Difficulties in diagnosis of intracranial meningiomas by computed tomography

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SUMMARY The false positive and false negative computed tomography diagnoses of meningioma made using EMI 1010 and 5005 machines on a consecutive series of patients seen over a period of four years are described. About 1.2% of intracranial meningiomas were not detected on initial CT scan, 6.6% were misdiagnosed including 5.2% which were thought to be malignant lesions; in 9.4% of the cases identified as meningioma another diagnosis was subsequently established of which 6.3% were malignant.

CT scanning shows an abnormality in patients with an intracranial tumour at the time of clinical presentation in a large majority of cases and earlier than any other radiological procedure.¹ This has modified the spectrum of preoperative investigation so that CT scanning has virtually replaced the combination of plain X-rays, pneumography, angiography and isotope scanning that was previously necessary for diagnosis. A previous study² has shown that the diagnosis of meningioma may be made on a precontrast scan in a high percentage of cases and this figure was further increased after post-contrast scanning. The experience gained from this study has been applied to routine examinations of scans and although complete reliance on CT has contributed to misdiagnosis in a few cases, the trend towards diminished use of other diagnostic methods for confirmation of the nature of the lesions has continued. We considered that analysis of the accuracy of CT in the diagnosis of intracranial meningiomas during this period would be of interest together with a critical appraisal of diagnostic errors.

Methods

The clinical and pathological record of all patients in the National Hospital for Nervous Diseases with a diagnosis of intracranial meningioma (excluding optic nerve sheath meningioma)

during the period of 1975 to 1978 were reviewed. All cranial CT scans in which a diagnosis of meningioma had been suggested during this period were also reviewed and data were correlated giving four groups:

- (1) CT diagnosis correct.
- (2) Meningioma present but no abnormality detected by CT.
- (3) Meningioma present but incorrectly diagnosed as a different pathology by CT.
- (4) Another pathology incorrectly diagnosed as meningioma by CT.

All examinations were performed on EMI 1010 or 5005.

Enhanced scans were made after viewing the plain scans in over 95% of the cases. The method of enhancement was by intravenous injection immediately prior to scanning of 70 mls sodium iothalamate containing 420 mgs I/ml.

Results

During the period of study a total of 347 patients with proven meningioma had CT examinations; 320 (92.2%) were correctly diagnosed on the initial scan. The remaining 27 (7.8%) were either considered to be normal (four cases), misdiagnosed as another pathology (19 cases) or diagnosed only as a non-specific tumour (four cases). The wrong diagnoses included glioma (13 cases), neurofibroma (two cases), metastases (one case), aneurysm (one case), craniopharyngioma (one case) and pituitary adenoma (one case). Twenty-six of these cases had plain X-rays and 24 were submitted to further studies.

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Angiography was performed in 22 of these 27 cases and in the majority (21) it showed a definite abnormality. However, the correct diagnosis was established in only 10 cases, in seven the findings were non-contributory, and in four the angiographic diagnosis was misleading (table 1). In the remaining 17 cases, misdiagnosed on CT scan, the correct diagnosis of meningioma was suggested by gamma scan (five cases), skull X-ray (two cases), encephalogram (two cases), and repeat CT scan (one case). A clinical diagnosis of meningioma was made in only five of these 27 cases. In 12 cases the correct diagnosis was not suggested prior to histological examination (table 2).

During the period under review meningioma was diagnosed on 353 CT scans. Out of this number 84.9% (300) were confirmed by histology and 5.7% (20) cases by angiography alone. Thirty-three cases (9.5%) were proved to have a different pathology. The majority (22) of these (67%) were malignant lesions. There were four cases of arterio-venous malformation and one aneurysm. The remainder were benign lesions including acoustic neuroma (two cases), pituitary adenoma (two cases) and craniopharyngioma (one case) (table 3). Thirty-one of these patients had plain X-rays and 25 were submitted to further study.

Angiography was performed on 25 cases

Table 1 Results of other investigations in meningiomas not detected or misdiagnosed on CT

Investigation	Total number	Normal	Positive		
			Misleading	Non-Contributory	Diagnostic
Skull X-ray	26	12 (46%)	2 (7.7%)	10 (39%)	2 (7.7%)
Isotope scan	11	1 (9%)	0	5 (45%)	5 (45%)
Angiogram	22	1 (4.5%)	4 (18%)	7 (32%)	10 (45%)
Pneumoencephalogram	7	1 (14%)	1 (14%)	3 (43%)	2 (29%)
Clinical	27	0	11 (41%)	11 (41%)	5 (19%)

Table 2 Methods of diagnosis of meningiomas not detected or misdiagnosed on CT. Diagnostic method suggesting correct diagnosis.

CT Diagnosis	Total	Angiogram (22)*	Isotope scan (11)*	Skull radiograph (24)*	Pneumoencephalogram (7)*	Clinical	Control CT (3)*	Total diagnosed prior to histology	Histology only
Glioma	13	3	3	0	1	1	0	7	6
Normal	4	1	0	1	1	1	1	2	2
Non-specific tumour	4	4	2	0	0	2	0	4	0
Neurofibroma	2	0	0	0	0	0	0	0	2
Secondary tumour	1	1	0	1	0	0	0	1	0
Craniopharyngioma	1	0	0	0	0	0	0	0	1
Pituitary adenoma	1	0	0	0	0	0	0	0	1
Aneurysm	1	1	0	0	0	1	0	1	0
Totals	27	10 (45%)	5 (45%)	2 (8.3%)	2 (23%)	5 (18.5%)	1 (33%)	15 (55%)	12 (45%)

* Total number of studies

Table 3 Method of diagnosis of lesions misdiagnosed as meningioma on CT. Diagnostic method suggesting correct diagnosis

Final diagnosis	Total	Angiogram (25)*	Isotope scan (14)*	Skull radiograph (31)*	Pneumoencephalogram (4)*	Clinical	Total diagnosed prior to histology	Histology only
Glioma	13	3	1	1	0	2	5	8
Acoustic neurinoma	2	0	0	0	0	1	1	1
Pituitary adenoma	2	0	0	1	0	2	2	0
Arteriovenous malformation	4	2	0	0	0	0	2	2
Metastasis	8	3	1	0	0	2	5	3
Craniopharyngioma	1	0	0	0	0	0	0	1
Aneurysm	1	0	0	0	0	0	0	1
Carcinoma (lacrimal)	1	1	0	0	0	0	0	1
Granuloma	1	1	0	0	0	0	1	0
Totals	33	9 (36%)	2 (14.3%)	2 (6.5%)	0	7 (21%)	16 (48.5%)	17 (51.5%)

* Total number of studies

(76%). All of the studies showed an obvious abnormality but in only nine cases was the angiogram diagnostic. In four cases it was non-contributory and in the remaining 12 it was misleading (table 4).

The initial CT misdiagnosis was corrected by other studies in 16 (48.5%) of cases. In the remaining 17 patients (51.5%) final pathology was only established by histological examination (table 3).

The scan findings in those meningiomas mistaken for other lesions and in the thirty-three cases which were mistaken for meningiomas are shown in table 5. In the malignant tumours in

the latter group, moderate or marked oedema and especially oedema of the white matter occurred in 40% compared with about 10% in meningiomas in general; in those meningiomas mistakenly called gliomas or metastases on CT the incidence of moderate or marked oedema was only slightly higher (15%). The incidence of mass effect and the pattern of enhancement was similar in both groups. In three cases a cystic meningioma was diagnosed as a glioma but cystic change was also present in histologically proven gliomas diagnosed as meningiomas. Two of the four arteriovenous malformations mistaken for meningiomas were thrombosed.

Table 4 Results of other investigations in lesions misdiagnosed as meningiomas on CT

Investigation	Total number	Normal	Positive		
			Misleading	Non-contributory	Diagnostic
Skull X-ray	31	14 (45%)	3 (9.7%)	12 (39%)	2 (6.5%)
Isotope Scan	14	1 (7.1%)	3 (21.4%)	8 (57%)	2 (14.3%)
Angiogram	25	0	12 (48%)	4 (16%)	9 (36%)
Pneumoencephalogram	4	0	3 (75%)	1 (23%)	0
Clinical	33	0	18 (55%)	7 (21%)	8 (24%)

Table 5

Scan findings on meningiomas not detected or misdiagnosed on CT			Scan findings of lesions misdiagnosed as meningiomas on CT	
Scan findings	Number	Comment	Number	Comment
Attenuation				
low	1 (3.7%)		2 (6.1%)	
isodense	8 (29%)		9 (27%)	
mixed	4 (15%)	(7 diagnosed as glioma)	2 (6.1%)	5 gliomas and 5 metastases
high	14 (52%)		20 (60%)	
Calcification	4 (15%)	(3 diagnosed as glioma)	10 (30%)	6 gliomas
				3 arteriovenous malformation
Bone erosion	0		1 (3%)	Glioma
Oedema				
0	10 (37%)		16 (48%)	
+	13 (48%) (4 w/m)*		8 (24%)	
++	3 (11%)		6 (19%) (3w/m)*	
+++	1 (3.7%)		3 (8.8%) (2 w/m)*	
Hyperostosis	1 (3.7%)	Thought to be normal	0	
Mass				
0	8 (29%)		7 (21%)	Two of arteriovenous malformations had +mass effect two had no mass effect
+	6 (22%)		10 (30%)	
++	13 (48%)		16 (48%)	
Enhancement				
Contrast medium not given	7 (26%)	Of the four cases with no enhancement	4 (12%)	In two cases of arteriovenous malformation contrast medium was not given and in the other two enhancement was found in only one.
None	4 (15%)	2 were diagnosed as normal, 2 as gliomas	1 (3%)	
Homogeneous	2 (7.4%)		21 (64%)	
Irregular	2 (7.4%)		4 (12%)	
Peripheral	3 (11%)		3 (9%)	
Cystic	3 (11%)		2 (6.1%)	
? Attached to bone	20 (74%)		23 (70%)	
? Attached to falx/tentorium	7 (26%)		10 (30%)	

*Well defined low attenuation spreading through white matter.

Table 6 Incident according to site

Site	Number	%	Lesions misdiagnosed as meningiomas	%	Meningioma not detected or misdiagnosed on CT	%
Convexity:	105	32.9				
—Frontal	49	15.3				
—Parietal	37	11.6				
—Occipital	5	1.6	13	11%	8	7.1%
—Temporal	14	4.4				
Parasagittal:	58	18.1				
—Frontal	26	8.1				
—Parietal	26	8.1	4	6.5%	4	6.5%
—Occipital	5	1.6				
—Temporal	1	0.3				
Sphenoid:	67	20.9				
—Wing	61	19	2	3.0%	3	4.3%
—Pterion	6	1.9				
Tentorium petrous	30	9.4	4	11.8%	2	6.3%
Intraventricular	10	3.1	0		1	9.1%
Parasellar	38	11.8				
—suprasellar	20	6.25	4	10.5%	5	13.2%
—subfrontal	18	5.6				
Posterior fossa	12	3.8	4	25%	4	25%
Total	320		32	9.1%	27	7.8%

Three of the arteriovenous malformations were partly calcified lesions and only one of the two given contrast medium showed enhancement.

Table 6 shows the distribution of the meningiomas in this series together with the site of incorrectly diagnosed lesions. In general agreement with other series³ sphenoid ridge or wing meningiomas are most common, followed by frontal and parietal convexity tumours. The proportion of incorrect diagnoses is similar in all regions except for the posterior fossa, where there is a much higher incidence of both false positive and negative misdiagnosis, and the sphenoidal ridge where, largely because of the high incidence of bone sclerosis misdiagnosis is less frequent.

Discussion

The detection rate of almost 99% confirms that CT is the most accurate screening test for meningioma. The undetected tumours were one *en plaque* cerebellar convexity tumour diagnosed by skull X-ray; one suprasellar tumour diagnosed only at surgery, causing compression of an optic nerve; one parasellar lesion shown by air encephalogram and follow-up CT; one parasagittal-falx meningioma, diagnosed by follow-up CT. The last three tumours were not shown even in

retrospect on the initial CT. In one case, the parasagittal tumour, contrast medium was not given for the first study.

The typical sites of meningiomas and well demarcated edges suggesting their extracerebral origin, especially when combined with their characteristic attenuation higher than that of the adjacent brain sometimes with psammomatous calcification and usually with homogeneous enhancement and little adjacent cerebral oedema in the white matter suggest the diagnosis, which may be confirmed by observing hyperostosis (16%) at the site of attachment to bone. Less frequently the bone is shown to be destroyed from the inner table (3%) and this also suggests the diagnosis in tumours adjacent to the vault. The meningiomas which were misdiagnosed as glioma were either intraventricular (one) (fig 1), irregularly lobulated cavitating masses (four) (fig 2) relatively small in relation to extensive white matter oedema (two) or the extracerebral attachment was not appreciated (six) (fig 3). Throughout the study it was realised that such atypical CT features could occur with meningiomas and led to four of them being diagnosed merely as peripheral intracranial tumour with the implication that further study was necessary to determine their type. Some of the difficulties

Fig 1 (a) Intraventricular meningioma. Plain scan. Irregular region of raised attenuation in left trigone region. Thought to be intracerebral and diagnosed as a glioma. (b), (c) Deep right parietal II astrocytoma. (b) Plain scan, (c) after contrast medium. The lesion appears to be intraventricular and shows dense enhancement. Diagnosed as intraventricular meningioma.

Fig 2 Meningioma. (a) Plain scan, (b) after contrast medium. The tumour is of low attenuation and has moderate surrounding oedema. There is irregular peripheral enhancement.

Fig 3 Meningioma. (a) Plain scan, (b) after contrast medium. Irregular mass of slightly increased attenuation showing dense enhancement with little peripheral oedema. Extracerebral attachment not appreciated.

are due to tumours being attached along the high and low convexities; coronal sections or coronal and sagittal reconstructions should be helpful in diminishing the number of errors in

these situations. Movement artefact was prominent in one case and contrast enhancement was omitted in five.

Most gliomas are of mixed attenuation, close to and below that of brain. Under 20% are of increased attenuation and show homogeneous enhancement. However, over 50% of metastases are of increased attenuation and two-thirds show homogeneous enhancement. The combination of a solitary peripheral malignant tumour with such characteristics is much less frequent but accounted for two-thirds of the false positive diagnoses of meningioma (fig 4). Our analysis shows that the incidence of moderate or marked intracerebral oedema (fig 5) is greater in these tumours and in some cases the tumour margin was rather ill defined (fig 6), which is uncommon with meningiomas. Two microgliomas were included in the group; they exactly simulated meningiomas and had little surrounding oedema. These tumours usually occur deep in the cerebral substance close to the central structures. One primary cerebellopontine angle tumour was also included. It involved the temporal and inferior frontal lobes with bilateral white matter oedema. In retrospect the septum pellucidum is obviously thickened (fig 7). Misdiagnosis is more significant when a benign pathology is mistaken for a glioma than vice versa. Hence there is a tendency to suggest more strongly the possibility since such a suggestion will invariably lead to biopsy and often to angiographic examination.

The difficulty with differential diagnosis of cerebello-pontine angle masses and with perisellar lesions is well known.⁴ A small percentage of neurofibromas, craniopharyngiomas and pituitary adenomas have CT characteristics more commonly found with meningiomas and vice

Fig 4 Secondary carcinoma. (a) Plain scan (b) after contrast medium. Mass of slightly raised attenuation with surrounding oedema, and dense enhancement. Diagnosed as meningioma.

Fig 5 Glioblastoma. Plain scan. Raised attenuation well defined temporal lobe lesion extending through tentorium with extensive oedema anterior to it. Thought to be a meningioma arising from the left petrous ridge.

Fig 6 Oligodendroglioma. (a) Plain scan (b) after contrast medium. Peripherally placed mass of increased attenuation with low attenuation medially thought to be a capping cyst. Diagnosed as meningioma.

versa (fig 8). Bone changes shown on plain X-ray and, occasionally, angiography are helpful in suggesting the correct diagnosis. Large, partly thrombosed aneurysms are of high attenuation, sometimes with peripheral calcification and diagnosis is confirmed when there is dense central enhancement. The clearly demarcated slightly increased attenuation and marked total enhancement of a patent aneurysm, is also generally

appreciated (fig 9) and the diagnosis at least sufficiently suspected to lead on to angiography.

Of particular interest are the four angiomatous malformations (AVM). Failure to appreciate this diagnosis pre-operatively is potentially hazardous. They are of increased attenuation due to content of blood or thrombus and frequently calcification in the walls of the blood vessels or damaged brain. There is also often microcyst formation or local atrophy causing regions of low attenuation and the enlarged blood vessels frequently show as round, oval or serpiginous aggregations depending on their orientation to the CT section, especially when they are enhanced by intravenous contrast medium. The enhancement is partly within the patent blood vessels but is also due to alterations in the blood brain barrier so that it is usually present even when the malformations are thrombosed.⁵ Mass effect occurs in less than 20% of angiomatous malformations unless there has been haemorrhage⁶; it is not usually marked and there is generally little or no low attenuation in the white matter beyond the confines of the AVM. All our AVMs mistaken for meningiomas (fig 10) were peripheral high attenuation lesions; three were partially calcified, two had slight mass effect, but none had any surrounding low attenuation. The two completely thrombosed malformations were rescanned with contrast medium and one enhanced. They were diagnosed only at operation but two others were patent and shown at angiography. CT features which in retrospect could have suggested the correct diagnosis were present in two and in none was there supporting evidence for the CT diagnosis of meningioma from any other study.

Two other lesions that may possibly be mistaken for meningioma are:

- (1) A large plaque of ossification projecting from the dura. However the absence of any adjacent unossified mass, of any abnormal enhancement and of any changes in the skull should suggest the correct interpretation.
- (2) An organising intracerebral haematoma extending superficially may rarely simulate a meningioma when the lesion remains of greater than brain density and enhancement is more extensive than the usual peripheral ring. Even then CT appearance will generally be atypical for meningioma and a detailed history will almost always be helpful by suggesting a resolving acute lesion.

An atypical irregular enhancement pattern was one cause of a mistaken diagnosis in meningioma but total absence of enhancement occurred

Fig 7 Lymphoreticular tumour temporal and inferior frontal extending into septum pellucidum. (a, b) Plain scan (c) after contrast medium, mixed high attenuation and isodense mass with surrounding oedema. Marked enhancement after conray. Thought to be a meningioma.

Fig 8 Meningioma. (a) Plain scan (b, c) after contrast medium. Isodense mass showing enhancement in and around the sella. Diagnosed as pituitary adenoma.

Fig 9 Meningioma. (a) Plain scan (b) after contrast medium. Rounded high attenuation suprasellar mass with dense enhancement. Diagnosed as aneurysm.

Fig 10 Thrombosed arteriovenous malformation. (a) Plain scan (b) after contrast medium. Peripheral mass of raised attenuation showing some enhancement with conray. Diagnosed as meningioma.

in only two cases; conversely however the homogeneous and dense nature of enhancement of some lesions was a contributory factor in their being misdiagnosed as meningiomas. It is therefore unlikely that larger amounts of iodine given by bolus or contrast infusion during the examination would have favourably influenced our diagnostic accuracy.

Plain X-rays show bone changes related to the attachment of the meningioma, prominent vascular grooves leading to this region or calcification within the tumour in some 30–50% of cases⁷ and it has been claimed that a specific diagnosis of meningioma is possible by angiography in over 70% of cases.^{8,9} However, in our unusual cases in which CT diagnosis was difficult the plain X-rays were diagnostic in only 12.5% and, though angiography revealed a mass in all except one case, it was diagnostic of meningioma in only 45% and in 18% the angiographic report suggested a malignant tumour. Similarly, in the cases misdiagnosed as meningioma on CT scan the angiogram was considered to support this diagnosis in almost 50%. Only eight (24%) of lesions misdiagnosed as meningioma, and three (11%) of the meningiomas undetected or misdiagnosed on CT had no other studies than CT and plain X-rays, the remainder having angiography, isotope scan or pneumoencephalography.

It may be considered unsatisfactory that, despite being aware of the difficulties of CT

diagnosis, there was still a false negative rate of 7.8% and a false positive rate of 9.5%, but CT is the most accurate method for detection and specific diagnosis of meningioma. Other radiological methods are also particularly accurate in the diagnosis of this tumour, but are less valuable in the difficult cases which have not been diagnosed by computed tomography.

Despite computed tomography and other radiological procedures an incorrect diagnosis was rectified only by biopsy in 3.2% of meningiomas and 4.8% of the lesions diagnosed as meningiomas were shown on histology to be other conditions, mainly malignant tumours.

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