Relative Diagnostic Value of Air Study and Angiography in Suprasellar Masses

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Experience has shown that changes in the size and configuration of the sella turcica associated with visual symptoms with or without endocrinological deficiency indicate the presence of a sellar or suprasellar tumor but these signs do not indicate the exact location, size, or type of the neoplasm. Pneumoencephalography usually will give adequate information as to the size, shape, and degree of suprasellar extension of these tumors. The increasingly routine use of carotid angiography for all supratentorial lesions has not been evaluated properly from the point of view of these small midline basal neoplasms. It is our purpose to evaluate the relative efficacy of angiography versus encephalography for the delineation of sellar and parasellar tumors. Several authors in the past⁶,⁸,¹¹ have considered pneumography more reliable than angiography for the evaluation of the extrasellar extensions of pituitary adenomas. However, Chase and Taveras⁵ concluded recently that pneumography was superior in only 48 per cent of cases; both procedures were considered equal in 27 per cent and arteriography was considered superior in 25 per cent. El-Banhawy and El-Nadi⁴ came to the conclusion that both encephalography and angiography are important and complementary procedures for the investigation of sellar and suprasellar space-occupying lesions.

Material and Method

The material used in this study consists of 28 cases of space-occupying lesions arising from the pituitary gland, the sella turcica or immediately adjacent structures. All patients were seen by one or both of the authors at the Massachusetts General Hospital or at the Buffalo General Hospital. Only patients who had air studies and angiography performed during one hospitalization were included in order to obtain truly comprehensive data regarding the relative value of the two contrast studies. The majority had bilateral carotid angiograms, but those who had unilateral angiograms had contralateral compression for visualization of both anterior cerebral arteries.

A comparison of the important anatomical landmarks visualized on air studies and in angiography shows them to be in different anatomical position. The horizontal portion of the anterior cerebral artery corresponds fairly well to the chiasmatic cistern, but the ascending portion of the same artery is situated at some distance from the corresponding structures visualized on air studies—the frontal horn and cisterna laminae terminalis. Changes in the configuration of the carotid siphon and the supraclinoid part of the internal carotid artery are usually, but not always, reflected by changes in the outline of the sella turcica, chiasmatic cistern and anterior part of the third ventricle, respectively. Even less comparable is the relationship between the middle cerebral artery, the anterior choroidal artery and the temporal horn. Considering the spatial differences between these landmarks, it is not surprising that individual cases show changes of diagnostic value on air studies which may escape detection on angiograms and vice versa.

Chromophobe Adenomas

The sella turcica was greatly enlarged and the posterior clinoid processes were eroded or completely destroyed in 10 cases. It was normal in every respect in 1 patient.

All adenomas were verified by surgery. They varied in size, but none of them was
unusually large. This makes their radiological evaluation more valuable than would be the case with truly large tumors when any diagnostic roentgen-ray procedure would be informative. In 2 patients the adenoma was confined to the enlarged sella with minimal growth above the diaphragma sellae. Of the other 9 patients, the extrasellar extension pointed upward in 7. This upward extension varied from 0.5 to 2.5 cm. above the diaphragma sellae. In 2 patients, the extension was predominantly lateral.

Pneumography. The superior extension was outlined in lateral projections by air in the chiasmatic and crural cisterns which were filled in all cases. In all but 1 case, the outline of the suprasellar extension was enhanced further by a filling defect in the anterior inferior portion of the third ventricle (Figs. 1 and 2). A further advantage of the lateral projection is the ease with which the extension in an anteroposterior direction can be demonstrated. In anteroposterior projection the blunted lower end of the third ventricle indicates the height of the "dome" of the tumor (Fig. 1). Air studies indicated the extent of lateral projection of the tumor in only 4 patients. Asymmetry of the posterior portions of the olfactory sulci was the only indication of lateral extension in 1 of the patients. In the other patient with palsies of the 3rd and 6th nerves, the air study failed to indicate the lateral extension on the floor of the middle fossa, although this was found to be quite impressive at the time of operation.

Arteriography. The supraclinoidal portion of the internal carotid artery showed some degree of lateral displacement on anteroposterior views in 9 of the 11 patients. This displacement was slight in many cases and could not be classified definitely as abnormal had it not been associated with other changes of the arterial tree. The typical deformity noted on the lateral projection was a widening of the anterior genu or complete "uncoiling" of the siphon with occasional changes in caliber in the parasellar area (Fig. 3). This deformity was evident in 10 of the 11 cases including those of purely intrasellar adenoma. A considerable variation in the configuration of the two internal carotid arteries was noted in 4 patients although their adenoma was in the midline. The internal carotid arteries are seldom symmetrical even in normal subjects; a feature that accounts for the difficulty encountered in recognizing mild displacements or stretching of the arterial tree met with in these lesions. El-Banhawy and El-Nadi correctly described asymmetrical displacements of the carotid siphon as being characteristic of all sellar and suprasellar growths, but this asymmetry is even
more significant in purely intrasellar lesions. Bilateral angiograms, then, are necessary to draw maximum conclusions from this procedure. In the 2 patients with lateral extension of the adenoma there was further lateral displacement of the internal carotid artery on anteroposterior projection and in 1 case considerable narrowing of the artery on the side of the lateral extension.

Suprasellar extension of the adenoma would be expected to elevate the carotid bifurcation in anteroposterior projection. In the lateral projection this results in straightening and elevation of the supraclinoid portion of the carotid artery. This same displacement of the supraclinoid portion of the carotid artery is difficult to assess on anteroposterior projection since slight variations in the angulation of the central beam can simulate elevation or depression of the carotid bifurcation. It was seen definitely in only half of the cases. Displacements of the anterior cerebral artery are much more important for the demonstration of the suprasellar extension of the adenomas. In the lateral projection this elevation results in a smooth upward and backward curve of the first portion or the first and second portions of the anterior cerebral arteries. However, this sign alone is difficult to differentiate from a normal variation of the anterior cerebral artery. The anteroposterior projection is more valuable in this respect. The first portion of the artery is displaced upward in a curve which together with its mate from the opposite side outlines the dome of the suprasellar mass. This was seen very clearly in 5 of the 9 patients with suprasellar extension. In another 2, it was present to a lesser degree unilaterally. In the remaining 2 patients the course of the anterior cerebral artery had to be classified as normal. The changes in the anterior cerebral arteries were less pronounced when the carotid bifurcation itself was elevated. It is not surprising that the anterior cerebral arteries were less affected with predominantly lateral extension of the adenoma. The course of the anterior cerebral arteries can be quite normal even in the presence of large suprasellar extensions provided the extension is directed posteriorly behind the level of the anterior cerebral arteries (Fig. 1). A suprasellar mass of the same size when extending anteriorly is well outlined on arteriogram (Fig. 2). The anterior cerebral artery was of smaller caliber on one side in 4 out of 10 cases. The narrowing usually occurs on the side of the major portion of the adenoma. This sign is of minor importance unless it is associated with upward displacement of the artery.

The middle cerebral arteries showed no
abnormality. The posterior cerebral arteries when visualized were normal except in 1 patient with lateral extension of the adenoma. In this case the corresponding posterior communicating artery was elevated and stretched. Superior displacement of the anterior choroidal artery and the ganglionic branches was observed in 2 patients. These displacements by themselves did not add much to the diagnostic value of the angiogram. We have not observed tumor staining or true pathological vessels in the adenomas.

In summary, arteriography may supplement but does not supplant the air study in cases of pituitary adenoma. Changes in the course of the internal carotid artery usually reflect only the enlargement of the sella, although elevation of the terminal portion is indicative of suprasellar extension. The visualization of a large adenoma that bulges out from a greatly enlarged sella without extending high above the diaphragma sellae is accomplished better with air (Fig. 3). A high suprasellar dome usually is well outlined by either method. Posterior extensions can escape detection even in bilateral angiograms. In contrast to this, pneumograms with adequate filling of the suprasellar cisterns and of the third ventricle usually furnish all the necessary information.

**Craniopharyngiomas**

Five patients with craniopharyngioma were subjected to pneumography and bilateral carotid angiography. The sella tureica was normal in 4 cases. In 2 of the 5 patients, suprasellar calcification was evident on plain roentgenograms of the skull. At operation all patients showed large, partially solid and partially cystic tumors situated above the sella extending posterior to the sella.

**Pneumography.** In 2 patients the chiasmatic and crural cisterns were obliterated completely, a frequent finding in these tumors. A third patient showed maximum filling of the suprasellar cisterns, but this was too slight and irregular to be of diagnostic value. Another patient had good cisternal filling with a mass outlined anteriorly by the chiasmatic cistern and posteriorly by the crural cistern (Fig. 4). The 5th patient had complete obstruction of the interventricular foramina and ventriculography had to be performed and the cisterns could not be studied. However, the extent of the tumor was outlined clearly by the deformity in the third ventricle. This consisted in all cases of a large, round, concave filling defect in the anterior half of the ventricle reaching back to the level of the interventricular foramen (Figs. 4 and 5). The true size of these lesions

![Fig. 3. M. K., MGH 955677. Chromophobe adenoma.](image-url)
was considerably larger than the area of calcification. One patient showed some defect at the base of the anterior horns of the lateral ventricles (Fig. 6). The ventricular system was enlarged in 3 of the patients.

Carotid Arteriography. The carotid siphon was normal in 3 patients. In the remaining 2 the supraclinoid portion of the artery was displaced upward resulting in an opening of the siphon (Fig. 5). The anterior cerebral artery showed a backward and upward curve of its second portion on lateral projection in 1 patient (Fig. 4). In anteroposterior projections the anterior cerebral arteries were either normal or only slightly elevated in the midline (Figs. 4 and 6). The changes in the course of this vessel were mild and quite out of proportion to the true extent of the lesion.

The posterior communicating arteries, posterior cerebral arteries, and anterior choroidal arteries were displaced superiorly and laterally in 2 patients. Chase and Taveras have noted the importance of this finding, stating that it may be the only
arteriographic finding to suggest the presence of a posterior suprasellar mass.

In summary, air studies are the contrast method of choice for large craniopharyngiomas when neither changes in size of the sella nor calcification indicate the true size of the neoplasm (Fig. 5). The most consistent and reliable sign noted is the deformity of the third ventricle in the lateral view. The suprasellar cisterns are obliterated more frequently than in cases of suprasellar adenomas. Carotid arteriography was of inferior value in this series for the diagnosis of craniopharyngiomas. The anterior cerebral artery frequently is too far anterior to the mass of tumor to be sufficiently distorted for accurate diagnosis.

Meningiomas

There were 9 patients in this group. The tumors originated from the tuberculum sellae or anterior clinoids and extended upward and posteriorly, encroaching on the pituitary fossa and adjacent structures. Their size varied from 1 to 2.5 cm. in diameter. All were verified surgically. The sella was not enlarged in any of these patients and was completely normal in 2. In the others, various degrees of erosion and hyperostosis could be seen.

Pneumography. The tumor was visible in the lateral view in every case. We have seen cases of meningiomas of the tuberculum sellae with anterior-superior extension in the past (not included in this group since arteriography was not performed) in which the lesion was not evident on air studies since the mass was anterior to the chiasmatic cistern. Robertson* has stressed the necessity for careful inspection of the films to avoid missing even large meningiomas of this type. The crural cistern was filled in all of our cases, the chiasmatic cistern in all but 1. In 6 patients the chiasmatic cistern outlined the anterior border of the neoplasm (Figs. 7, 8 and 9).

The third ventricle showed a characteristic concave filling defect in its anterior portion on the lateral view. There was also posterior displacement of the interventricular foramen and the deformed third ventricle was displaced posteriorly in half of the cases. The anteroposterior views were less revealing. In 6 patients the lower end of the third ventricle was cut off (Fig. 7). The cisterns were filled sufficiently in only 4 patients to indicate the transverse diameter of the meningioma.

Carotid Arteriography. The suprachlinoi d portion of the internal carotid artery was

Fig. 6. L. B., BGH C74708. Craniopharyngioma.
elevated in 6 cases. In the lateral view this was demonstrated by an uncoiling of the siphon and posterior displacement of the supraclinoid portion. In anteroposterior projection this was revealed by upward and lateral displacement of the bifurcation of the internal carotid artery (Figs. 7 and 8). This finding was evident in 6 of the patients. The terminal portion of the siphon was narrowed in 1 patient. In another it was displaced downward, closing the siphon.

The anterior cerebral arteries showed the most striking change. In 5 of the patients these vessels outlined the tumor in the anteroposterior projection (Figs. 7 and 8). The horizontal portion of the anterior cerebral artery was displaced upward and laterally, forming an arch over the dome of the tumor. The lateral view showed some posterior displacement of the first portion of the anterior cerebral arteries (Figs. 7 and 8). In a 6th patient both anterior cerebral arteries were unusually narrow but not displaced. Two patients had entirely normal bilateral arterio-
grams without any changes in either the internal carotid or anterior cerebral arteries.

Direct visualization of the tumor by its vessels occurred only once; there was a typical vascular “blush” in the late arterial phase. In another patient, two small arteries could be seen along the tumor capsule.

The relatively small size of the meningiomas in our series accounts for the variations in our findings. Tucker et al.\textsuperscript{10} found that in large tumors the bifurcation of the internal carotid artery frequently was displaced posteriorly and compressed downward. Chase and Taveras\textsuperscript{2} also stated that tumors in the anterior suprasellar area tend to produce downward and posterior displacement of the siphon. This occurred in only 1 of our patients. Irregularities in the size of the lumen of the internal carotid and anterior cerebral arteries, or both, were noted in more than half of the angiograms in the series of Tucker et al.\textsuperscript{10} because large meningiomas of the tuberculum sellae often surround and compress these arteries. Staining of tumor vessels in the same series occurred in only 4 out of 17 cases.

In summary, arteriography is more reliable in outlining suprasellar meningiomas than other masses that occur in the suprasellar area. The superiority of angiography with these lesions is accounted for by the anterior position of these tumors and their close association to the anterior cerebral arteries. For the same reason, air studies may fail to reveal the tumor, although this has not occurred in our series. Occasionally, a small meningioma protruding over the sella produces distortion of the cisterns without displacing vessels. Tumor vessels are visualized infrequently.

**Aneurysms**

Aneurysms occurring in the carotid tree encroaching on the sella can simulate pituitary adenoma to such perfection that differential diagnosis is impossible on the basis of visual, endocrinological, or sellar changes alone. A typical example included in the present series showed progressive enlargement of the sella. The sellar volume increased from 1,160 mm\textsuperscript{3} to nearly 6,000 mm\textsuperscript{3} within 5 years. The air study failed to differentiate between aneurysm and pituitary tumor with suprasellar extension. Such cases are the strongest indication for arteriography despite the relative rarity of these aneurysms. This case also stresses the necessity of bilateral visualization of the arteries. Although

\[\text{Fig. 9. B. C., MGH 1090675. Tuberculum sellae meningioma.}\]
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Fig. 10. M. McC., MGH 160979. Adenocarcinoma of the sphenoid sinus.

the aneurysm was very large, it filled exclusively from one side. Contralateral angiograms showed only displacement of the anterior cerebral artery as with any suprasellar mass.

One of our cases illustrates the reverse error in diagnosis; i.e., suspicion of an aneurysm in a case of chromophobe adenoma. This patient had diminished visual acuity, bitemporal hemianopsia and minimal evidence of hypopituitarism. Plain roentgenograms showed a considerably enlarged sella with thinning of the posterior clinoids and erosion of the floor. He had experienced several episodes of severe epistaxis. They always were preceded by severe occipital headache, nuchal rigidity and nausea. During two of these episodes, a lumbar puncture was performed and bloody cerebrospinal fluid was obtained under increased pressure. With the history of repeated episodes of subarachnoid hemorrhage associated with sellar erosion, a tentative diagnosis of aneurysm was made. Bilateral carotid angiograms failed to show an aneurysm and operation revealed a typical chromophobe adenoma.

Other Conditions

In 1 patient an adenocarcinoma of the sphenoid sinus invaded the sella and simulated a primary pituitary neoplasm (Fig. 10). The sella was enlarged and eroded. Pneumography demonstrated a suprasellar extension of the lesion by elevation of the interpeduncular cistern and obliteration of the chiasmatic cistern. The anterior recesses of the third ventricle were obliterated and its floor was elevated. Carotid angiograms were for the most part noncontributory. The only sign was a slight opening of the siphon. This could represent a normal variant in an arteriosclerotic 71-year-old patient.

Another patient presented bitemporal hemianopsia without endocrinological deficiency and an apparently normal sella. Pneumography revealed normal cisterns and ventricles except for complete lack of filling of the chiasmatic cisterns. Angiography showed normal internal carotid arteries. The horizontal part of the anterior cerebral arteries was elevated near the midline on antero-posterior projection. This portion also was displaced somewhat posteriorly in the lateral projection. At operation, no tumor was encountered but the chiasmatic cistern was greatly enlarged and filled with trapped cerebrospinal fluid. This was in agreement with radiographic findings and a diagnosis of optochiasmatic arachnitis was made.

Discussion

The distortion of the ventricles and subarachnoid cisterns by tumors in the vicinity of the sella turcica is well known. The angio-
graphic changes, on the other hand, are not so well defined. Curry and Culbreth have pointed out that normal variations of the upper part of the internal carotid artery may be interpreted erroneously as parasellar masses. Variations in angulation of the central ray can produce or exaggerate normal variations or mask real changes.

There have been few true comparisons of the two methods of contrast examination. Chase and Taveras in their work on angiography in suprasellar tumors stated that pneumography is superior to angiography in that it gives a more precise indication of the size and shape of the tumor. In general, angiography is considered superior to pneumography when it gives specific histological diagnosis by visualization of tumor circulation, or by visualization of a vascular lesion such as aneurysm. We might add that in our hands angiographic visualization of tumor vessels in these lesions proved to be the exception. Chase and Taveras also mentioned that small tumors of the tuberculum sellae are difficult to detect angiographically and that posterior suprasellar tumors with no intrasellar component are the most difficult to diagnose by angiography. Our findings support this view.

El-Banhawy and El-Nadi reached similar conclusions. They felt that encephalography and angiography are complementary procedures. Their summary on the relative value of the two contrast methods is certainly valid: "Encephalography provides us with a cross section of the tumor in the sagittal plane at the middle line, while angiography illustrates a cross section in the coronal plane at the level of the anterior cerebral arteries." However, as Hanelin and Bakay have pointed out, it is not generally appreciated that the suprasellar cisterns (cisterna laminae terminalis, cisterna chiasmatis, cisterna interpeduncularis) and the cisterna pontis often can be visualized on the anteroposterior projection. If the transverse diameter of a suprasellar mass is 2 cm. or more, the resulting deformity of the suprasellar cisterns can be detected with a central-ray angulation of 20 to 35 degrees. A mass less than 2 cm. in transverse diameter is not detectable on the anteroposterior projection since it will cause no lateral bulging of the cisterns.

An uncontestable advantage of carotid angiography is its ability to demonstrate an aneurysm in the sellar region that could simulate a neoplasm in air studies. The rare incidence of these aneurysms (about 1 per cent of all sellar lesions) detracts somewhat from the practical importance of this advantage. Furthermore, even bilateral angiography sometimes fails to demonstrate the aneurysm because of lack of filling of the aneurysmal sac.

Angiography does have a potential advantage in the follow-up studies of patients operated upon. Obliteration of the suprasellar cisterns, particularly the chiasmatic cistern, frequently follows transfrontal exploration of the sella which may render evaluation by pneumography difficult, although deformity of the third ventricle may be sufficient for this purpose.

**Summary**

The relative diagnostic value of pneumoencephalography and carotid arteriography was studied in 28 patients with space-occupying lesions arising from the pituitary gland, sella turcica or immediately adjacent structures. Only patients who had air studies and angiography performed during one hospitalization were included in this series.

In cases of pituitary adenoma angiography supplements but does not supplant air studies. Pneumography was always diagnostic of extrasellar extension while angiography might not reveal a posterior-superior extension.

Air studies are the contrast method of choice for craniopharyngiomas when neither changes in the size of the sella nor calcification indicate the true size of the neoplasm. Carotid angiography was of inferior diagnostic value in this series because the anterior cerebral artery frequently is too far anterior to the tumor to be sufficiently distorted for diagnosis.

Arteriography is more reliable in outlining
suprasellar meningiomas than other masses that occur in the suprasellar area. The superiority of angiography is accounted for by the anterior position of these tumors and their close association to the anterior cerebral arteries. For the same reason, pneumography might fail to reveal the tumor, although this has not occurred in this series.

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