95 ± 4.5 mL/year and 0.73% ± 3.7%/year ($P = .007$ and .012, respectively). Analysis of risk factors for ascending aortic growth revealed only the use of antithrombotic medication as possibly significant.

Conclusions: Computed tomography volume measurements provide an objective method for ascertaining aortic size and monitoring expansion. Patients with small-to-moderate ascending aortic aneurysms who are carefully followed and managed appropriately have slow aneurysm growth and a small risk of rupture or dissection. Annual computed tomography screening may not be indicated, and elective resection—absent other surgical indications—is not necessary. The rupture/dissection risk for even larger aneurysms in carefully followed patients may be lower than currently believed. (J Thorac Cardiovasc Surg 2014;147:68-74)

ACD

Aortic aneurysm disease is the 15th most common cause of death in individuals aged more than 65 years. On the basis of a population study from 1980 to 1994, the incidence of thoracic aortic aneurysms is described as 10.4 per 100,000 person-years, and the frequency of diagnosis is probably now higher, given improved imaging techniques and an aging population.[1,2] The natural history of thoracic aortic aneurysms is poorly understood. To decide on the appropriate treatment strategy for each individual patient, it is critical to be able to estimate the risk of rupture or acute dissection because rupture and dissection are often lethal, mandating preemptive intervention in high-risk patients.[3,4]

Aneurysms of the ascending aorta are often indolent and frequently discovered incidentally.[1] How should we proceed with small-to-moderate size aneurysms of the ascending aorta? Guidelines suggest intervention at a diameter of 5.5 cm because the risk of rupture of an aneurysm is known to increase dramatically with ascending aortic (AA) size greater than 6 cm.[5,6] However, it is important to bear in mind that size and growth are determining factors only in asymptomatic patients: Patients with pain or uncontrolled hypertension and those with connective tissue disease or a family history of dissection are at high risk and need to be treated differently.[5,7]

Early reports of growth rates have concluded that thoracic aortic aneurysms usually grow slowly,[8-12] and it has been assumed that more rapid growth puts the patient at increased risk even when the usual diameter thresholds for operation have not been reached. But growth needs to be monitored, and to be reliable, measurements must be performed in an accurate, reproducible manner. Imaging techniques include echocardiography (transthoracic and transesophageal), computed tomography (CT), magnetic resonance imaging, and angiography.[6] Each one illustrates the aorta in a different way, allowing assessment of size and shape. At the same time, each imaging technique has

From the Department of Cardiothoracic Surgery,[a] Mount Sinai Medical Center, New York, NY; Department of Radiology,[b] Mount Sinai Medical Center, New York, NY; and Department of Health Evidence and Policy,[c] Mount Sinai Medical Center, New York, NY.

Disclosures: Authors have nothing to disclose with regard to commercial support.

Read at the 38th Annual Meeting of The Western Thoracic Surgical Association, Maui, Hawaii, June 27-30, 2012.

Received for publication June 20, 2012; revisions received Dec 21, 2012; accepted for publication June 27, 2013; available ahead of print Aug 19, 2013.

Address for reprints: Sarah Geisbüsch, MD, Mount Sinai Medical Center, Department of Cardiothoracic Surgery, One Gustave L. Levy Pl, PO Box 1028, New York, NY 10029 (E-mail: sarahgeisbuesch@hotmail.com).

0022-5223/$36.00

http://dx.doi.org/10.1016/j.jtcvs.2013.06.030

Abbreviations and Acronyms
AA = ascending aortic
CT = computed tomography
SD = standard deviation
SE = standard error

disadvantages that may mislead one in evaluating the size of the aorta. Furthermore, measurements using different imaging techniques are often hard to compare with one another.

It is important to understand the natural history of thoracic aneurysms, especially in the AA, to intervene before a fatal complication occurs. To avoid being too aggressive in cases in which an aneurysm is unlikely to rupture or dissect, we must develop a reliable method to evaluate size and serially monitor growth. We have frequently observed that reported size changes in AA aneurysms, usually increases, are due to measurements taken at different levels or angles in serial studies. The ideal technique for measuring the aorta would remove as much subjectivity as possible. Because of the methodological problems involved in consistently measuring diameters, as well as the conceptual inadequacy of describing a complex 3-dimensional structure with a single linear measurement, we developed a more objective means of quantifying AA size using volume measurements. We believe that this technique adds to the reliability of CT scan estimation of size and growth, especially when comparison with earlier imaging studies is difficult or impossible.

MATERIALS AND METHODS

From 2009 to 2011, 232 patients (167 male, 65 female) were referred for management of AA aneurysms and advised to continue surveillance rather than undergo operation. Aneurysms of small-to-moderate size, in the absence of operative indications such as pain, a family history of aneurysm with rupture or dissection, or evidence of recent aneurysm enlargement, or a contraindication to operation such as the presence of other life-threatening medical conditions, defined the surveillance group. All patients underwent CT scans at the Mount Sinai Medical Center. Volume measurements and measurements of aortic diameters were carried out. Patients were excluded from the study if they had an aneurysm 5 cm or greater elsewhere in the aorta, an aortic operation before the scans were undertaken, or Marfan syndrome. A total of 66 patients admitted to the emergency department (35 male/31 female) without AA pathology who had similar scans served as a reference group. This retrospective analysis, using a review of medical records, was approved by an institutional review board and did not require individual patient consent.

Of the 232 surveillance patients, 166 had more than 1 scan, allowing the calculation of growth rates; 157 patients had 2 scans, and 9 patients had 3 scans. A total of 971 patient-years was monitored. Only scans that were more than 3 months apart were included in the analysis of growth rate. To calculate growth rates, first and last measurements were taken in cases of multiple CT scans. The median (range) time between the first and last scans was 1.1 (0.4-4.3) years. During the observed interval, 273 other patients underwent elective AA operations at the Mount Sinai Medical Center on initial presentation.

Computed Tomography Measurements

All measurements and divisions of the aorta into segments were undertaken using Aquarius by TeraTecon, Inc (San Mateo, Calif) and carried out by the same analyst (I.O.). The aorta for each patient was divided into 4 segments: ascending aorta, arch, descending aorta, and abdominal aorta. The volumes of each separate segment were calculated using the dedicated software. Segments were defined as follows: The *ascending aorta* extends from the root to the proximal origin of the innominate artery, the *arch* extends between the proximal origins of the innominate and the left subclavian artery, the *descending aorta* extends from the distal origin of the left subclavian artery to the proximal origin of the celiac axis, and the *abdominal aorta* extends from the celiac axis to the iliac bifurcation. The planes separating the segments were drawn perpendicular to the central axis of the aorta. The proximal extent of the ascending aorta was obtained by trimming along the aortic valve manually in multiple planes. After the regions of the aorta were segmented, each slice was compared with the source dataset by the analyst to be sure that all areas of interest were covered and correlated with the source data. The ascending aorta as defined by this process is shown in Figure 1.

Because 95% of the subjects in the surveillance group had only 2 scans, growth rates were estimated by calculating the increase in volume over time between the scans, and extrapolating to obtain a yearly rate. Volumes were analyzed and compared by segment and for the aorta as a whole. For further analysis, the aorta was divided into 2 parts: the ascending aorta and the distal aorta, including the arch and descending and abdominal aortas.

Statistical Analysis

Data are described as mean ± standard deviation (SD) and percentage. Wilcoxon, Mann–Whitney, chi-square, and *t* tests were used to compare differences between groups. Linear regression using the least-squares method was used to describe the relationship between the AA volume and diameter, and the relationship between AA volume growth rate and potential predictors listed in Table 1. For the latter, factors that had a P value less than .2 were further considered in the stepwise multivariate regression analysis. All analyses were performed using SAS software version 9.2 (SAS Institute Inc, Cary, NC).

RESULTS

Patient Cohort

The mean age at the time of the first scan was 63.6 ± 12.3 years in the surveillance group and 57.7 ± 17.8 years in the control group ($P = .014$). Significantly more patients in the surveillance group were male (35/66, 53% of the control vs 167/232, 72.0% of the surveillance patients; $P = .004$) and hypertensive (32/66, 48.5% in control vs 165/200, 81.5%, in the surveillance group; information could not be obtained for 32 patients; $P < .001$). Body mass index was 29.0 ± 6.0 kg/m^2 in controls and 28.5 ± 4.9 kg/m^2 in the surveillance group ($P = .585$). Some 31.8% of control patients (21/66) had ever smoked versus 30.8% of the surveillance group (56/180), with information missing for 52 of the surveillance patients ($P = .916$). Hyperlipidemia was diagnosed in 21 of 49 control patients (42.9%), whereas 114 of 198 patients (57.6%) in the surveillance group had a confirmed history of hyperlipidemia ($P = .064$). Ten surveillance patients had chronic aortic type B dissection.

Clinical Outcome

None of the patients experienced rupture, dissection, or death during the interval of surveillance. Three patients in