CALCIFICATION IN INTRACRANIAL NEOPLASMS *

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This study of the histopathologic patterns of calcification was undertaken to provide a basis for the interpretation of the roentgenographic appearance of the shadows cast by these deposits, since the presence of calcium salts in intracranial neoplasms affords an accurate localization of such lesions in routine roentgenograms.

MATERIAL AND METHODS

The histologically verified intracranial tumors of all types treated in the Department of Surgery during the period 1930–1950 were reviewed. The series consisted of 1577 neoplasms.

Our classification of the material generally follows that of Bailey and Cushing,[1] except that spongioblastoma polare has been grouped with the astroblastomas. For purposes of comparison with the series of other authors an attempt was made also to regroup the tumors within the concept of gliomas introduced by Kernohan.[2,3]

In cases difficult to classify, additional sections and special stains were used. The stains were hematoxylin and eosin, Mallory's phosphotungstic acid hematoxylin, Heidenhain's azan, Nissl's azure eosin, Perdrau's, and in the more recent material, Hortega's silver carbonate methods.

Gross morphology is not reviewed in this report as it has been considered by others.[4-7]

HISTOLOGIC PATTERNS OF CALCIFICATION

For the sake of classification, calcium deposits were grouped according to the occurrence of the dominant histologic pattern, and were divided into four types.

Pattern I. The type of calcification most frequently encountered occurred within blood vessel walls. This form, designated as pattern I, shows small globules or calcospherites within the adventitia or media of the smaller vessels and the endothelium of capillaries. In early stages these calcospherites appear as spherical or coalesced globules marking the course of the involved vessel. In more advanced stages the vessels are entirely calcified, have no lumina, and appear as solid cylinders (Figs. 1 to 4). In larger vessels, the calcium deposits appear

* Received for publication, February 26, 1952.

as small, spherical globules within the media. Coalescence of these globules in later stages converts the vessel into a rigid tube which appears in cross section as a ring of calcium.[8]

Pattern II. When the changes described as pattern I involve adjacent blood vessels whose zones of necrosis overlap (Fig. 13), concentric layers of calcium marking the former site of each vessel result in a conglomerate mass of calcium. This is designated as pattern II. It superficially resembles pattern III.

Pattern III. In pattern III calcium salts are deposited in an area of old hemorrhage or necrosis. A solid layer of calcium having irregular borders and no discernible vascular pattern is seen (Figs. 7 and 8).

Pattern IV. Pattern IV consists of several types: (a) globules of calcium as seen within tumor cells (Figs. 15 and 16), (b) calcific changes within the stroma of a tumor or its capsule (Figs. 9 to 11), (c) calcific changes at the periphery of a tumor, but not related to types (a) or (b). Under certain conditions, as, for instance, the presence of psammoma bodies, it was not always possible to determine whether the calcification occurred within blood vessel walls or within tumor elements.

Pathogenesis of Calcification

Chemical studies were not undertaken. Fully developed calcification gives no indication as to its origin, but many stages of the development of calcified areas were observed. In patterns I and II, uninvolved vessels in the vicinity of those calcified showed swelling and hyalinization of their walls. By the time calcium droplets could be seen, nuclear structure was no longer observed. It thus appeared that necrosis was associated with the deposition of calcium, at least in some of the vessels.

The antecedent necrosis in pattern III was often evident even after calcification was advanced. Ischemic or hemorrhagic infarction appeared to be the basis of the necrosis. In pattern IV, psammoma bodies were frequently associated with hyalinization and calcified cells were obviously non-viable. The earlier stages of these types were not observed. An explanation for the interstitial calcium deposits was not apparent.

Incidence of Calcification

On histologic examination, calcification was found in 207 or 13.1 per cent of 1577 intracranial tumors. Pattern I was most common and occurred 93 times with the highest incidence in the oligodendrogliomas (15 of 34 cases). Pattern IV was seen in 85 tumors, chiefly craniopharyngiomas (39 of 58 cases). Pattern III was present in 20

tumors of which 5 were ependymomas (5 of 55 ependymomas). Pattern II was least often represented, occurring only 9 times in the series, with a tendency to be associated with glioblastoma multiforme. These figures, however, are not statistically significant (Tables I and II).

Location of Calcium Deposits

Tumors of the Cerebral Hemispheres

Supratentorial gliomas of the cerebral hemispheres showed calcium deposits in 12.5 per cent, the incidence varying with the tumor type, being highest in the oligodendrogliomas (53 per cent) and high, also, in the ependymomas (32.2 per cent). The most common type of calcification was pattern I, which occurred most frequently in oligodendrogliomas (Fig. 2 and Table I). In the category of neuroblastic tumors, which include the neurocytomas and neuroblastomas, calcification was seen in 3 of 7 cases, one case showing calcification of blastomatous neurons (Figs. 15 and 16). Among the gliomas limited primarily to one lobe (determined by necropsy and operative findings), calcification was found more commonly in the frontal region, usually within oligodendrogliomas or astrocytomas (Table III).

The largest number of calcified gliomas (reclassified according to Kernohan[2]) occurred in astrocytomas, grades 2 and 3 (25 of 284 tumors) (Tables V and VI).

The ependymomas showed calcification in 10 cases of which 8 were classified histologically[9] as the cellular type and 2 as the myxopapillary type. One of the two papillomas of the choroid plexus of a lateral ventricle was found to have calcium deposits.

Calcium deposits were present in 40, or 18.6 per cent, of 215 meningiomas; 34 calcified tumors belonged to the supratentorial group. Among these cases there were 28 of meningotheliomatous, 4 of psammomatous, and 2 of lipomatous type.[6,10] Calcification in meningiomas occurred typically in the hyalinized vessels of the whorl formations (Fig. 14). In this group the calcified tumors were located more frequently in the frontal and parasagittal regions (Tables III and IV).

Tumors in the Region of the Third Ventricle

Among the tumors of the region of the third ventricle occur the gliomas arising primarily in the basal ganglia and thalamus. Although glioblastoma multiforme occurred most frequently in this region, calcification in these structures was limited to astrocytomas, oligodendrogliomas, and ependymomas. Calcification was observed in one tumor of the optic nerve (spongioblastoma polare). None of the colloid cysts

TABLE I

Microscopic Calcification in Supratentorial Tumors (1930–1950)

		Sex		Age (years)					Average age (years)	Average duration of preoperative symptoms (months)	No. operated upon	No. necropsied	No. receiving x-ray therapy	5-yr. survival	No. tumors of various patterns of calcification				No. with calcification visible roentgenologically
		M	F	0–15	16–30	31–40	41–50	Over 50							I	II	III	IV	
Astrocytoma	Total.....165	109	56	14	45	51	37	18	34	20	163	37	7	14					
	No. calc... 24	15	9	1	7	8	6	2	35	21	24	3	2	5	16	0	3	5	14
Astroblastoma	Total..... 31	22	9	7	4	4	7	9	37	12	29	12	3	6					
	No. calc... 3	3	0	0	0	1	1	1	51	5	2	1	1	1	3	0	0	0	0
Glioblastoma multiforme	Total.....398	263	135	14	39	66	138	141	45	7	388	119	21	4					
	No. calc... 25	16	9	1	8	2	6	8	40	13	23	9	3	0	12	4	3	6	4
Oligodendroglioma	Total..... 34	19	15	3	7	5	7	12	39	20	34	10	0	8					
	No. calc... 18	9	9	2	4	2	3	7	35	10	18	7	0	7	15	0	1	2	14
Ependymoma	Total..... 31	15	16	13	8	5	3	2	22	19	31	6	6	11					
	No. calc... 10	5	5	5	3	2	0	0	16	46	10	2	2	6	3	2	4	1	6
Neuroblastic tumors	Total..... 7	2	5	1	3	1	2	0	31	41	7	0	0	0					
	No. calc... 3	0	3	1	2	0	0	0	20	25	2	0	0	0	1	1	0	1	2
Papilloma of choroid plexus	Total..... 3	1	2	1	2	0	0	0	16	36	3	1	1	1					
	No. calc... 1	0	1	0	1	0	0	0	20	1	1	0	0	1	1	0	0	0	0
Colloid cyst	Total..... 8	4	4	1	5	1	1	0	25	16	7	3	0	2					
	No. calc... 0																		
Tumors of pineal region	Total..... 19	13	6	9	6	2	0	2	23	11	18	15	4	2					
	No. calc... 8	5	3	4	2	0	0	2	29	15	8	7	1	1	6	0	1	1	7
Teratoma	No. calc... 4	4	0	4	0	0	0	0	7	1	3	3	1	1	0	0	0	4	0
Pituitary tumors	Total..... 97	50	47	3	19	24	33	18	41	28	96	20	27	33					
	No. calc... 5	2	3	0	2	2	0	1	36	9	4	3	2	1	1	0	2	2	1
Craniopharyngioma	Total..... 58	33	25	28	9	9	8	4	22	19	58	14	0	13					
	No. calc... 39	23	16	22	6	3	5	3	10	17	39	12	0	7	0	0	0	39	30
Optic nerve tumors	Total..... 16	8	8	14	0	0	0	2	15	21	16	5	2	7					
	No. calc... 1	1	0	1	0	0	0	0	15	72	1	1	0	0	0	0	0	1	0
Meningioma	Total.....193	78	115	3	20	33	73	64	45	27	186	32	2	67					
	No. calc... 34	9	25	1	1	4	14	14	50	32	31	6	0	14	16	1	1	16	19
Sarcoma	Total..... 23	12	11	4	3	4	9	3	37	8	23	4	5	2					
	No. calc... 2	2	0	0	0	0	2	0	46	42	2	0	1	1	0	0	1	1	2
Metastatic tumors	Total..... 72	48	24	0	4	11	21	36	49	6	72	9	1	0					
	No. calc... 1	1	0	0	0	0	1	0	45	9	1	0	0	0	1	0	0	0	0

Total, 1155; with calcification, 178

TABLE II

Microscopic Calcification in Posterior Fossa Tumors (1930–1950)

		Sex		Age (years)					Average age (years)	Average duration of preoperative symptoms (months)	No. operated upon	No. necropsied	No. receiving x-ray therapy	5-yr. survival	No. tumors of various patterns of calcification				No. with calcification visible roentgenologically
		M	F	0–15	16–30	31–40	41–50	Over 50							I	II	III	IV	
Cerebellar glioma	Total..... 101	44	57	63	25	6	0	7	14	10	98	12	6	44					
	No. calc... 12	7	5	6	5	1	0	0	17	17	12	3	0	6	9	0	2	1	4
Brain stem glioma	Total..... 48	26	22	24	12	5	3	4	21	10	29	36	2	1					
	No. calc... 2	2	0	2	0	0	0	0	13	1	2	1	0	0	2	0	0	0	0
Ependymoma	Total..... 24	13	11	17	1	2	3	1	15	5	22	7	8	2					
	No. calc... 3	2	1	3	0	0	0	0	4	3	3	3	1	0	1	1	1	0	1
Medulloblastoma	Total..... 72	41	31	58	8	6	0	0	11	6	69	19	46	6					
		32	26	58					7	4	55	16	34	4					
	No. calc... 4	4	0	4	0	0	0	0	9	4	4	0	3	0	2	0	1	1	0
Papilloma of choroid plexus	Total..... 6	6	0	0	0	2	4	0	47	9	6	0	1	0					
	No. calc... 2	2	0	0	0	0	2	0	47	13	2	0	0	0	1	0	0	1	0
Acoustic tumors	Total..... 93	38	55	0	18	17	32	26	42	33	91	29	0	22					
	No. calc... 0																		
Hemangioblastoma	Total..... 22	17	5	3	4	5	8	2	36	11	22	7	1	3					
	No. calc... 0																		
Meningioma	Total..... 22	13	9	0	0	4	9	9	49	23	21	4	0	3					
	No. calc... 6	4	2	0	0	1	1	4	55	28	5	1	0	0	3	0	0	3	0
Sarcoma	Total..... 11	9	2	4	7	0	0	0	16	11	11	1	7	0					
	No. calc... 0																		
Metastatic tumors	Total..... 23	15	8	0	1	6	9	7	48	7	23	6	0	0					
	No. calc... 0																		

Total, 422; number with calcification, 29.

of the third ventricle, papillomas of the choroid plexus of the third ventricle, or meningiomas of the tuberculum sellae were calcified (Table III).

Of 58 "craniopharyngiomas," 39 or 67.2 per cent were calcified. Of these 28 were designated as adamantinoma, 22, or 78.6 per cent, of which contained calcium characteristically adjacent to the epithelial

TABLE III

The Occurrence of Calcification as to Location (Operative or Necropsy Findings)

		Involving primarily one cerebral lobe				Involving more than one cerebral lobe
		Frontal	Parietal	Temporal	Occipital	
Astrocytoma	Total	51	20	19	0	60
	No. calc.	8	5	2	0	9
Astroblastoma	Total	8	2	8	1	8
	No. calc.	2	0	0	0	1
Glioblastoma multiforme	Total	72	55	76	6	167
	No. calc.	4	3	7	0	10
Oligodendroglioma	Total	10	4	0	1	15
	No. calc.	6	2	0	1	8
Ependymoma	Total	4	8	8	1	7
	No. calc.	2	1	2	1	3
Meningioma	Total	87	32	40	2	16
	No. calc.	15	7	5	1	5

Tumors of third ventricle and adjacent structures

	Total	No. calc.
Craniopharyngioma	58	39
Pituitary tumors	97	5
Meningioma, tuberculum sellae	4	0
Optic nerve tumors	16	1
Colloid cyst	8	0
Papilloma of choroid plexus	1	0
Tumors of pineal region	19	12
Basal ganglia and thalamus		
Glioblastoma multiforme	26	0
Astrocytoma	21	2
Oligodendroglioma	6	1
Ependymoma	5	2

cells (Fig. 9). In tumors of this group classified as "epithelial" 16 of 28 cases, or 57.1 per cent, were calcified, the calcium being in either the stroma of the tumor (Fig. 11) or in the cystic spaces (Fig. 10). In this group were one teratoid tumor which showed no calcium deposits and one suprasellar teratoma which contained cartilage and bone.

Of 19 tumors of the pineal region 12, or 63.2 per cent, were calcified.

Calcium deposits were found in 7 pinealomas and in one pinealoblastoma. In 4 teratomas of the pineal region the calcium was deposited in cartilage and bone. The most frequent pattern was that of type I, which was present in 6 pinealomas (Fig. 4).

Pituitary neoplasms were classified as chromophobic in 92 cases and eosinophilic in 5. Calcium was found in 5, or 5.4 per cent, of those of chromophobe type (Fig. 12); of these 2 were of pattern III (Table I).

Tumors of the Posterior Fossa

The gliomas of the posterior fossa showed predominance of pattern I with less selectivity as to tumor type. In 94 astrocytomas of the cerebellum, calcification occurred 12 times, or in 12.8 per cent; and in 72 medulloblastomas, 4 times, or 5.6 per cent (Figs. 5 and 6). In

TABLE IV

Locations of Supratentorial Meningiomas

	No. of tumors	No. calc.
Parasagittal		
Frontal	35	6
Parietal	13	4
Frontal	35	3
Parietal	19	3
Temporal	5	0
Occipital	2	1
Fronto-parietal	8	4
Temporo-parietal	4	1
Parieto-occipital	4	0
Sphenoid ridge	36	5
Olfactory groove	18	6
Tuberculum sellae	4	0
Interventricular	4	0
Gasserian ganglion	6	1
Total	193	34

48 astroblastomas (spongioblastoma polare of Bailey) which involved the brain stem, 2 were calcified and both showed pattern I. With reclassification of the cerebellar gliomas, calcification was found most frequently in astrocytoma, grade 2[3] (Table VI).

Of 24 ependymomas of the posterior fossa there were calcium deposits in 3, classified histologically as epithelial type (2 cases) and cellular type (1 case) (Figs. 7 and 8). Two examples of papilloma of the choroid plexus in the fourth ventricle had calcium deposits.

In the posterior fossa, 6, or 27.3 per cent, of the 22 meningiomas were calcified; 5 were of the meningotheliomatous and one of the

psammomatous type. In this region two major tumor groups, acoustic schwannoma (93 cases) and hemangioblastoma of the cerebellum (22 cases), were without calcification (Table II).

Metastatic Tumors

Of 95 examples of surgically treated metastatic tumors, only one, and that from bronchogenic carcinoma, was calcified (pattern I). This group was heterogeneous, with 72 tumors in the supratentorial region

TABLE V

Supratentorial Astrocytomas (Reclassified)

Grade of tumor malignancy	Number of patients	Number of cases with calcification	Average age (years)	Average preoperative duration of symptoms (months)	Average postoperative survival (months)
1	24 (32)	3	31 (33.9)	18.5 (20.8)	28 (73.6)
		3	29	18	50
2	80 (38)	12	33.6 (38.2)	18.2 (11.2)	27 (23.8)
		12	30	18.2	48.5
3	143 (37)	13	45 (40.4)	11.6 (11.8)	10.2 (11.5)
		13	43	11	22.4
4	37 (54)	3	41.7 (42.6)	5.2 (7.3)	12.3 (6.6)
		3	25	8.3	23.3
Total	284				

This material is based on cases who survived over 1 month after operation. Many of these patients are still living. Figures in parentheses are reported figures of Kernohan *et al.*[2,3]

and 23 in the posterior fossa. In the supratentorial group there were 22 tumors from bronchogenic carcinoma, 10 melanoblastomas, 5 hypernephromas, 5 from cutaneous structures, 3 from breast, 2 from oral mucosa, and one each from cervix, rectum, and stomach. One case was a chorio-epithelioma. In 21 cases the site of the primary tumor remained clinically and pathologically obscure.

Of the 23 metastatic tumors in the posterior fossa 8 were of pulmonary origin, 3 hypernephromas, 2 hemangiosarcomas (from ilium and petrous bone), one each from breast, stomach, rectum, rectosigmoid, nasopharynx, ovary, and uterus. In 3 cases the primary site was not established.

CALCIFICATION WITHIN AGE GROUPS

In the age group 0 to 15 years the incidence of calcification was highest in craniopharyngioma (22 of 28, or 78.6 per cent) (Table I). The most frequently calcified cerebral glioma was ependymoma with 5 of 13 examples, or 38.5 per cent. Eight, or 89 per cent, of 9 tumors

of the pineal region were calcified (Table I). Calcification occurred in 9.5 per cent of the astrocytomas of the cerebellum and in 6.9 per cent of medulloblastomas in the posterior fossa tumors of the same age group (Table II).

The gliomas of the adult group (older than 15 years) did not show calcification characteristic of any tumor type or age group. The supratentorial gliomas, glioblastomas, and oligodendrogliomas were more

TABLE VI

Cerebellar Astrocytomas (Reclassified)

Grade of tumor malignancy	Number of patients	Number of cases with calcification	Average age (years)	Average preoperative duration of symptoms (months)	Average postoperative survival (months)
1	32 (109)	3	12.1	9.6 (13.9)	89 (78)
		3	19	24	50.5
2	35 (14)	8	17	17.5 (11.7)	75 (74.6)
		8	18.5	19.3	62
3	9 (8)	1	24	5.5 (8.5)	30 (84)
		1	10	7.5	20
4	0 (0)				
Total	76				

This material is based on cases who survived over 1 month after operation. Many of these patients are still living. Figures in parentheses are reported figures of Kernohan *et al.*[2,3]

frequently calcified after age 50. Calcification of the meningiomas was more frequent after age 40, although this trend was not statistically significant (Table I).

CALCIFICATION IN RELATION TO SEX

The gliomas were more common in males while meningiomas were proportionately more frequent in females. No significant difference with regard to sex was noted in the occurrence of calcification (Table I).

PREOPERATIVE DURATION OF SYMPTOMS IN RELATION TO CALCIFICATION

For glioblastoma multiforme the duration of preoperative symptoms was 13 months for calcified tumors and 7 months for the total group. In ependymoma it was 46 months for calcified tumors and 19 months for the total group. However, it was shorter in calcified oligodendrogliomas in which it was 10 months for calcified neoplasms and 20 months for the total group. For the other types of tumor there was no significant difference (Tables I and II).

Survival with Relation to Calcification

A survival period of 5 years was used as an index for prognosis. In the supratentorial group, patients with calcified ependymoma, astrocytoma, and oligodendroglioma had a significantly longer survival period than corresponding cases without calcification (Table I). In the posterior fossa no significant relationship was noted between the survival periods of patients with calcified tumors and the total group (Table II).

Roentgenographic Calcification

Calcification was demonstrated microscopically in 207, or 13.1 per cent, of the 1577 tumors. Of 192 tumors in which calcification was found microscopically, the roentgenologist reported calcification radiographically in 104 or 54.2 per cent. The supratentorial tumors having microscopic calcification had confirmatory radiologic changes in 59.6 per cent (99 of 166). Tumors of the posterior fossa showing microscopic calcium salts had this finding confirmed by x-ray in 19.2 per cent (5 of 26) (Tables I and II).

Discussion

Although no attempt was made to correlate microscopic calcification with roentgenographic shadows, a consideration of the three major histologic patterns, as demonstrated in this study, may occasionally aid in the interpretation of the roentgenogram. The first pattern gives rise to a flocculent or worm-like shadow resembling the vascular pattern as it appears on the arteriogram.[11] The granules correspond to the cross section and the parallel radiations to the longitudinal view of the calcified vessels. The second and third patterns may appear on the roentgen film either as a single large shadow or as a solid sheet of calcium. Pattern IV includes calcification of several types, and does not cast a characteristic shadow.

Since a large proportion of this study was based upon biopsy material, calcification noted on the roentgenogram[12] was not necessarily represented in microscopic sections of the tissue and, conversely, the minute amounts noted microscopically were not necessarily visible radiographically because of their size and position. It is reasonable to assume that minute calcium fragments seen microscopically in medulloblastoma would not be visible through the dense bone of the posterior fossa. No systematic study of the size, density, and distribution of calcium salts necessary to cast a shadow in roentgenograms of the skull is available from the literature.

Although radiologic diagnosis of the neoplastic type from the pattern of the calcium salts has not been attempted, this pattern, combined with pertinent clinical information, may suggest the true nature of the lesion. This information becomes useful in the interpretation of roentgenograms of patients with symptoms of space-occupying lesions when calcium deposits are visible. In children, sheets or masses of supratentorial calcium in the roentgenogram suggest the presence of an ependymoma.[13] Calcification in the suprasellar region in children is highly suggestive of craniopharyngioma (Figs. 21 and 22). From our material no definite histopathologic diagnosis could be made when calcification occurred in the pineal region of children.[14] Calcification in neoplasms visualized by x-ray in the posterior fossa of children is most suggestive of astrocytoma or ependymoma of the cerebellum (Figs. 24 and 25).

In adults, roentgenographic correlation with the histologic tumor type is more difficult. However, in the middle-aged group, calcified tumors of the frontal region are most likely to be astrocytoma or oligodendroglioma. In those patients over the age of 50, oligodendroglioma is the most probable lesion (Fig. 18). Calcified lesions of the parasellar region are more prone to be craniopharyngioma (Figs. 21 and 22) than a primary neoplasm of the pituitary gland (Fig. 23). Calcification in close association with the dura or falx may suggest the diagnosis of meningioma[13] (Figs. 19 and 20). This should not be confused with the physiologic calcification which occurs commonly at these sites. Elsewhere, calcification in the supratentorial region may be of any histopathologic type (Fig. 17).

Conclusions

Each of 1577 verified tumors of the central nervous system was studied for microscopic calcification. Calcification was found in 207 or 13.1 per cent.

Four histologic patterns of calcification were differentiated in this study and three of these occurred frequently.

When calcification is visible in the roentgenogram, a consideration of these microscopic patterns and their locations, when correlated with clinical data, may in certain instances suggest the histologic structure.

In this series an insufficient number of cases was examined following roentgen therapy to ascertain any relationship between irradiation and the occurrence of calcification in particular tumor types.

Calcification occurred in our series in every major tumor group except the schwannomas and hemangioblastomas.

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DESCRIPTION OF PLATES

PLATE 174

FIG. 1. Supratentorial glioblastoma multiforme with calcified blood vessels, pattern I. Hematoxylin and eosin stain. × 155.

FIG. 2. Oligodendroglioma with beginning confluence of calcified blood vessels, pattern I. Hematoxylin and eosin stain. × 130.

FIG. 3. Cerebral astrocytoma with calcified blood vessel wall, pattern I. Hematoxylin and eosin stain. × 155.

FIG. 4. Calcified blood vessel in pinealoma, pattern I. Hematoxylin and eosin stain. × 155.

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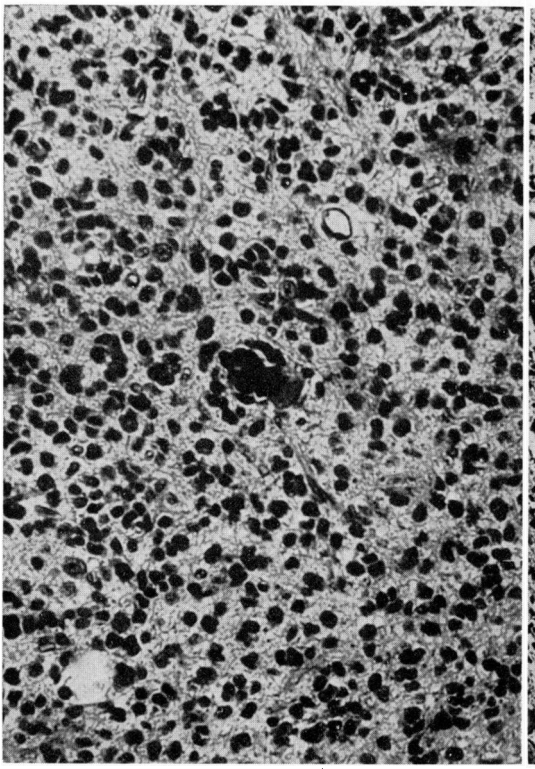

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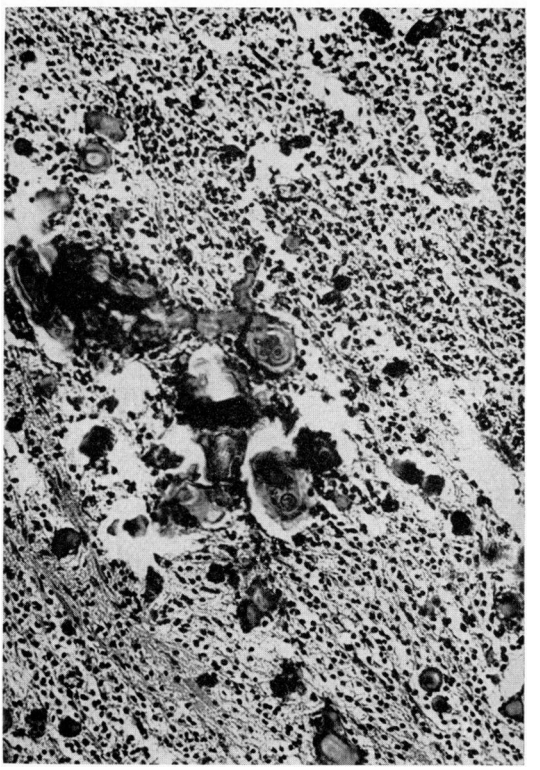

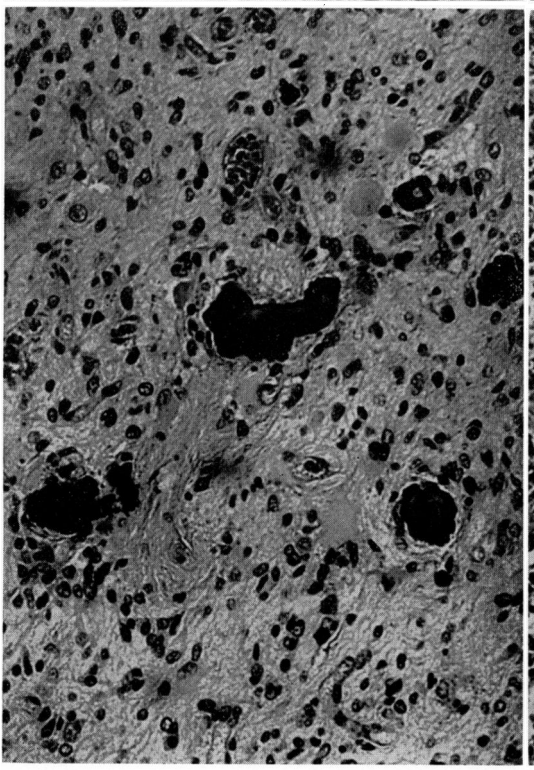

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PLATE 175

FIG. 5. Medulloblastoma with calcification of pattern I. Hematoxylin and eosin stain. × 140.

FIG. 6. Cerebellar astrocytoma with calcification of pattern II. Hematoxylin and eosin stain. × 150.

FIG. 7. Epithelial ependymoma from the posterior fossa, showing calcification of pattern III in an area of necrosis. Hematoxylin and eosin stain. × 125.

FIG. 8. From the same ependymoma as Figure 7, showing another area of calcification of pattern III. Hematoxylin and eosin stain. × 125.

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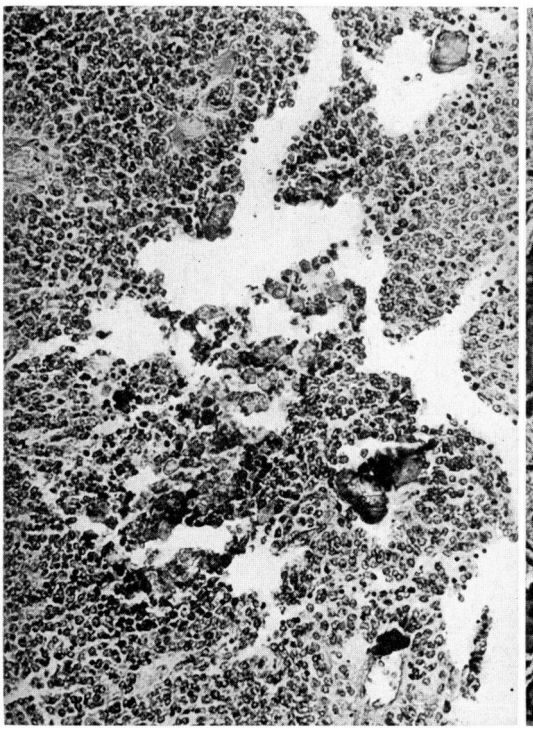

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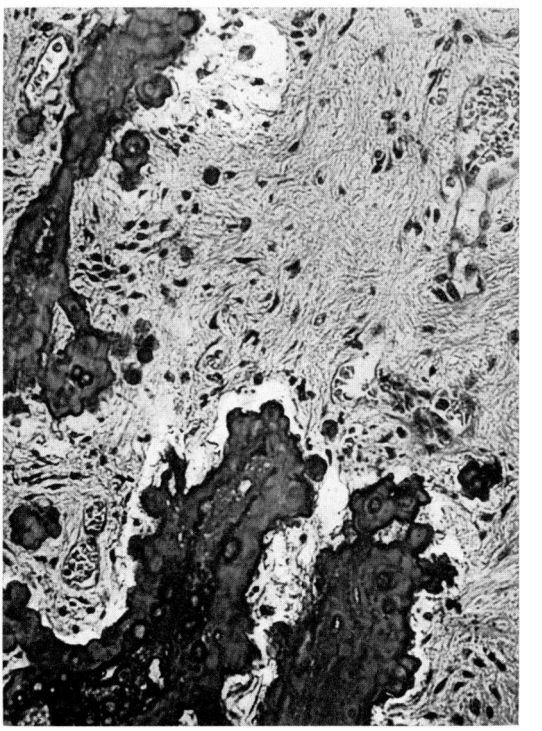

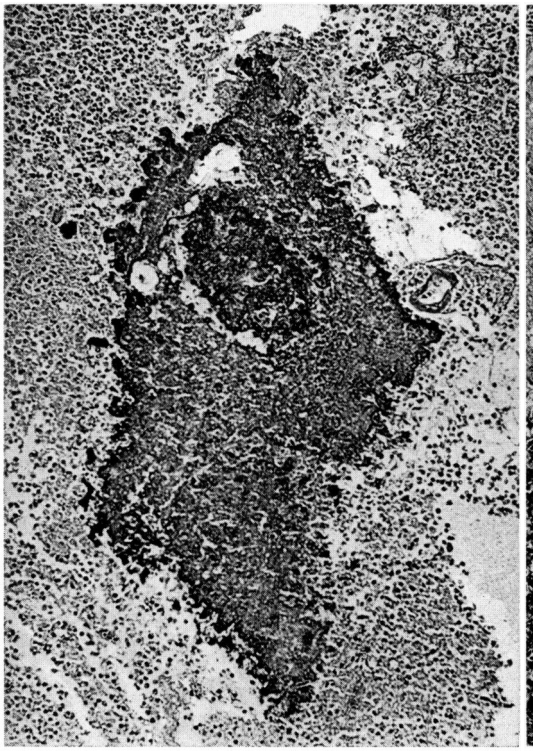

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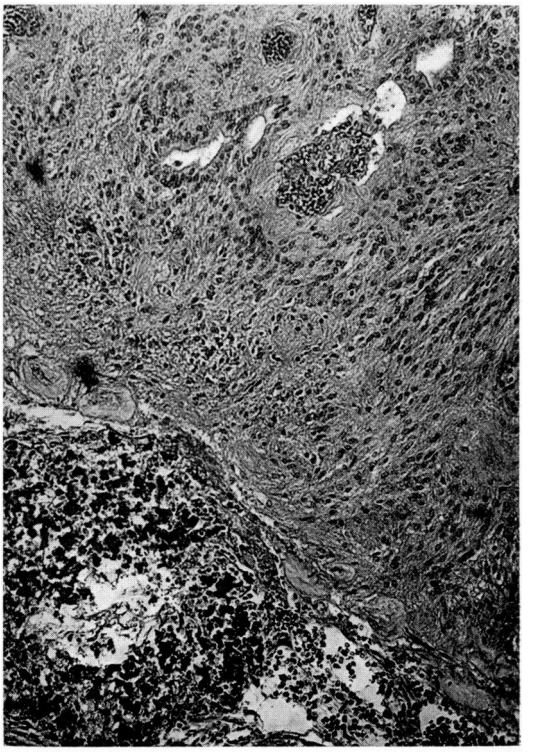

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PLATE 176

FIG. 9. Craniopharyngioma with calcification surrounded by epithelial cells, pattern IV. Hematoxylin and eosin stain. × 130.

FIG. 10. Craniopharyngioma adjacent to pituitary gland with calcification of pattern IV. Hematoxylin and eosin stain. × 145.

FIG. 11. Craniopharyngioma with sheets of calcification of pattern IV. Hematoxylin and eosin stain. × 130.

FIG. 12. Chromophobe adenoma of the pituitary gland showing calcification in blood vessel, pattern I. Hematoxylin and eosin stain. × 145.

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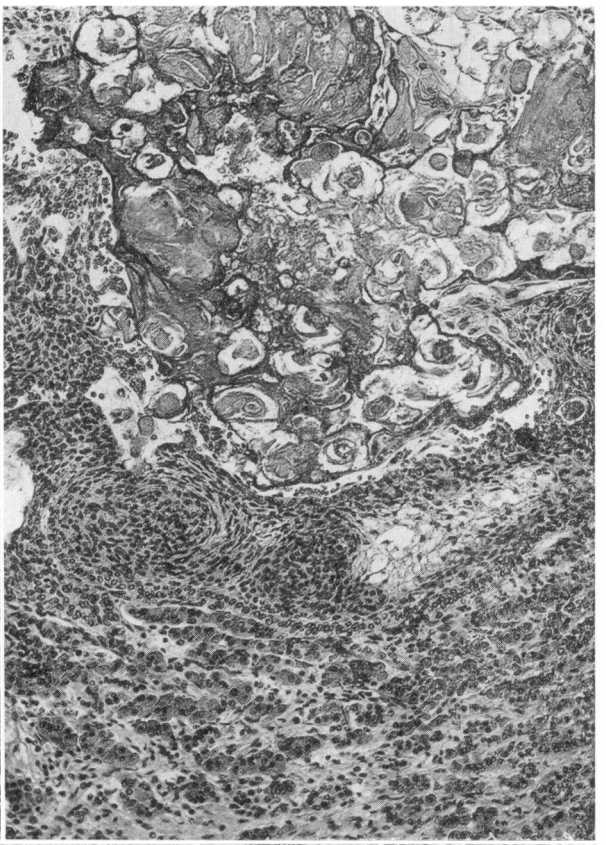

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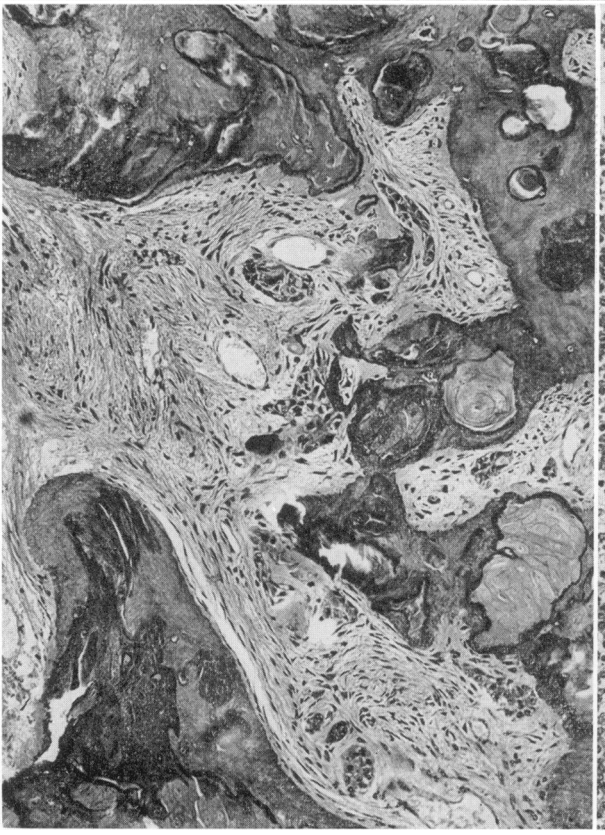

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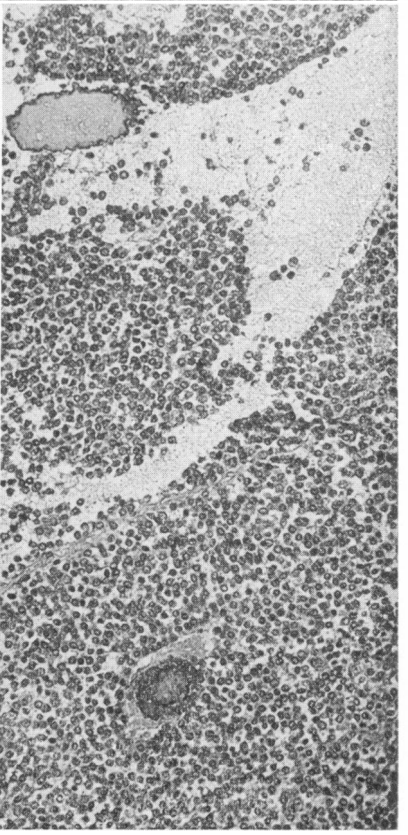

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FIG. 13. Meningotheliomatous meningioma of the olfactory groove, showing confluence of calcified blood vessels of pattern II. Hematoxylin and eosin stain. × 125.

FIG. 14. Meningioma of the choroid plexus showing calcification of pattern I. Hematoxylin and eosin stain. × 132.

FIG. 15. Neurocytoma with living ganglion cells (below) and calcified ganglion cells (above), pattern IV. Hematoxylin and eosin stain. × 132.

FIG. 16. Neurocytoma with multiple calcified ganglion cells, pattern IV. Hematoxylin and eosin stain. × 118.

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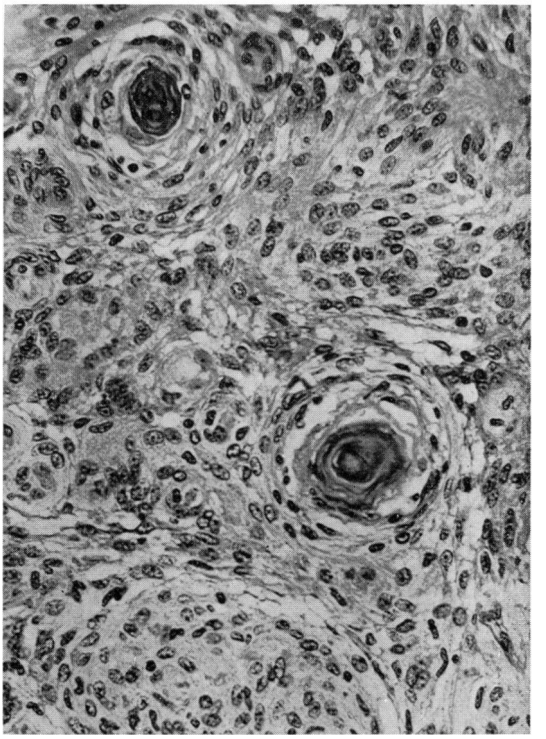

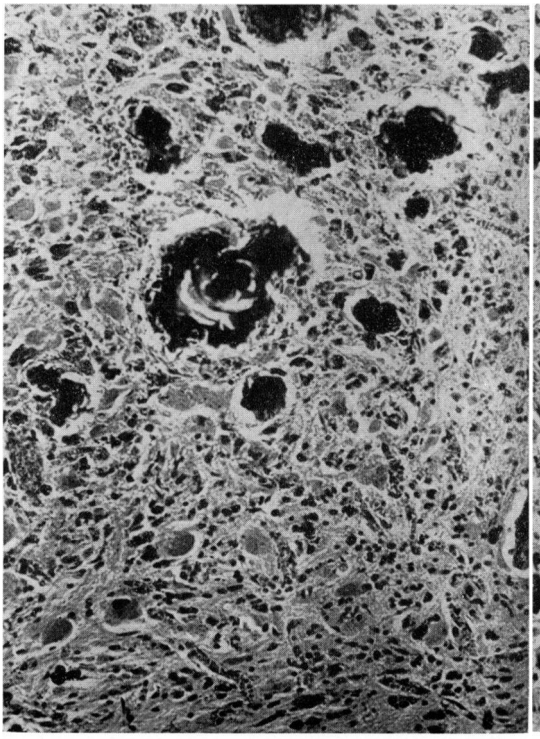

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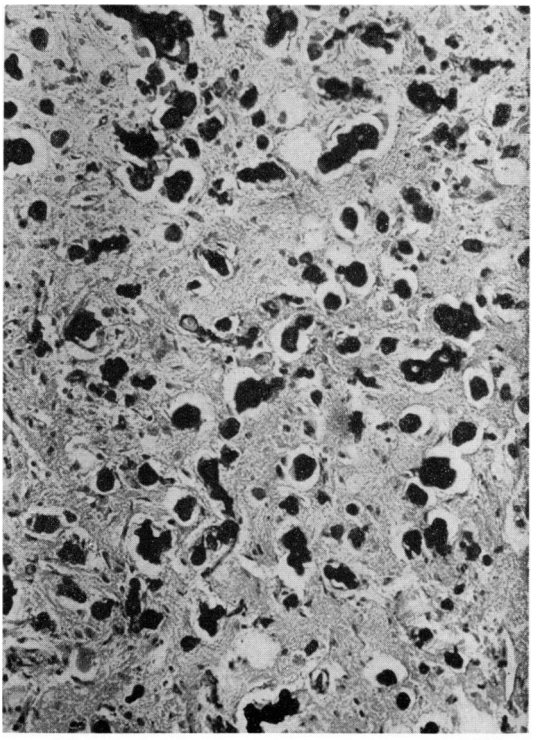

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PLATE 178

FIG. 17. Roentgenogram of neurocytoma with calcification in the occipital region.

FIG. 18. Roentgenogram of calcified oligodendroglioma of the frontal region.

FIG. 19. Roentgenogram of calcified sphenoid ridge meningioma.

FIG. 20. Roentgenogram of calcified meningioma of the olfactory groove.


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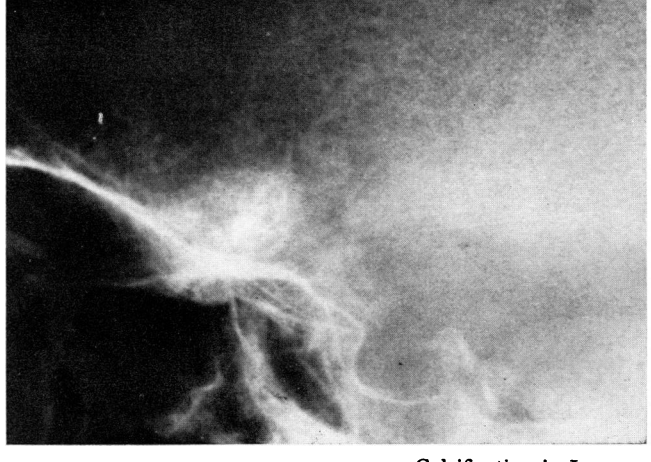
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PLATE 179

FIG. 21. Roentgenogram of a calcified intrasellar craniopharyngioma.

FIG. 22. Roentgenogram of a calcified intrasellar and extrasellar craniopharyngioma.

FIG. 23. Roentgenogram of calcification in a chromophobe adenoma of the pituitary gland.

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PLATE 180

FIG. 24. Ventriculogram showing calcification in cerebellar astrocytoma of the posterior fossa.

FIG. 25. Ventriculogram showing calcification in ependymoma of the posterior fossa.

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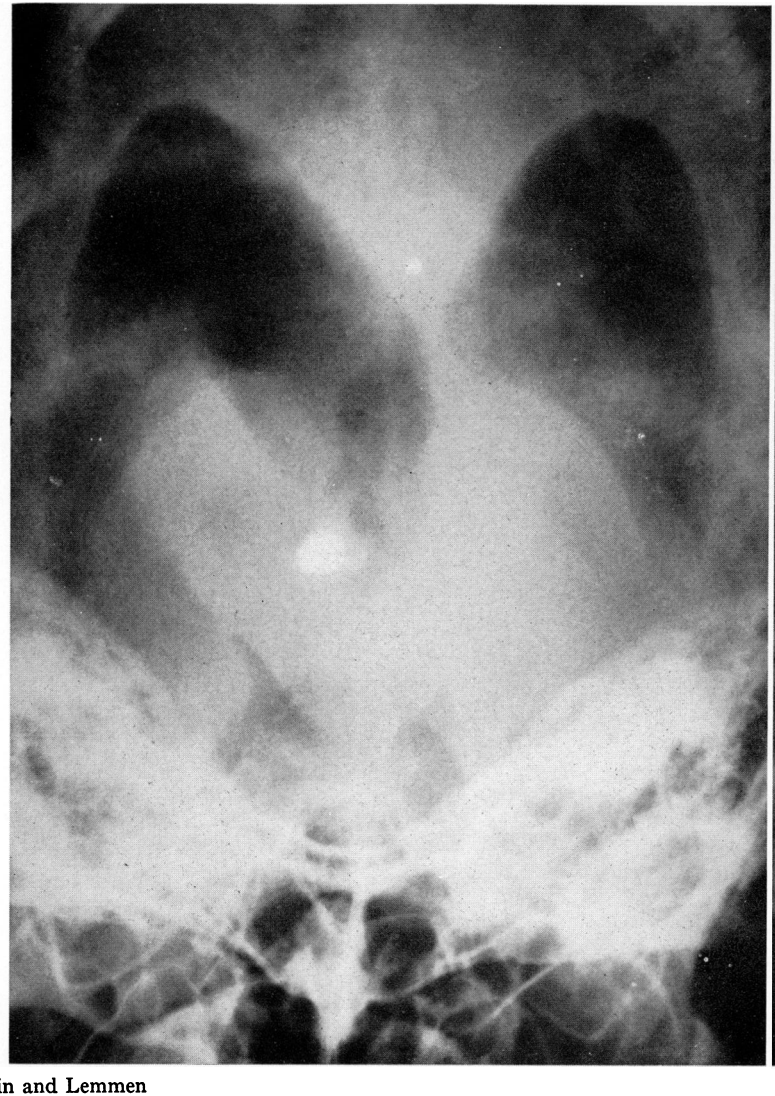

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