Aortic Length: Angiocardiographic Measurements

By Charles T. Dotter, M.D., Douglas J. Roberts, Jr., B.A., and Israel Steinberg, M.D.

Statistical analysis of measurement of aortic length made on 250 angiograms indicates that arteriosclerosis, hypertension and syphilitic aortitis produce elongation of the aorta. Aortic length varies widely among normal individuals but is roughly ten times the caliber of the ascending aorta. Syphilitic aortitis produces disproportionate elongation of the ascending portion of the aorta as compared to arteriosclerosis or hypertension.

ANGIOCARDIOGRAPHY affords an accurate delineation of aortic form and contour during life; it allows measurement of aortic length and diameter. By means of measurements made upon angiograms, it has been possible to determine the range in caliber of the normal and diseased aorta. In 1949, the results of measurement of the caliber of the normal thoracic aorta at four anatomically fixed points—midascending, transverse, descending and diaphragmatic—were reported. Measurement of 100 normal aortas (including those with arteriosclerosis) indicated that the caliber (for all ages) of the midascending aorta ranged between 16 and 38 and averaged 28.6 mm. In a study of 51 patients with syphilitic aortitis, the range for the same point of measurement was from 38 to 70 mm. and the average caliber was 45.4 mm.

No study of the length of the thoracic aorta, as measured during life, has been reported. The relationship of age, arteriosclerosis, syphilis and hypertension to aortic length has hitherto not been investigated. Accordingly, for academic as well as clinical reasons, the following angiographic study of the length of the thoracic aorta was undertaken.

Method

The material for this study comprised 250 selected angiograms. All were made in the left anterior oblique or left lateral projection so as to afford a side view of the thoracic aorta; all were exposed at a 72 inch target-film distance so as to minimize distortion and enlargement of the aorta and secure a film comparable to the standard chest film; all were made during suspended deep inspiration. Films selected were of a quality adequate to allow satisfactory measurement. Unfortunately, technical progress at the time most of the films were made did not allow for timing of exposure with respect to the phase of the cardiac cycle. Variations in the length of the aorta occurring between systole and diastole are probably not sufficient to render the results of this study invalid. Measurements of aortic length were made with a commercially obtained map measuring device which consisted of a small rotating wheel connected through a gear to a calibrated scale, attached to a handle. The small wheel was rolled along the desired aortic contour and the length read directly from the dial, thus effecting the duplicatable measurement of curved lines with a reasonable degree of accuracy.

The following four measurements were made (see fig. 5B):

Length of Thoracic Aorta. This measurement was made by determining the length of the outer border or contour of the thoracic aorta from the upper border of the anterior sinus of Valsalva to the point where the aorta passed through the left leaf of the diaphragm (fig. 5B, A to C). A smooth continuation of the aortic arch was carried through the points of origin of the brachiocephalic arteries in making this and the following measurement.

Length of Ascending Aorta. This length was measured, as above, from the sinus of Valsalva to the point of juncture of the posterior margin of the left subclavian artery with the aortic arch (fig. 5B, A to B). No attempt to measure the length of the transverse arch was made, this segment being included in the ascending and descending limb measurements.

Length of Descending Aorta. This length was measured, as above, from the left subclavian artery to the diaphragm (fig. 5B, B to C).

Caliber of Midascending Aorta. The maximum width of the midascending aortic lumen was determined, measurement being made perpendicular to

From the Department of Radiology of The New York Hospital—Cornell Medical Center.

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the aortic walls with a centimeter rule (fig. 5B, line D).

Following measurement, all cases were classified into groups according to clinical data. Statistical analysis was applied to three major groups. (1) Eighty-four normal subjects in whom cardiac or aortic disease other than arteriosclerosis did not exist. (2) Fifty-one patients with syphilitic aortitis without aneurysm. (3) Twenty-six patients with hypertension (46 patients) or because of a positive serologic test for syphilis in the absence of evidence of aortic disease (43 patients). Too few cases of rheumatic heart disease or specific congenital lesions were available to warrant analysis. The statistical evaluation of results was conducted in accord with recognized procedure.3

RESULTS

Normal Subjects, Including Those With Arteriosclerosis

The angiocardiograms of 84 cases were measured in which it could be reasonably certain on

<table>
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<th>Table 1.—Mean Aortic Measurements in Normal (Including Arteriosclerotic), Syphilitic, and Hypertensive Patients</th>
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<td>Diagnosis</td>
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<td>Normal</td>
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the basis of available data that no aortic disease other than atherosclerosis existed. No case with a positive serologic test for syphilis or with hypertension (above 140/90) was included. No case with rheumatic or congenital heart disease was considered acceptable, even though there was no evidence of aortic involvement. Arteriosclerosis was included in the normal group since, during life, it is impossible to exclude its presence, and since this condition is universally present in hospital patient material. Arteriosclerotic aortas were likewise included in the other groups studied. Average measurements as made in the three groups studied are presented in table 1.

The 84 cases ranged in age from 9 to 74; the mean age was 42.8 years. The thoracic aorta ranged in length from 21 to 48 cm. with a mean length of 33.2 cm. The calculated standard deviation from this mean was ±5.07.

The thoracic aorta increases in length with age. The relationship between age and total length of the thoracic aorta is graphically presented in figure 1. By applying the method of “least squares,” a formula for predicted aortic length was derived (length = 6.76 + 15.86 log10 age) and is shown as a smooth curve through the scattered individual plots from which it was derived. Thus, ideally, the aorta of a 30 year old patient should be 30 cm. in length; that of a 45 year old patient, 33 cm. It is apparent from the wide scattering of individual observations that no precise numerical definition of the elongated aorta is warranted. It was found that the aorta in males was usually slightly longer than in females.

An attempt was made to correlate the length of the ascending and descending limbs of the aorta. In youth, the ascending aorta composes about 33 per cent of the length of the thoracic aorta while as age and arteriosclerosis increase this percentage approaches 40 per cent. A wide variation in individual measurements was encountered, however, and it is believed that this ratio is of little statistical or diagnostic value. By comparing the values for aortic caliber and length, it was seen that the length of the thoracic aorta, roughly speaking, is ten times the caliber of its middescending limb. This relationship is significantly altered in the presence of syphilis of the aorta.

Patients with Syphilitic Aortitis

The angiocardiograms of 51 cases of syphilitic aortitis were subjected to measurement as described above. The age range for this group was 36 to 73 years, the mean age 52.4 years. The mean length of the thoracic aorta in this group was 36.9 cm., the increase in length as compared with the normal appearing mainly as an increase in length of the ascending limb. The caliber of the middescending
aorta was disproportionately increased (mean, 42.6 mm.) as compared with the increase in aortic length. In the presence of syphilitic aortitis, aortic length is usually less than ten times the midascending caliber, a point of potential diagnostic significance. Measurements of aortic length in syphilitic aortitis are plotted against age in figure 2, as is a curve expressing these points. In figure 4, the curves for normal, syphilitic and hypertensive aortic length are compared and indicate that both syphilis and hypertension add to the aortic elongation due to the aging process. Observation of the relative lengths of ascending and descending

![Graph](http://circ.ahajournals.org/)

**Fig. 1.** Normal and arteriosclerotic group (84 cases). Length of thoracic aorta plotted against age. Predicted aortic length shown as solid black line. *(length = 6.76 + 15.86 log10 age)*

**Fig. 2.** Group with syphilitic aortitis (51 cases). Length of thoracic aorta plotted against age. Statistically derived curve expressing these measurements shown as solid black line.
limbs of the aorta in syphilitic aortitis shows a relatively greater increase in length of the ascending aorta as compared with the descend-
served measurements of aortic length are plotted against age in figure 3 and a curve derived from these points is superimposed. The relative elongation of the aorta due to hypertension, syphilis and aging processes including arteriosclerosis is compared in figure 4. The caliber of the ascending aorta in the hypertensive group was not as great as that in the syphilitic group. In the hypertensive, as in the "normal" group, aortic length was about ten times the caliber of the ascending aorta.

**DISCUSSION**

The measurements herein presented allow certain generalizations. It is apparent that normal length of the thoracic aorta covers a fairly wide range. It follows that knowledge of the aortic length in a given instance cannot be expected to be of significant diagnostic value.

Both syphilitic aortitis and hypertension produce elongation of the aorta; in each instance the elongation adds to that produced by age (and arteriosclerosis). In figure 5 are shown the angiocardiograms and aortic measurements in the following cases: A. a 68 year old man with hypertension and moderate arterioscle-

![Fig. 5. Angiocardiograms, left anterior oblique projection, aorta opacified. A. (N.Y.H. $404$ 769) Hypertension; 68 year old male with blood pressure of 172/106. Aortic length, 45 cm.; ascending aortic length, 16 cm.; descending aortic length, 29 cm.; caliber, midascending aorta, 39 mm. B (N.Y.H.) $511$ 373) Syphilitic aortitis; 56 year old male with blood pressure of 135/75. Aortic length, 36 cm.; ascending aortic length, 16 cm.; descending aortic length, 20 cm.; caliber, midascending aorta, 45 mm. Sites of measurements indicated as described in text.](image-url)
caliber and length of the ascending as compared with the thoracic aorta may suggest the presence of syphilitic aortitis.

Uncounted variables exist which have not been taken into consideration in this study. Aortic length probably varies significantly with body habitus. It would not be surprising to learn that the ectomorph has a longer aorta than the mesomorph. No correlation with weight, height, surface area or other anthropometric measurements was possible because of the limited number of cases available for study.

CONCLUSIONS

1. An angiocardiographic study of the length of the thoracic aorta has been made and the results presented in: (a) 84 cases without aortic disease other than arteriosclerosis; (b) 51 cases of syphilitic aortitis; (c) 26 cases of hypertension.

2. Age, arteriosclerosis, syphilis and hypertension all appear to produce aortic elongation and are additive in this respect.

3. Syphilitic aortitis produces disproportionate elongation and dilatation of the ascending portion of the aorta as compared with arteriosclerosis or hypertension. This fact is of significance in the angiocardiographic diagnosis of syphilitic aortitis.

4. In the absence of aortic disease other than arteriosclerosis, the length of the thoracic aorta may be roughly predicted from the following formula: $length = 6.76 + 15.86 \log_{10} age$. A wide variation from this curve occurs normally, the standard deviation from the mean length being $\pm 5.07$.

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CHARLES T. DOTTER, DOUGLAS J. ROBERTS, JR. and ISRAEL STEINBERG

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