

Diagnosis of masses presenting within the ventricles on computed tomography

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Summary. The radiological and clinical features of 90 histologically verified intraventricular masses were reviewed. Computed tomography (CT) and plain X-rays were available in all and angiograms in over half the cases. The localisation, effects on the adjacent brain substance and the presence and degree of hydrocephalus was evident on CT. Two-thirds of colloid cysts presented as pathognomonic anterior third ventricular hyperdense masses and the other third were isodense; an alternative diagnosis should be considered for low density masses in this situation. Plexus papillomas and carcinomas mainly involved the trigone and body of a lateral ventricle of young children and caused asymmetrical hydrocephalus; the third ventricle was occasionally affected also in children and the fourth ventricle more frequently and usually in adults. Two-thirds were hyperdense, one-third of mixed or lower density. The meningiomas were dense trigonal tumours of adults generally arising in the choroid plexus, but two tentorial meningiomas passed through the choroidal fissure and caused a predominantly intraventricular mass. Gliomas frequently thickened the septum and generally involved the frontal segments of the lateral ventricles. They may be supplied by perforating as well as by the choroidal arteries, which supply most other vascularised masses within the ventricles. Only 10% of our cases did not fall into one of the former categories; these included low density non-enhancing dermoid or epidermoid tumours and higher density enhancing metastatic or angiomatous masses.

Key words: Intraventricular tumours – computed tomography – meningioma – choroid plexus papilloma – colloid cyst – glioma

Introduction

Masses within the ventricular system are of several different pathological types [1–4]. Due to their common siting in non-evocative regions they often present similar non-specific clinical manifestations [5–9]; localisation and differential diagnosis are dependent on radiological investigation [2, 5, 10–13].

The present study records the clinical and radiological findings in 90 patients with intraventricular masses shown on CT. The similarities and differences between the various histologies are assessed and discussed in relation to previous literature.

Material and methods

Patients attending The National Hospitals for Nervous Diseases and The Hospital for Sick Children during the last 3 years in whom a mass was shown on CT to be lying predominantly within the ventricular system were selected for further study. Histological diagnosis was established in only 90 patients who form the basis of this report: glioma [30], choroid plexus papilloma [21], colloid cyst [17], meningioma [13] and miscellaneous conditions [9], including dermoid [1], epidermoid [2], craniopharyngioma [1], metastatic adeno-carcinoma [2], metastatic melanoma with intraventricular haemorrhage [1], cavernous angioma [1], thrombosed angiomatous malformation [1]. CT studies and plain X-rays were available in all patients, angiography in 48 patients and air studies in 9 cases.

Results

Age and sex (Table 1)

In the series overall there were equal numbers of males and females; in the meningioma group there

Table 1. Clinical summary of 90 patients with intraventricular masses

Tumour Number of cases	Sex		Age		Age of presentation	Main clinical abnormalities	Additional findings		
	M	F	<15	>15	Range, mean				
Glioma 30	19	11	16	14	2-66 18.5 ±	headache visual memory personality fits papilloedema hemisindrome	22 8 5 2 2 17 3	tuberous sclerosis neurofibromatosis spinal symptoms	6 1 ^a 2
Choroid plexus papilloma 21	10	11	3	18	9/52-26 5.21 ±	vomiting ataxia large head papilloedema hemisindrome	12 3 11 6 3	recurrent choroid plexus papilloma spinal metastases	2 1
Benign choroid plexus papilloma 14	6	8	3	11	6.81 ±	vomiting ataxia large head papilloedema hemisindrome	9 1 9 4 1	recurrent spinal metastases	2 1
Malignant choroid plexus papilloma 7	4	3	0	7	2.24	vomiting ataxia large head papilloedema hemisindrome	3 2 2 2 2		
Colloid cyst 17	9	8	17	-	18-74 42.5 ±	headache visual memory papilloedema hemisindrome	12 7 4 9 1		
Meningioma 13	1	2	10	1	6-58 38.9 ±	headache visual memory papilloedema hemisindrome	8 1 1 5 3	neurofibromatosis (widespread) bilateral intra- ventricular meningiomas	1 ^b 1
Miscellaneous 9	4	5	9	-	24-51 43.7 ±	headache visual ataxia hemisindrome	4 6 3 1		
Total 90	45	45	57	33	2/12-74 29.9 ±				

^a In addition to Grade II astrocytoma in the right lateral ventricle extending from the roof, there was a Grade II astrocytoma in the left cerebellum

^b In addition to meningioma in the left trigone, the patient had surgery for bilateral acoustic neurofibromas and multiple spinal neuromas

was marked sex difference, 12 females to 1 male and in the glioma group males were affected almost twice as often as females. The age range was wide but each main tumour group had a typical age distribution. Choroid plexus papillomas occurred in children (mean 5.21 years) and most, including all those with malignant papillomas, were under 3 years. Gliomas (mean 19.6 years) were mainly found in patients under 30 years of age. Meningiomas, with one exception in a child aged 6 years, were all in adults (mean

38.9 years). Colloid cysts were typically found in older adults (mean 42.3 years).

Clinical abnormalities (Table 1)

Six patients had clinically manifest tuberous sclerosis and two had neurofibromatosis. With the exception of the choroid plexus papillomas, headache was the most usual symptom in all groups and visual disturbances, including field defects, blurring of vision

Table 2. Plain x-ray findings

Tumour		Normal	Abnormal			
			Open sutures	Abnormal sella	Calcifications	Asymmetry of skull
Glioma	30	27% (8)	27% (8)	37% (11)	20% (6)	10% (3)
Choroid plexus papilloma	21	9.5% (2)	71.4% (15)	4.8% (1)	–	33.3% (7)
Benign choroid plexus papilloma	14	14.3% (2)	57% (8)	7.1% (1)	–	21.4% (3)
Malignant choroid plexus papilloma	7	0%	100% (7)	–	–	57% (4)
Meningioma	13	38.5% (5)	7.9% (1)	30.8% (4)	15.4% (2)	0% (–)
Colloid cyst	17	17% (8)	0% (–)	53% (9)	0% (–)	0% (–)
Miscellaneous	9	67% (6)	0% (–)	11% (1)	22% (2)	0% (–)

**Fig. 1.** Cranial asymmetry and widened sutures. Choroid plexus papilloma

and diplopia were frequent. The plexus papillomas presented mainly with persistent vomiting, which was sometimes initially mistaken for a systemic condition such as a urinary tract infection. Head enlargement was commonly present with the plexus papillomas and less frequent with plexus carcinomas.

Papilloedema was the most common physical finding in all groups. Hemisyndromes were unusual but proportionally more frequent in malignant lateral ventricular papillomas and meningiomas. Fits were rare, being documented in only three patients all under the age of 5 years, one with a choroid plexus papilloma shunted 4 years previously and the

other two with gliomas, one involving the third and the other a lateral ventricle.

Back pain and/or paraparesis occurred in three patients with lateral ventricular tumours. In one Grade IV astrocytoma and one choroid plexus papilloma these occurred later after surgical treatment of the intracranial tumour and juxtamedullary masses were shown on myelography. The other patient, who had tuberous sclerosis, presented with back pain and was shown to have focal expansion of the lumbar spinal canal. At the same admission an ependymoma arising from the right caudate nucleus and causing hydrocephalus was discovered and treated prior to myelography and subsequent spinal surgery for an ependymoma of the filum terminale.

Plain skull x-ray findings (Table 2)

Plain skull X-rays were most frequently abnormal in choroid plexus papillomas (90%) and least often in the meningiomas (38.5%). Widened sutures were common with plexus papillomas reflecting the young age distribution. Asymmetry of skull, always larger on the side of the tumour, was frequent with choroid carcinomas (57%) and papillomas (33%) (Fig. 1) but occurred also with gliomas (10%). Sellar erosion was most frequent with the colloid cysts (53%). Calcification was not common in any tumour type but occurred mostly in the glioma group (20%) though in some of these it was present in calcified tubers remote from the neoplasm.

Location of tumour (Tables 3 and 4)

The meningiomas were mainly in the lateral ventricles and more often on the right. Most of them originated from the choroid plexus in the trigone; separate meningiomas were present in each trigone in one case. One interesting meningioma originated in

the velum interpositum and extended through a cavum septum pellucidum and the vulva of the corpus callosum to displace in third ventricle posteriorly (Fig. 2). Another tumour in a case with absence of the septum pellucidum occupied the bodies of both lateral ventricles. Two meningiomas were attached to the tentorium and extended through the choroidal fissure to expand within the ipsilateral ventricle (Fig. 3).

Choroid plexus papillomas (67%) and gliomas (63%) were also commonly in the lateral ventricles. Choroid plexus papilloma always involved the trigone and in only one recurrent case was there extension to a frontal horn. The gliomas involved the ventricular bodies (95%) and the frontal horns (39%)

Table 3. Intraventricular location of tumour

Tumour	Lateral ventricles left, right	Third ventricle	Fourth ventricle
Glioma	30 63.3% (19)	16.7% (5)	20% (6)
Choroid plexus papilloma	21 66.7% (14) ^a	9.5% (2)	23.8% (5) ^b
Benign choroid plexus papilloma	14 57% (8)	71.4% (1)	35.7% (5)
Malignant choroid plexus papilloma	7 86% (6)	14% (1)	–
Meningioma	13 100% (13) ^c	–	–
Colloid cysts	17 –	100% (17)	–
Miscellaneous	9 22.2% (2)	11% (1)	66.7% (6)
Total	90 53.3% (48)	17.8% (25)	18.9% (17)

^a In left lateral ventricle 86% (12)

^b All benign

^c In left lateral ventricle only 7.7% (1) In right lateral ventricle only 69.3% (9) In both ventricles 23% (3)

and less frequently the trigones (26%). There was no difference in the distribution of the glioma subtypes (astrocytoma, ependymoma, oligodendroglioma) except for the giant cell astrocytomas which all involved a frontal horn and usually arose from the region of the Foramen of Monro.

Colloid cysts are tumours of the anterior part of the third ventricle. Other tumours uncommonly involved the third ventricle but gliomas (18%), choroid plexus papillomas (10%) and the craniopharyngioma in our series did so.

The fourth ventricle was the site of most of our miscellaneous group of tumours though gliomas (20%) and benign choroid plexus papillomas (36%), occupied it as well.

CT features (Table 5)

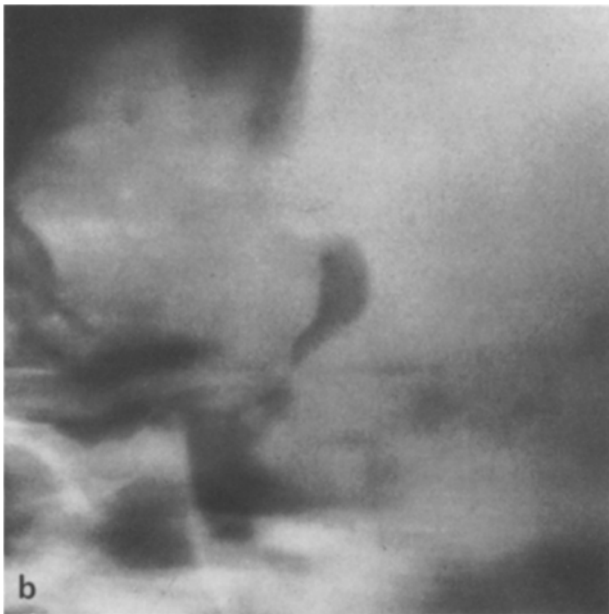
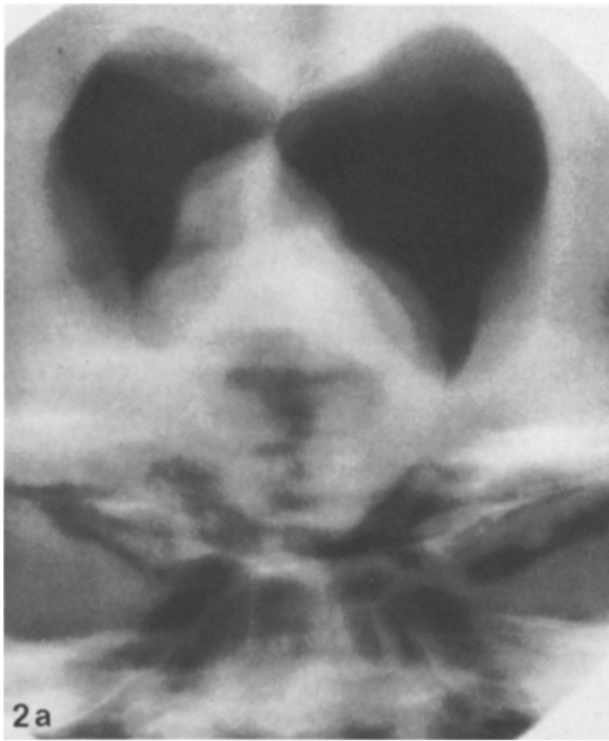
The tumour was of increased density in all meningiomas, in most colloid cysts (69%) and in under half (43%) of the choroid plexus papillomas. Mixed density was mostly found in gliomas (47%) and in a few (19%) choroid plexus papillomas, in which regions of increased density were always present. One-third of choroid papillomas (35%) and rather less of the colloid cysts (29%) (Fig. 4) and gliomas (23%) were isodense with brain substance. Of the seven giant cell astrocytomas, three were isodense, three mixed and one of high density. Only seven tumours were entirely of lower density than brain; these included two gliomas which showed irregular enhancement, two epidermoids, one dermoid and a craniopharyngioma which showed no enhancement, and one choroid plexus papilloma of the lateral recess of the fourth ventricle which enhanced markedly.

Table 4. Location of tumour within the lateral ventricles

Tumour in lateral ventricles	Frontal horns	Bodies	Trigone	Temporal horns	Occipital horns
Glioma	19 36.8% (7)	94.7% (18)	26.3% (5)	10.5% (2)	5.3% (1)
Choroid plexus papilloma	14 7% (1) (recurrent)	21% (3)	100% (14)	7% (1)	7% (1)
Benign choroid plexus papilloma	7 14% (1)	28% (2)	100% (7)	–	14% (1)
Malignant choroid plexus papilloma	7 –	14% (1)	100% (7)	14% (1)	–
Meningioma	13 7.7% (1)	23.1% (3)	84.6% (11)	7.7% (1)	–
Miscellaneous	3 –	33% (1)	100% (3)	–	–

Fig. 2a and b. Antero-posterior (a) and lateral (b) tomography during pneumo-encephalography. Mass between frontal horns and anterior to third ventricle. Meningioma of velum interpositum

Fig. 3a–d. Tentorial meningioma. Plain scan a–d, contiguous sections. The densely calcified tumour lies mainly within the right trigone though its medial part is within the choroidal fissure. At surgery the tumour was attached to the free edge of the tentorium, passing through the fissure into the ventricle



Smooth margins were usual in meningiomas (69%) and colloid cysts (71%); lobulation occurred in about a quarter of gliomas, benign plexus papillomas and meningiomas; irregular margins were very frequent in plexus carcinomas (71%), less common in plexus papillomas (43%), gliomas (40%) and colloid cysts (29%) but were only observed in one meningioma (8%).

Calcification was visible in meningiomas (46%), gliomas (20%) and plexus papillomas (Fig. 5) (24%) but never in colloid cysts.

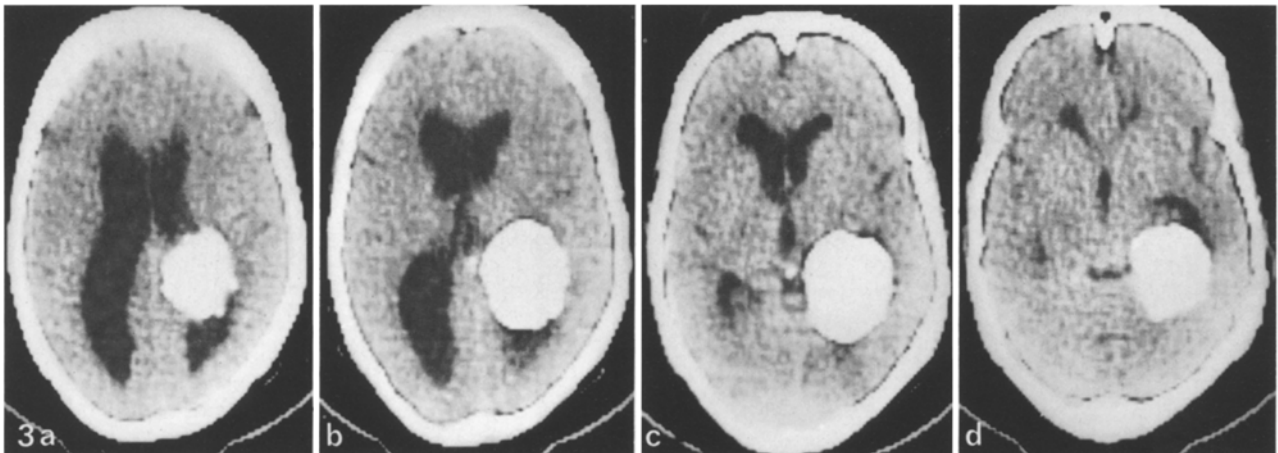
Contrast enhancement was present in all tumours with the exception of all but one of the colloid cysts and the epidermoids and dermoid. Large low density cystic or necrotic regions, confirmed at surgery, were present in gliomas (21%) including two giant cell astrocytomas and in one malignant papilloma (Fig. 6).

Hydrocephalus was equally common with gliomas, colloid cysts and choroid plexus papillomas and was manifestly of communicating type in 50% of the latter. Meningiomas more often caused local dilatation around and proximal to the tumour than generalised widening of the lateral ventricles (Fig. 7).

Low density areas in the brain tissue adjacent to the tumour occurred most often with plexus carcinomas (43%) not infrequently with the plexus papillomas (21%) (Fig. 8) and gliomas (20%), and uncommonly with meningiomas (9%). Thickening of the septum pellucidum was confined to the glioma group (37%) (Fig. 9), with one exception; the meningioma originating in the velum interpositum grew into a cavum septi pellucidi and bulged into both frontal horns (Fig. 10).

Angiographic features (Table 6)

The main blood supply to lateral ventricular meningiomas and choroid plexus papillomas was from the lateral choroidal arteries, which also supplied 25% of the gliomas. The medial posterior choroidal arteries



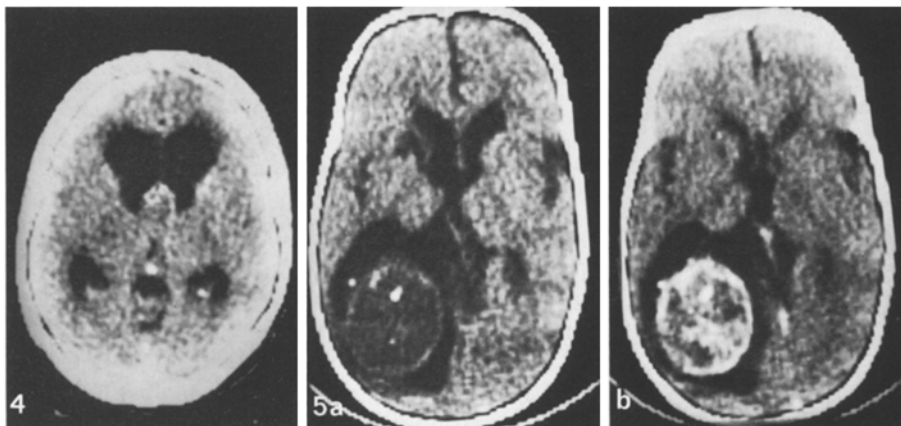


Fig. 4. Colloid cyst, isodense with cerebral substance

Fig. 5a and b. Mass of mixed attenuation, including calcification, before (a) and after (b) intravenous contrast. Choroid plexus papilloma

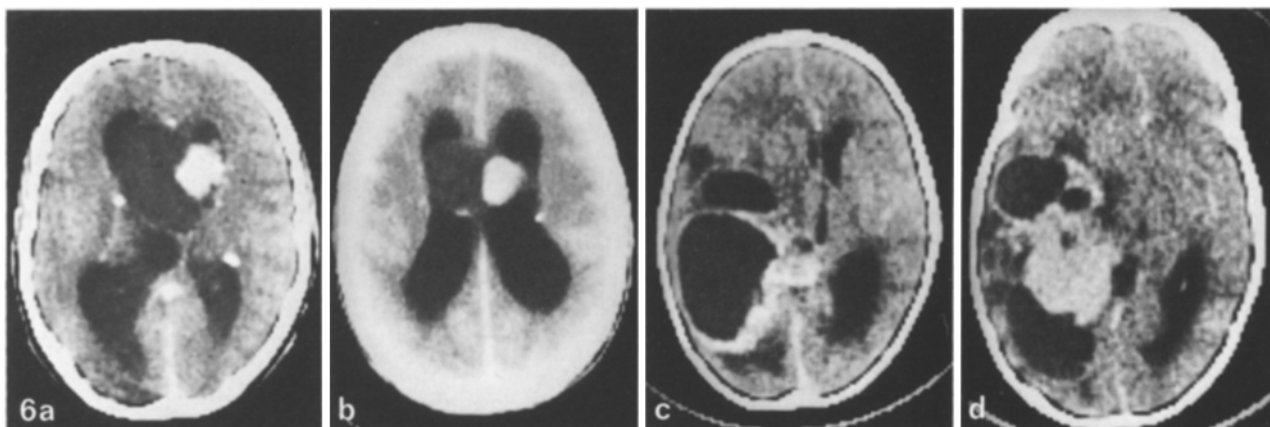


Fig. 6a–d. Cystic elements in intraventricular tumours: a and b = Giant cell astrocytoma (associated with tuberous sclerosis); c and d = Choroid plexus papilloma

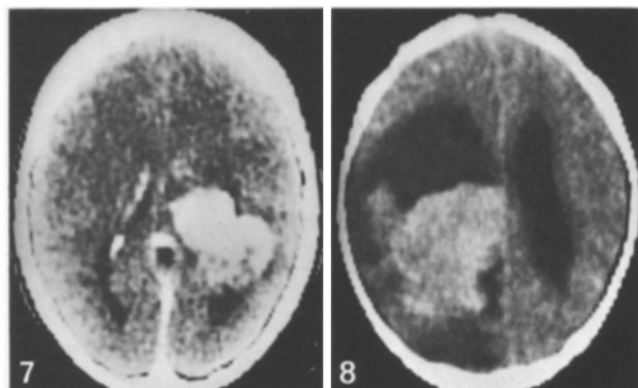


Fig. 7. Focal dilatation of the ventricle around mass

Fig. 8. Cerebral low density adjacent to intraventricular tumour. Malignant choroid plexus papilloma

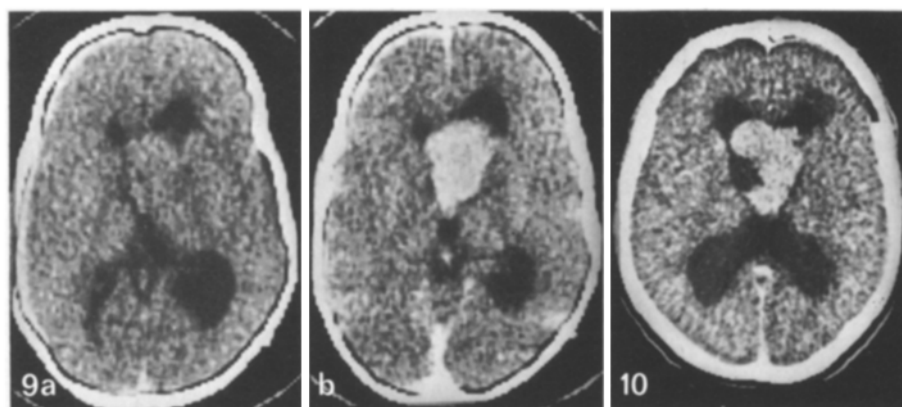


Fig. 9a and b. Tumour involving septum pellucidum, scans before (a) and after (b) intravenous contrast medium. Glioma

Fig. 10. Meningioma occupying velum interpositum and bulging into frontal horns (enhanced scan)

Table 5. CT findings in 90 patients with intraventricular masses

CT features	Glioma	Choroid plexus papilloma	Benign choroid plexus papilloma	Malignant choroid plexus papilloma	Meningioma	Colloid cyst	Miscellaneous
	30	21	14	7	13	17	9
<i>Density relative to brain</i>							
(a) increased	23.3% (7)	42.9% (9)	35.7% (5)	57% (4)	100% (13)	69% (11)	67% (6)
(b) similar	23.3% (7)	33.3% (7)	42.9% (6)	14% (1)	0% (0)	29% (5)	0% (0)
(c) decreased	6.7% (2)	4.8% (1)	7.1% (1)	–	0% (0)	0% (0)	44% (4)
(d) mixed	46.7% (14)	19.0% (4)	14.3% (2)	29% (2)	0% (0)	6% (0)	0% (0)
<i>Margins</i>							
1. Well defined							
(a) smooth	36.7% (11)	28.6% (6)	28.6% (4)	29% (2)	69.1% (9)	71% (12)	22% (2)
(b) lobulated	23.3% (7)	19.0% (4)	28.6% (4)	–	23.1% (3)	0% (0)	33% (3)
2. Irregular	40.0% (12)	52.4% (11)	42.9% (6)	71% (5)	7.7% (1)	29% (5)	56% (5)
<i>Calcification</i>	20.0% (6) ^a	23.8% (5)	21.4% (3)	29% (2)	46.2% (6)	0% (0)	22% (2)
<i>Contrast enhancement</i>	100% (30)	100% (21)	100% (14)	100% (7)	100% (11) ^c	6% (1)	–
<i>Hydrocephalus</i>							
(a) bilateral	93.3% (28)	90.5% (19) ^b	85.7% (12)	100% (7)	30.8% (4)	94% (16)	67% (6)
(b) local	–	–	–	–	38.5% (5)	–	–
<i>Low density in adjacent brain</i>	20.0% (6)	33.3% (7)	21.4% (4)	43% (3)	7.7% (1)	0% (0)	11% (1)
<i>Thickened septum pellucidum</i>	36.7% (11)	0% (0)	–	–	7.7% (1)	0% (0)	0% (0)

^a In addition calcification was present in tubers in 6 patients (20%)

^b Associated in 47.6% (10) with enlarged subarachnoid spaces and basal cisterns and asymmetrical in 33.3% (7)

^c In 2 patients contrast medium was not injected

supplied all tumour types including glioma (30%) involving the septum pellucidum. Supply from lenticulo-striate (35%) and thalamo-perforating (5%) arteries occurred only in gliomas involving the floor or lateral walls of the ventricle (Fig. 11).

Spiral arteries were shown in both malignant and benign choroid plexus papillomas (Fig. 12). Discrete tumour vessels occurred in only two gliomas (10%), two benign and one malignant plexus papillomas. An homogeneous tumour blush was seen invariably in meningiomas, and occurred in some choroid plexus papillomas (Fig. 13); in the other papillomas and in most of the gliomas the blush was irregular and it was very faint in one-third of the latter. The other gliomas (25%) were avascular and no circulation was shown in one plexus papilloma in addition to the colloid cysts.

Drainage into subependymal veins was demonstrated in all meningiomas and almost two-thirds of choroid plexus papillomas and gliomas. In 22% of choroid plexus papillomas considerable dilatation of atrial veins was noted. All the colloid cysts caused typical localised deformity of anterior parts of the internal cerebral veins or their tributaries near the Foramina of Monro.

Discussion

Truly intraventricular masses arise from the ventricular walls [3] and lie within the ventricular cavity; they include choroid plexus papillomas, colloid cysts, meningiomas, some ependymomas [1, 9, 14] and uncommon dermoids, epidermoids and metastases to the choroid plexus [4]. Intraventricular cysticerci which may be fixed or mobile with head position, cause low density masses which sometimes show ring enhancement and become symptomatic by causing hydrocephalus. They may be recognised when associated with diagnostic appearances of parenchymal cysticercosis and suspected when a patient is from an region when the disease is endemic. There were no cases in our series [15, 16].

The other tumours predominantly involving the ventricles originate in the adjacent brain [2–14] but on radiological examinations appear as intraventricular masses. Such pseudo-ventricular masses include glial tumours of all types and rare meningiomas extending through choroidal fissures. The difficulties prior to the use of CT of separating radiologically the true intraventricular tumours from the pseudo-ventricular have been discussed by Jefferson and Jack-

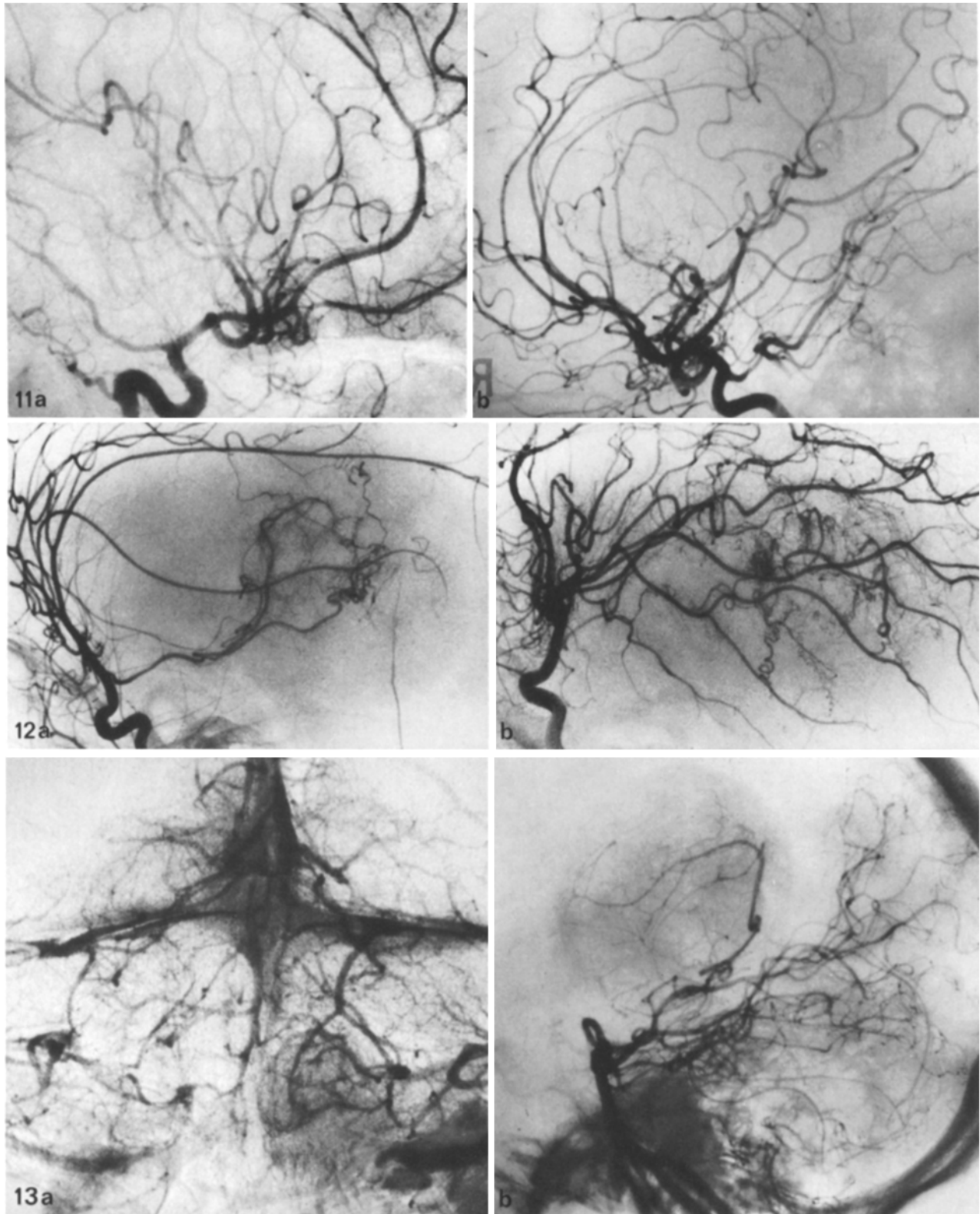


Fig. 11 a and b. Supply from perforating arteries – **a** third ventricular glioma. **b** Septal glioma

Fig. 12 a and b. Spiral arteries in – **a** malignant plexus papilloma and **b** benign plexus papilloma

Fig. 13 a and b. Capillary blush in **a** choroid plexus papilloma in lateral recess of fourth ventricle. **b** Meningioma of right lateral ventricular trigone

Table 6. Angiography findings in patients with intraventricular masses

Angiographic features	Glioma (20)	Benign choroid plexus papilloma (7)	Malignant choroid plexus papilloma (3)	Meningioma (9)	Colloid cyst (4)	Miscell- aneous (6)
<i>Feeding arteries</i>						
Anterior choroidal	15% ^c (3)	57% (4)	100% (3)	77% (7)	–	16% (1)
Medial posterior choroidal	30% (6)	14.3% (1)	33% (1)	44% (4) ^d	–	16% (1)
Lateral posterior choroidal	25% (5)	42.9% (3)	100% (3)	33% (3)	–	32% (2)
Lenticulo-striate	35% (7) ^b	–	–	–	–	–
Anterior thalamoperforating	5% (1)	–	–	–	–	–
No feeders identified	10% (2)	–	–	–	–	64% (4)
<i>Tumour blush</i>	75% ^c (15)	85.7% (6)	100% (3)	100% (9)	–	32% (2)
<i>Drainage into subependymal veins</i>						
	65% (13)	42.9% (3)	100% (3)	100% (9)	–	48% (3)
<i>Other observations</i>						
Occlusion of arteries	–	–	33% (1)	tentorial	100% – 4	–
Hypertrophy of veins	–	14.3% (1)	33% (1)	artery supply (2)	displacement of anterior end of internal cerebral veins	–

^a In 5% (1) of the patients this was the main feeder

^b In 30% (6) of the patients these were the only feeders

^c In 25% (5) of the patients the blush was very faint

^d In 11% (1) of the patients this was the only feeding artery

son [14], Numaguchi et al. [3] and Bernasconi and Cabrini [2]. CT generally localises more accurately and may suggest the likely histology [17] and all the masses selected for this study appeared on CT to be exclusively within the ventricular lumen.

Low density changes in the adjacent brain tissue were found in one-third of our choroid plexus papillomas and one of the meningiomas (Table 5). Low density, which occurs with both benign and malignant papillomas though commonly with the latter, has not been described as a feature of these tumours. It is most prominent in the white matter adjacent to the tumour and spreads in the distribution of vasogenic oedema, though in the presence of hydrocephalus it may be augmented by periventricular lucencies or rarely, when a malignant papilloma narrows or occludes arteries, ischaemic low density may be superadded.

In intracranial meningiomas, oedema has been related to marked vascularity and malignancy [18, 19]. In four of seven patients with intraventricular meningiomas, reported by Mani et al. [13], there was white matter oedema similar to that occurring in one of our cases. The reason why oedema is present in some intraventricular meningiomas and absent in the majority is by no means clear, though disruption of the ependyma by the tumour is possibly an important factor. Peritumoural oedema, though generally common in gliomas, occurred in only 20% in this series though major brain swelling may have

been taken as an indication of parenchymal tumour and have excluded the case from the series.

Metastases to the spinal theca are more frequent in gliomas involving the ventricular system than in those confined to the brain substance [20]. They are especially common in malignant astrocytomas [20] but are described in choroid plexus papillomas also. The separate ependymomas involving the ventricles and spinal cord in our patient with tuberous sclerosis were probably of multi-centric origin.

Characteristic CT features were observed in colloid cysts, choroid plexus papillomas and meningiomas. Third ventricular colloid cysts are invariably located adjacent to the Foramina of Monro within the anterior part of the ventricle with generally well defined smooth margins (71%), increased density (69%) and lateral ventricular hydrocephalus (94%). The only other pathology simulating a colloid cyst in this series was an entirely intra-third ventricular craniopharyngioma. This tumour was, however, of very slightly lower than brain density and although this does not exclude a colloid cyst it should lead to consideration of alternative diagnoses. Sage et al. [10] reported possible difficulties in the differentiation of colloid cysts from almost entirely intra-third ventricular gliomas; angiography, by showing abnormal circulation in the latter, may then be helpful in establishing the diagnosis [9, 10, 21].

Lateral ventricular plexus papillomas mainly occur in young children and meningiomas are virtually

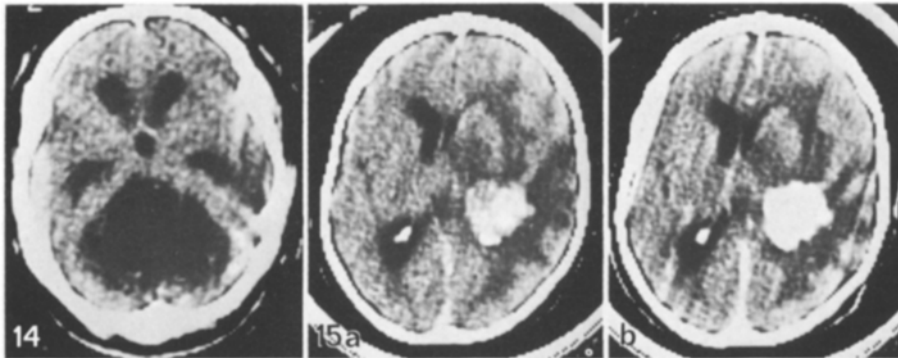


Fig. 14. Hypodense mass occupying and expanding the fourth ventricle. Dermoid tumour

Fig. 15 a and b. Hyperdense enhancing tumour in right trigone. Metastatic carcinoma, before (a) and after (b) intravenous contrast

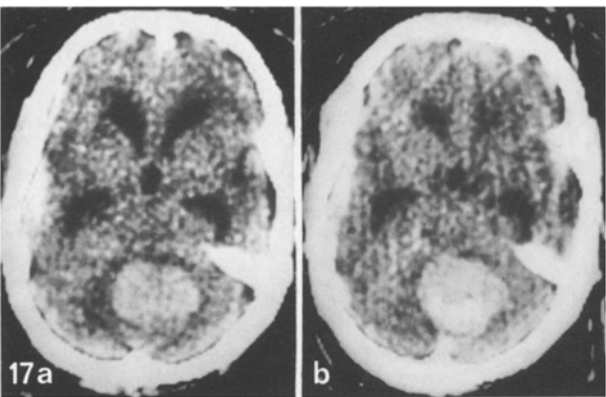
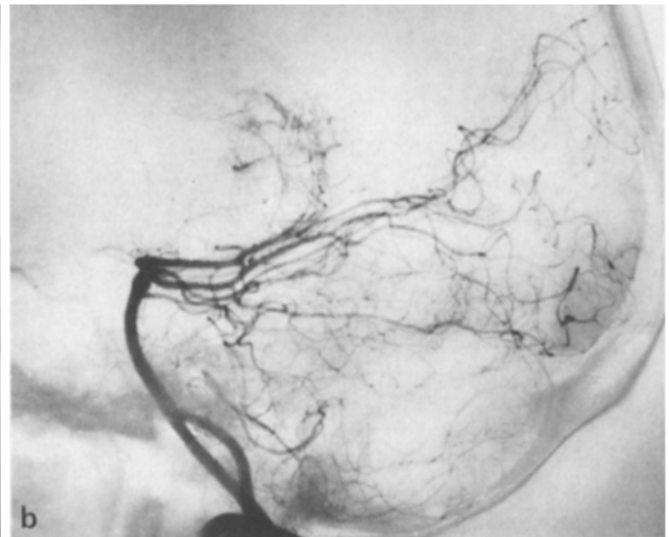
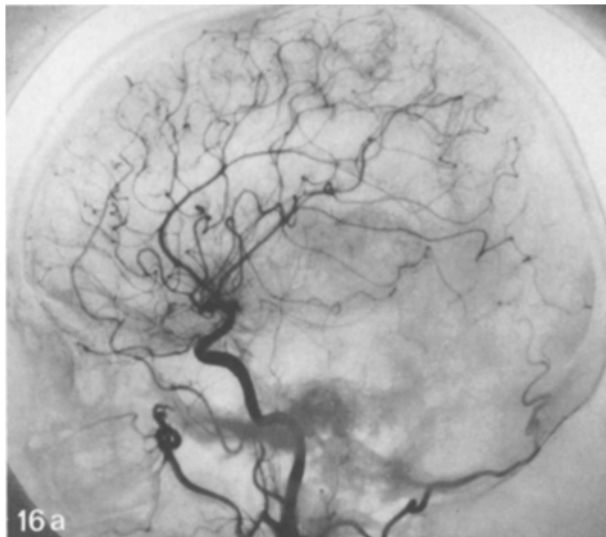


Fig. 16 a and b. Irregular pathological circulation shown by carotid (a) and vertebral (b) angiography. Metastatic carcinoma in right lateral ventricular trigone (see Fig. 15)

Fig. 17 a and b. Hyperdense enhancing tumour mass within fourth ventricle. Metastatic carcinoma, before (a) and after (b) intravenous contrast

confined to adults. Tumours of both types are located mainly in the trigones, extending into the bodies of the lateral ventricles, but rarely into the frontal horns. The much rarer papillomas of the third ventricle are also mainly in children, but those in the fourth ventricle are more frequent in adults. Meningiomas and many papillomas are of higher than brain density, and almost invariably enhance. However, isodense choroid plexus papillomas are not infrequent and indeed were dominant in one series [9]. The hydrocephalus produced by meningiomas is

usually localised to the ipsilateral trigone and temporal horn, whereas in plexus papillomas superadded communicating hydrocephalus is generally present. Blood supply is from the choroidal arteries in both tumours, but the tumour blush is more homogeneous in meningiomas. Generally similar findings in meningiomas and choroid plexus papillomas have been recorded in previous series [2, 6–8, 13, 22–31], though the frequency of malignancy in our plexus papillomas was much higher (33%) than previously reported [9, 33]. It has been suggested that demonstra-

tion of spiral arteries and early draining veins is a useful angiographic sign of malignant papillomas [32], but they occurred in both benign and malignant papillomas in our series.

The female/male ratio of meningiomas was more pronounced than in previous reports [1, 23, 24] and the unexpected predominant location in the right trigone compared with previous series in which the left was mainly involved merely emphasises the unreliability of deductions derived from observations made on small series. The occurrence of meningioma together with bilateral acoustic neuromas is a well known feature of neurofibromatosis.

Though all parts of the ventricles can be involved, gliomas were most commonly within the bodies of the lateral ventricles often extending into the frontal horns, as has been emphasised by Bernasconi and Cabrini [2]. Gliomas associated with tuberous sclerosis typically arise from the region of the head of the caudate nucleus near one Foramen of Monro [1, 4, 34]. This was reflected in the current series in which five tumours were giant cell astrocytomas, and one an ependymoma; two giant cell astrocytomas, occurring independently of other evidence of tuberous sclerosis were similarly sited. Exophytic gliomas usually had a broad base on the ventricular wall [2, 4], frequently thickened the septum pellucidum and were irregular in outline. They were generally of mixed density, and uncommonly entirely of low density; calcification, often very dense, was present in 20%. Enhancement, though frequently not pronounced, was always present. Blood supply from perforating arteries present in over one-third of gliomas, was not seen in other tumours.

Epidermoids typically show as non-enhancing low density masses [3]. Those situated in the fourth ventricle cause enlargement with a tendency to retention of the ventricular shape rather than rounding or deforming it, as may be expected with tumours of harder consistency or cysts under tension. Our two cases and the single dermoid had typical CT appearances (Fig. 14) and were avascular on angiography.

Subependymal metastases from systemic neoplasms did not occur in this series. Haematogeneous dissemination to the cerebro-spinal fluid through the choroid plexuses has been described as the usual route of subarachnoid seeding from systemic malignancies, but the plexus is uncommonly enlarged by metastatic involvement, as occurred in two cases in the present series, and both were misdiagnosed as meningioma. Mastectomy for carcinoma had been performed three years previously in one patient; an irregular enhancing mass in the right trigone was associated with marked vasogenic oedema and mass effect (Fig. 15) and angiography showed an irregular

blush (Fig. 16), consistent with a metastasis. The other involved the fourth ventricle (Fig. 17) and since there was no known primary tumour the correct diagnosis could not have been anticipated.

The fourth ventricular choroidal melanoma presented with intraventricular haemorrhage associated with enhancing mass in the fourth ventricle, which could have been a metastasis from the previously treated cutaneous melanoma or a primary neoplasm. Its nature was evident when pigmentation was noted at surgery.

A thrombosed angiomatous malformation (AVM) may be diagnosed if CT reveals a tubular or multi-nodular density, suggesting a conglomeration of enlarged vessels, but the case in this series, an ependymoma was suspected because of moderate mass effect and diffuse enhancement. Angiography showed only a few abnormal vessels and an irregular blush and the AVM, which was completely thrombosed, was only definitely diagnosed at surgery.

The cavernous haemangioma was a hyperdense enhancing mass in the fourth ventricle, which showed no circulation on vertebral angiography and was not diagnosed until histological examination.

Conclusion

Intraventricular tumours are detected and localised by CT which also reveals the degree of associated hydrocephalus and of changes in the adjacent brain substance.

Most colloid cysts have pathognomonic CT appearances. Plexus papillomas occur mainly in children in the trigones of the lateral ventricles and cause communicating hydrocephalus, frequently with skull asymmetry. Meningiomas are dense tumours in the same situation in adults.

The gliomas tend to be located more anteriorly in the lateral ventricles, and cause thickening of the septum pellucidum. They may be supplied by perforating arteries in addition to the choroidal arteries which supply tumours arising from the choroid plexuses.

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