AJNR

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AJNR Am J Neuroradiol 1986, 7 (1) 55-60
http://www.ajnr.org/content/7/1/55

High-Resolution Computed Tomography of the Basilar Artery: 1. Normal Size and Position

Wendy R. K.Smoker[1]
Michael J. Price[2]
William D. Keyes[1]
James J. Corbett[3]
Lindell R. Gentry[1]

Normal high-resolution computed tomographic (CT) scans of 126 patients were reviewed to define the diameter, height of the bifurcation, and transverse position of the normal basilar artery. The mean diameter of the normal basilar artery is 3.17 mm at the level of the pons. In 92% of normal subjects, the basilar bifurcation is located in the interpeduncular cistern adjacent to the dorsum sellae or in the suprasellar cistern below the level of the floor of the third ventricle. In 98% of normal individuals, the basilar artery courses in the midline or in a paramedian position, medial to the lateral margins of the clivus and dorsum sellae.

"Ectasia" (Gr. "ektasis" = dilatation, expansion) of the basilar artery, first described by Morgagni [1] in 1761, is a recognized clinical and pathologic entity. Although the CT demonstration of basilar artery ectasia has been the subject of numerous reports in recent years, the exact radiologic basis for this diagnosis is a matter of considerable debate [2–7]. Various measurements for the length, diameter, and height of the normal basilar artery, based upon angiographic studies or autopsy examinations, have been reported [8–14]. Recently, in an article primarily concerning CT of the normal pituitary stalk, Peyster et al. [15] incidentally reported a mean basilar artery diameter of 3.2 mm at the level of the dorsum. However, there has been no specific study addressing the normal diameter, height, or transverse position of the basilar artery on high-resolution CT scans.

Because of our interest in vertebrobasilar dolichoectasia and the difficulty encountered when attempting to define this entity on CT, we examined, retrospectively, posterior fossa CT scans to define the diameter, height (level of the basilar artery bifurcation), and transverse position (side-to-side) of the normal basilar artery. We believed that once criteria for defining the "normal" artery were established, applications of our normal values could be used more clearly to define vertebrobasilar dolichoectasia.

Materials and Methods

Contrast-enhanced, high-resolution posterior fossa CT scans of 214 randomly selected patients were reviewed. All examinations had been performed on either a GE CT/T 8800 or a Picker 600 scanner immediately after drip infusion of 150 ml Conray 60. Five mm contiguous sections were obtained parallel to the orbitomeatal line. Eighty-eight examinations were excluded from further evaluation because of patient motion or posterior fossa abnormalities that clearly, or possibly, influenced the size and position of the basilar artery. Abnormalities included postoperative states, mass lesions, infarctions, and subdural or epidural collections. The other 126 normal CT examinations form the basis of this study. There were 73 males and 53 females in the study population, ranging in age from 4 to 85 years (table 1).

A 20 diopter lens and reticle accurate to 1/10 mm was used to measure the diameter of the basilar artery at the level of the midpons. Measurements were made directly on CT hard copies and corrected for CT minification.

The height of the basilar artery bifurcation was assessed in relation to normally demon-

Received December 12, 1984; accepted after revision May 8, 1985.

[1] Department of Radiology, University of Iowa Hospital and Clinics, Iowa City, IA 52242. Address reprint requests to W. R. K. Smoker.

[2] Department of Ophthalmology, University of Iowa Hospitals and Clinics, Iowa City, IA 52242. Present address: Boston University School of Medicine, Boston, MA 02215.

[3] Department of Neurology, University of Iowa Hospitals and Clinics, Iowa City, IA 52242.

***AJNR* 7:55–60, January/February 1986**
0195–6108/86/0701–0055

TABLE 1: **Distribution of Patient Age**

Age	No. of Patients (%)
0–9	5 (4.0)
10–19	2 (1.6)
20–29	9 (7.1)
30–39	20 (15.9)
40–49	14 (11.1)
50–59	29 (23.0)
60–69	31 (24.6)
70–79	14 (11.1)
80–89	2 (1.6)
Total	126 (100.0)

TABLE 2: **Criteria for Assignment of Basilar Artery Height**

Height	Plane of Basilar Bifurcation*
0	At or below dorsum sellae
1	Within suprasellar cistern (one cut above dorsum)
2	At level of third ventricle floor (one cut above suprasellar cistern)
3	Indenting and elevating floor of third ventricle (two or more cuts above suprasellar cistern)

* As seen on 20° inclined, 5-mm-thick, posterior fossa CT scans.

strated structures (dorsum sellae, suprasellar cistern, and third ventricle) as outlined in table 2 and illustrated in figure 1. Similarly, the most lateral position of the basilar artery, at any point throughout its course, was assessed in relation to normally imaged CT structures (clivus margin, dorsum sellae, and cerebellopontine angle cisterns) as outlined in table 3 and illustrated in figure 2.

Results

In general, the females were younger than the males, the mean age of the female population being 43.9 years versus 55.3 years for the males. To assess the significance of gender differences, *t* tests for independent means were computed for 36 matched pairs of males and females within 1 year of each other in age. No statistically significant gender differences were found in the diameter, height, or transverse position of the basilar artery.

The distributions for diameter, height, and transverse position are presented in table 4. It can be seen that these distributions are skewed in different directions and to different degrees. The use of *mean* and *standard deviation* to establish 95% intervals for defining normal ranges of variation is, therefore, inappropriate. Instead, we established normal ranges by selecting limits that exclude (as precisely as possible) the most extreme 5% of the distributions.

Table 5 shows distribution statistics, normal ranges, and criteria for abnormality of the three CT variables. Although it is not possible to include exactly the middle 95% for height and position, the criteria for abnormal diameter, height, and position are straightforward and make sense in terms of the resolution of measurement of the three CT variables.

Table 6 presents the nonparametric correlation matrix for the four variables. Position, height, and diameter exhibit statistically significant, positive relations ($p < 0.01$). The three CT variables seem to be positively related to age, although only one correlation is statistically significant. Given the weakness of these correlations and the nature of the distributions obtained, analysis of normal ranges for age subgroups does not prove to be useful and is, therefore, not reported.

Discussion

The diameter, height, and position of the normal basilar artery has received little attention in the CT literature. The high-resolution, thin-section techniques available with current-generation scanners permit demonstration not only of the size, but also of the course of the basilar artery. Peyster et al. [15] reported that the basilar artery is demonstrated 90% of the time on 5 mm contrast-enhanced CT scans. Weisberg [7] was able to identify the basilar artery in 94% of normal patients on "routine"-thickness contrast-enhanced CT scans.

Diameter of the Basilar Artery

In a review of 291 autopsy specimens, Wollschlaeger et al. [14] found a mean basilar artery diameter of 3.26 mm measured 3 mm from the origin of the basilar artery. Busch [13] reported the average diameter to be 4.1 mm in normal patients and 4.5 mm in patients with atherosclerotic disease, also based upon measurements made at autopsy. On the basis of angiographic studies, Yu et al. [8] reported a mean diameter of 2.7 mm (range, 1.5–3.5). On high-resolution contrast-enhanced CT scans, Peyster et al. [15] reported mean diameters of 3.2 mm at the level of the dorsum and 3.6 mm in the suprasellar cistern.

Our mean diameter of 3.17 mm, measured at the midpons level, is essentially identical to previous CT [15] and autopsy [14] reports. These mean diameters are higher than the 2.7 mm reported by Yu et al. [8] based upon angiographic studies. Correlations between CT and angiographic measurements may not be as comparable as previously considered [4]. Axial CT sections may image an ectatic basilar as it courses transversely. This, combined with the effects of partial-volume averaging, may produce spurious enlargement of the vessel on CT (fig. 3).

Despite our attempts at precision by using a 20 diopter lens and fine reticle to measure the basilar diameter from hard copies (a cumbersome method at best), our mean diameter was identical to that of Peyster et al. [15], whose measurements were obtained by either cursor track-ball and "measure distance" functions at the scanner console or millimeter ruler measurements, corrected to anatomic size, taken from hard copies. Therefore, we consider the basilar artery to be normal in diameter if it measures 1.9–4.5 mm (3.17 mm ± 2 SD) with "measure distance" functions on the scanner console.

Peterson et al. [4] accepted a definition of abnormal diameter as greater than 5.3 mm measured on CT. This value was chosen since it represented 2 SD above the mean described by Wollschlaeger et al. [14]. We find this to be somewhat generous since, on the basis of our findings, diameters greater than 4.5 mm should be considered ectatic.

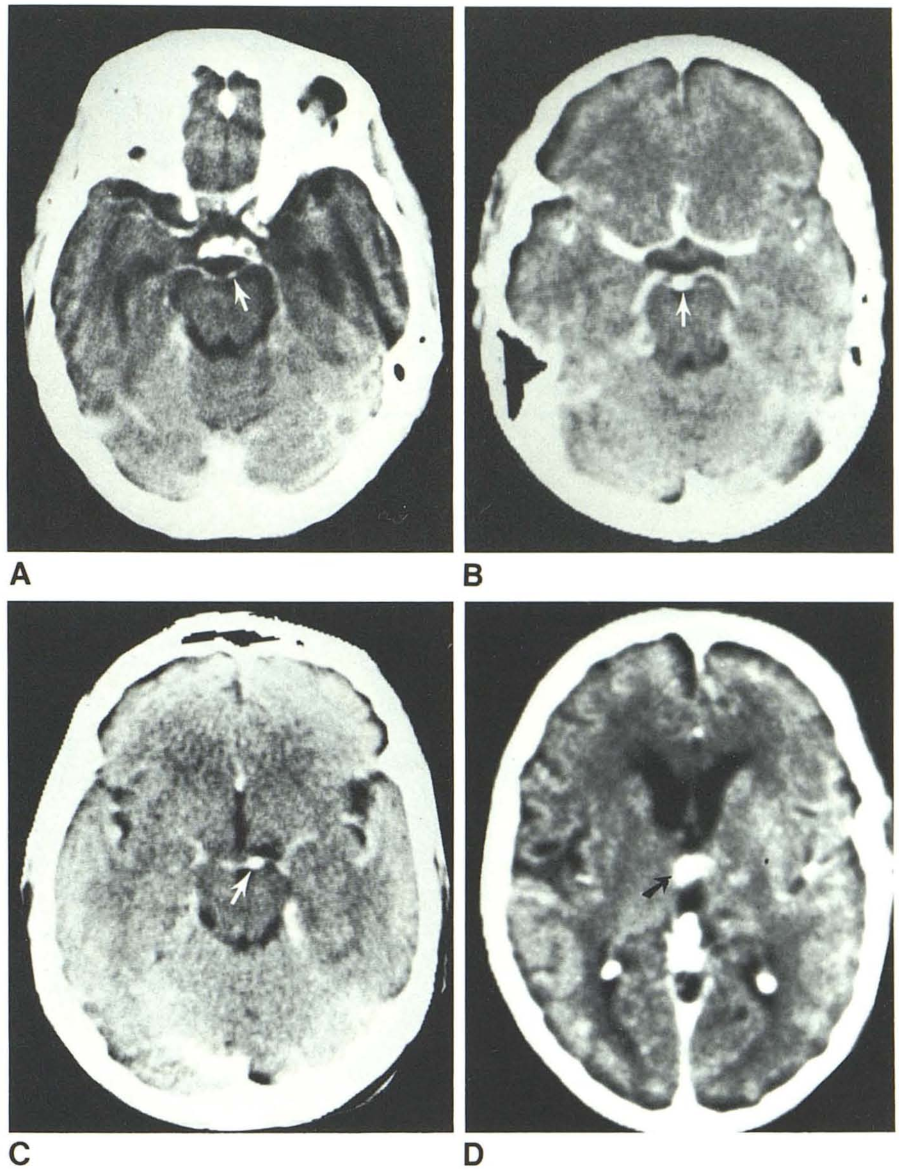

Fig. 1.—Examples for assignment of basilar artery (*arrows*) height (H) (see table 2). **A**, H = 0. Basilar bifurcation is at level of dorsum sellae; **B**, H = 1. Bifurcation is in suprasellar cistern; **C**, H = 2. Bifurcation is at level of floor of third ventricle; **D**, H = 3. Distal basilar artery indents floor and projects into third ventricle.

Height of the Basilar Artery Bifurcation

Yu et al. [8] reported the average distance of the basilar tip above the dorsum to be 1.9 mm (range, 0–6.5 mm) based upon angiographic studies, while Radner [11] found it to be at the level of, or as high as 1 cm above, the anterior clinoid line. The highest value of the basilar tip reported by Krayenbühl and Yasargil [12] was 13 mm above this line. Others have reported the bifurcation to occur within the interpeduncular cistern [9, 10]. Greitz and Löfstedt [10] considered the normal basilar bifurcation to be within the posterior superior quadrant of a circle with a radius of 20 mm and a center close to the dorsum sellae. According to Deeb et al. [6], on CT the "normal basilar tip appears as a dot immediately anterior to the pons or between the cerebral peduncles." We imaged the basilar bifurcation within the interpeduncular cistern, at the level of the dorsum, or within the suprasellar cistern, just slightly below the third ventricle floor, in 92% of our cases. Termination above this level is considered to be abnormal.

Position of the Basilar Artery

We found that the normal basilar artery is midline in its course 55% of the time and paramedian, but medial to the lateral margin of the clivus and dorsum sellae, 43% of the time (table 3). This generally agrees with the findings of Weisberg [7], who, based on CT studies, described the position of the basilar artery as "usually midline but eccentric in one-quarter of cases." Takahashi [9] described the course of the basilar artery as "frequently curved or tortuous and often deviated slightly from the midline." Adachi (cited in [9])

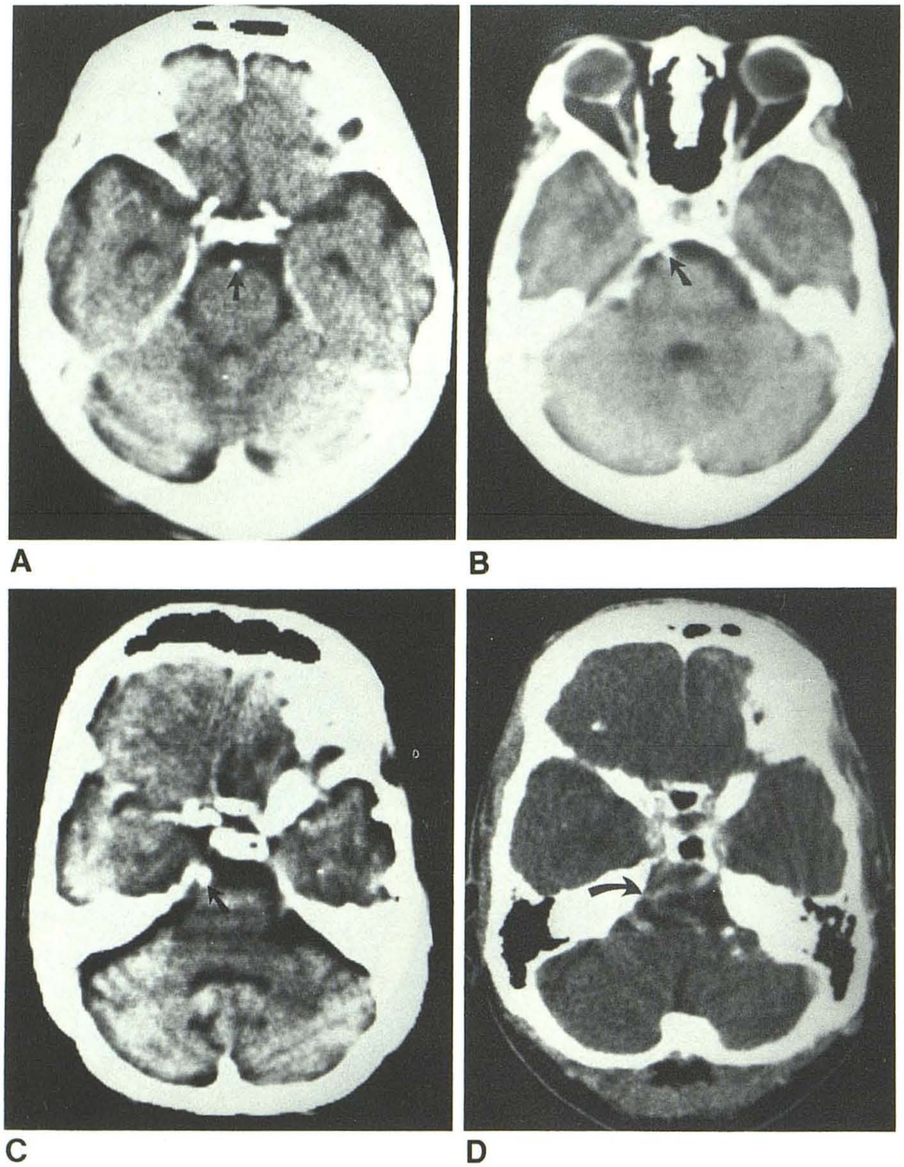

Fig. 2.—Examples for assignment of most transverse position (P) of basilar artery (*arrows*) (see table 3). **A**, P = O. Midline position. **B**, P = 1. Artery is paramedian in position, but medial to lateral clivus margin; **C**, P = 2. Artery courses lateral to lateral margin of dorsum sellae; **D**, P = 3. Basilar artery originates in right CPA cistern. Distal vertebral arteries are clearly demonstrated.

TABLE 3: **Criteria for Assignment of Basilar Artery Position**

Position	Most Lateral Position Identified throughout Course of Basilar Artery
0	Midline throughout
1 (R or L)	Medial to lateral margin of clivus or dorsum sellae
2 (R or L)	Lateral to lateral margin of clivus or dorsum sellae
3 (R or L)	In cerebellopontine angle cistern

found a perfectly straight course of the basilar artery in only 25% of patients. In only 2% of our "normal" cases was the basilar artery lateral to the clivus margin (or dorsum sellae) at some point throughout its course.

When the basilar artery is paramedian in location, it is to the right of midline (26.2%) more often than to the left (17.5%). This may be explained hemodynamically: When one vertebral artery is dominant, the left vertebral artery is more often larger than the right [16–19], resulting in flow-related deviation of

TABLE 4: **Distribution of Basilar Artery Measurements**

Measurement	No. (%)
Diameter (mm):	
1.60	3 (2.4)
1.87	5 (4.0)
2.14	4 (3.2)
2.40	5 (4.0)
2.67	23 (18.2)
2.93	12 (9.5)
3.20	31 (24.6)
3.47	14 (11.1)
3.74	9 (7.1)
4.01	13 (10.3)
4.27	2 (1.6)
4.54	1 (0.8)
4.81	2 (1.6)
5.34	1 (0.8)
6.14	1 (0.8)
Total	126 (100.0)
Height:	
0	45 (35.7)
1	71 (56.4)
2	10 (7.9)
3	0
Total	126 (100.0)
Position:	
0	69 (54.8)
1R	33 (26.2)
1L	22 (17.4)
2R	1 (0.8)
2L	1 (0.8)
Total	126 (100.0)

TABLE 5: **Distribution Statistics (n = 126)**

	Diameter (mm)	Height	Position
Mean	3.17	...	...
Median	3.20	...	...
Standard deviation	0.726	...	...
Normal range	1.86–4.53	0–1	0–1
% Normal	95	92	98
Criteria for abnormality	≤1.85 ≥4.54	≥2	≥2

TABLE 6: **Nonparametric (Spearman rho) Correlations**

	Age	Position (deviation)	Height
Position	0.30	...	...
(Deviation)	0.002*	...	...
Height	0.22	0.38	...
	0.02	0.000*	...
Diameter	0.15	0.26	0.36
	0.097	0.006*	0.000*

* $p < 0.05/6 = 0.01$

the basilar artery to the right.

We consider the position of the basilar artery to be normal if it lies medial to the margin of the clivus or dorsum sellae throughout its course. Demonstration of any part of the artery lateral to the clivus or dorsum is considered to be abnormal.

ACKNOWLEDGMENTS

We thank Kevin S. Berbaum for performing the statistical analysis on our data and Trish Blaylock for assistance in manuscript preparation.

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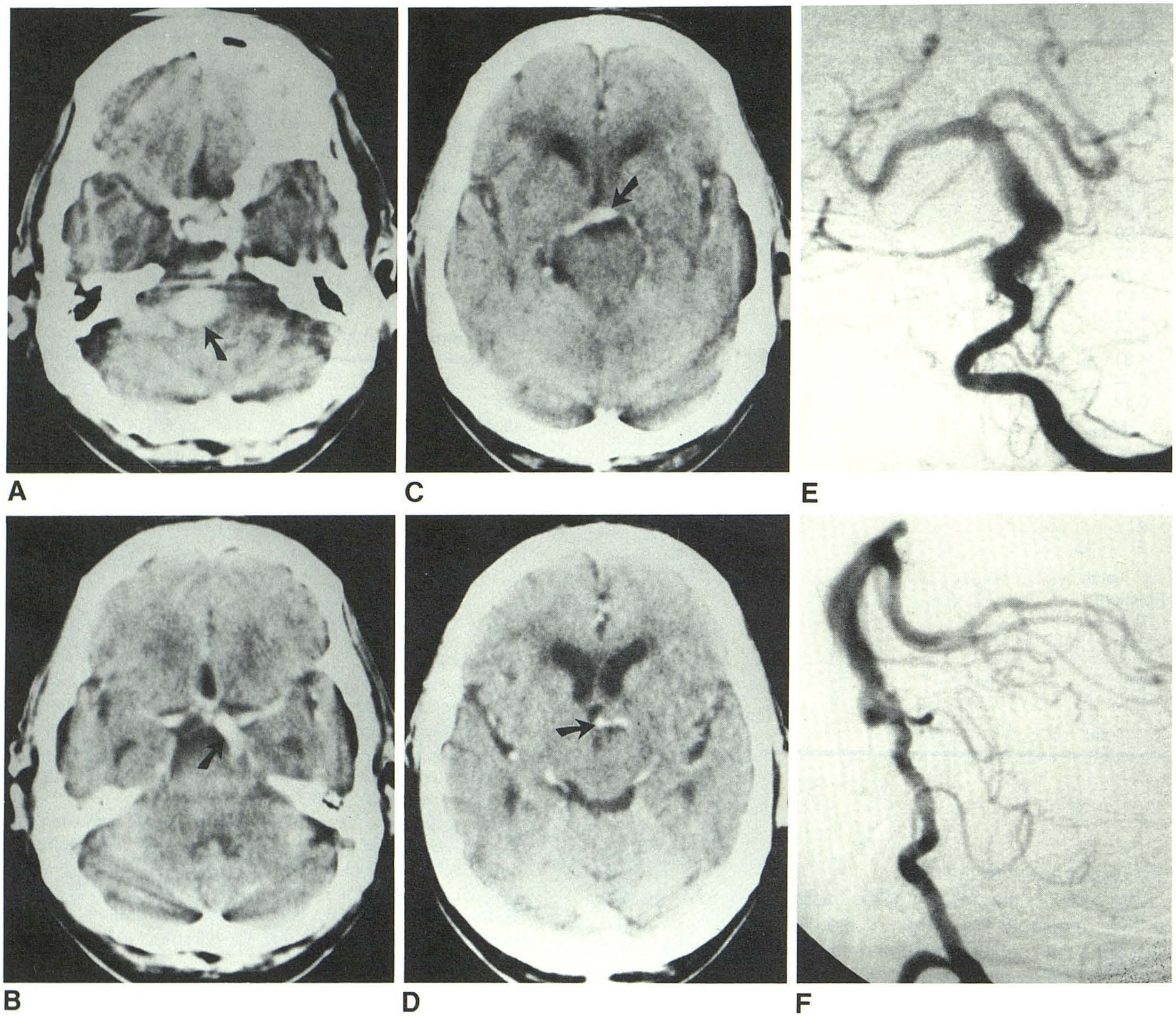

Fig. 3.—Discrepancy between diameter of basilar artery (*arrows*) as seen on serial CT sections and angiography. **A**, Marked ectasia of proximal basilar artery. **B**, Moderate ectasia at level of suprasellar cistern. **C** and **D**, More distal parts of basilar artery appear only mildly ectatic. Anteroposterior (**E**) and lateral (**F**) intraarterial digital subtraction angiograms reveal atherosclerotic plaguing and subsequent irregularity of basilar artery, which appears mild to moderately ectatic throughout its course. No area is identified in proximal part, which corresponds to area of marked ectasia on CT (**A**). Axial CT section was obtained in plane with basilar artery oriented transversely. This, combined with partial-volume averaging, produced "false ectasia" on CT.

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