Computed tomography in the diagnosis of retinoblastoma

PAUL G. ARRIGG, THOMAS R. HEDGES III, AND DEVRON H. CHAR

From the Ocular Oncology Unit, University of California, San Francisco, CA 94143, and the Department of Ophthalmology, Tufts-New England Medical Center, Boston, Mass 02111, USA

SUMMARY The role of orbital computed tomography (CT) in the management of retinoblastoma is reviewed. All 21 patients with retinoblastoma studied with high-resolution computed tomography had intraocular calcification demonstrable in at least one eye. 83% of tumours showed evidence of calcification on CT scan. The degree of calcification appeared to depend on tumour size; only small tumours were devoid of calcification. The amount and distribution of calcification was similar on both histological study and CT scan. In patients under 3 years old in whom a retinoblastoma is suspected the presence of calcification on CT is virtually diagnostic of it. Patients with leucocoria without calcification on CT probably have a simulating lesion.

Computer assisted tomography (CT) is a useful, adjunctive diagnostic test in the evaluation of patients with possible retinoblastoma.¹⁻⁴ Calcium, usually complexed with denatured DNA, is present in approximately 95% of histologically examined retinoblastomas.⁵ Improvement in our ability to detect intraocular calcification with high-resolution, thin-section CT scanning may increase accuracy in differentiating retinoblastomas from other simulating lesions. In addition orbital/brain CT can be used to determine if there is retrobulbar extension of a retinoblastoma, involvement of the central nervous system, or development of either secondary orbital or pineal tumours.

We have evaluated the role of computer assisted tomography in a series of patients with retinoblastoma to determine the incidence of calcification in these tumours; to delineate which factors, such as age, tumour size, or tumour location, influence the development of calcification; and to correlate CT with histopathology.

Material and methods

Twenty-one patients with retinoblastoma with high-resolution, thin-section CT scans performed prior to therapy between 1977 and 1981 were studied. All patients were examined in the Ocular Oncology Unit

at the University of California, San Francisco, by one of us (D.H.C.). Three patients with Coats's syndrome were also scanned. All had typical findings with yellowish exudate and telangiectasia; two presented with leucocoria.

Eighteen scans were performed with a GE 8800 CT scanner. In these cases 1.5 mm contiguous axial scans were obtained through the orbits, with thicker sections through the rest of the head. Coronal and oblique reformations were routinely performed.⁶ Six patients were initially examined with a GE 7800 scanner with 5 mm overlapping sections through the orbits. Patients were sedated with 5 mg/kg of pentobarbitone (Nembutal) intramuscularly.

Thirteen of the 21 patients had unilateral involvement and 8 had bilateral tumours. The patients' ages ranged from 2 months to 4½ years, with a mean of 19 months. Thirteen patients presented with leucocoria, 4 with strabismus, 1 with buphthalmos, and 3 with tumours discovered incidentally on paediatric examination.

All patients with unilateral retinoblastoma had lesions which precluded alternative therapy, and these eyes were enucleated. Seven of 8 patients with bilateral tumours also had one eye enucleated. All enucleated eyes were examined histologically; several eyes were stained for calcium with alizerin red. Histochemical findings were compared to CT changes. CT demonstration of calcium was unequivocal in all cases; the attenuation coefficient over the CT attenuation coefficient over the area was >300 units.

Correspondence to Devron H. Char, MD, Ocular Oncology Unit, Science 315, University of California, San Francisco, CA 94143, USA.

Results

All 21 patients had calcification demonstrable in at least one eye by CT scan (Table 1). One eye contained a small tumour which did not show calcification with the GE 7800 scanner; when it was studied with the GE 8800 scanner calcification was detected. Twenty-four of 29 eyes with retinoblastoma had calcification within clinically detectable tumours on CT scan. Seventeen of 20 eyes (85%) showed calcification with the GE 8800 CT scanners; 6 of 9 eyes (65%) studied with the GE 7800 showed calcification.

All tumours not showing calcification on CT examination were small. The largest of these, studied with the GE 7800 scanner, measured 13 mm in diameter and 3 mm in elevation. The smallest lesion showing calcification by a GE 8800 CT scanner was 8 mm in diameter and 4 mm thick. The presence of calcification did not appear to be related to the age of the patient at the time of diagnosis. In one case calcification was not clearly demonstrated on routine axial sections; it was more readily observed on reformations.

Two patterns of calcification were observed on CT scans of retinoblastoma-containing eyes. A regular, nonhomogeneous pattern was observed in 14 eyes containing large tumours (Fig. 1). Seven eyes containing only smaller tumours showed a homogeneous pattern of calcification (Fig. 2). All 20 eyes with large tumours were enucleated and had microscopic evidence of calcification. A close correlation was found between the amount and distribution of calcium on both pathological and CT examinations. The histological findings with alizerin red stain of the patient whose CT was shown in Fig. 1 are demon-

Table 1 Evidence of tumour calcification on CT scan

	Eyes with calcified tumours on CT examination*		Eyes without calcified tumours on CT examination†	
	Both scanners	GE8800/GE7800	Both scanners	GE8800/GE7800
Bilateral tumours	10	7/3	6	3/3
Unilateral tumours	13	10/3	0	0

* The smallest tumour in this group was 4 mm thick.

† The smallest tumour in this group was less than 2 mm thick.

strated in Fig. 3. Twelve patients had one eye with stage V retinoblastoma. In 7 of these cases there was bilateral involvement; 5 had unilateral disease.

Two patients had microscopical evidence of tumour spread past the lamina cribosa of the optic nerve. This was not detected by CT scan. One additional patient showed apparent enlargement of the optic nerve on CT scan; there was no histological evidence of invasion of the optic nerve. No patient had evidence of gross extraocular or intracranial tumour.

Three patients with Coats's syndrome were also studied. None of these patients had demonstrable calcification on either axial CT or with computer reformation (Fig. 4).

Discussion

High-resolution, thin-section CT scanning can detect calcification within retinoblastomas with a high

Fig. 1 Nonhomogeneous pattern of calcification observed in large tumours.

Fig. 2 Homogeneous pattern of calcification observed in small tumours.

degree of accuracy. We have found tumour calcification on CT examination of all retinoblastoma patients studied; 85% of tumours had calcium flecks on GE 8800 scans. High-resolution, thin-section studies resulted in a higher incidence of detection of calcification than previously recorded.¹⁻³ These CT findings approached the 95% incidence of calcification detection by histochemical techniques.⁵ Those tumours not showing calcification both by high-resolution CT and by pathological examination tended to be small. The largest tumour not showing calcification by CT was 13 mm in diameter and 3 mm in thickness, whereas the smallest tumour showing calcification by CT was 8 mm in diameter and 4 mm in thickness. There was good correlation between the nature and degree of calcification seen microscopically and that seen on CT scan. Factors other than tumour size, such as the patient's age and the location of the tumour did not appear to influence the presence of calcification on CT scan.

The CT demonstration of calcification in retinoblastomas may be useful in the differentiation of retinoblastoma from other simulating lesions. In our experience none of the simulating lesions, including optic nerve head drusen, retinal astrocytoma, choroidal haemangioma with previous haemorrhage, choroidal osteoma, toxocariasis, chronic retinal detachment associated with retrolental fibroplasia, persistent hyperplastic primary vitreous, Coats's disease, retinal dysplasia, or trauma tend to contain calcification in the age group (0-3 years) in which retinoblastoma is usually diagnosed.^{7,8} In children under 3 years old suspected of having a retinoblastoma the presence of calcification on CT scan

Fig. 3 Alizerin red stain of a large retinoblastoma. This is the same patient as shown in Fig. 1. ($\times 0.6$).

may be considered virtually diagnostic of this tumour. Conversely, in a patient under 3 years old with leucocoria or a total retinal detachment the absence of calcifications on 1.5 mm contiguous orbital CT scans with computer reformation makes the diagnosis of retinoblastoma quite unlikely. Unfortunately, in children over 3 years old the value of this diagnostic test is less well defined. Some of the simulating entities listed above can produce calcification in older children.

The high resolution GE 8800 CT scanner showed calcification more frequently than did an earlier

Fig. 4 CT scan of patient with Coats's disease presenting as leucocoria.

generation (GE 7800) scanner. Even with the lower resolution CT scanning at least one eye in every patient studied showed calcification.

In our ocular oncology unit we routinely obtain CT scans on patients suspected of harbouring a retinoblastoma. We have found it to have slightly greater sensitivity than ultrasonography, and we believe that the CT examination of patients with suspected retinoblastomas may also be useful in determining retrobulbar spread, intracranial metastases, and second tumours.^{6,9} Our findings demonstrate that subtle retrobulbar optic nerve involvement cannot be reliably predicted by CT. In 2 of our patients CT showed normal optic nerves were shown to contain tumour on histologic examination. In another case an optic nerve which appeared swollen on CT scan was found to be normal histologically. In other studies of patients with advanced orbital or intracranial retinoblastoma CT has demonstrated extraocular disease.²

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