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Case Report

Clinical features and surgical treatment of calcified meningiomas: a report of 58 cases

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Abstract: In order to study clinical features and surgical treatment of calcified meningiomas (CMs), fifty-eight patients with CMs who were surgically treated were analyzed and tumor characteristics and treatments were studied and compared with the literature. Subjects with CMs were an average of 53.5 year-of-age and CMs were frequently found in the cerebral convexity, falx, tentorium and middle cranial fossa, and were uncommonly in the sellar region and rarely in the pineal body area. CMs were symptomatic in 14% of cases and calcification occurred most commonly intratumorally and rarely in the wall of the meningioma. Calcification shapes were various and were found in transitional, meningothelial, fibroblastic and psammomatous meningiomas, and rarely in malignant and atypical meningiomas. There was no or mild peritumoral edema in most cases and a poor blood supply was common for most CMs. Simpson Grade I-II resection was achieved for 52 cases and grade III for the remaining 6 cases. Postoperative mortality was 1.7% and no tumor recurrence was observed after a follow-up of 48 months (on average) for all subjects. CMs have marked clinical characteristics compared with meningiomas and are associated with an excellent post-surgical prognosis.

Keywords: Calcified meningioma, clinical features, treatment, prognosis

Introduction

A calcified meningioma (CM) is usually diagnosed with computed tomography (CT), and is defined as a meningioma with high-density area that has a non-contrast CT scan value greater than 80 Hu [1-5]. CMs accounted for 15% of all meningiomas on average [4-6] and according to diagnostic criteria, 58 cases of CMs in our clinic were treated surgically and confirmed by CT and pathology, accounting for 6.55% of all meningiomas that we observed from January 1999 to June 2009.

Materials and methods

Patients and CT scan

We studied 57 subjects (16 males) aged 19-75 years-of-age (mean: 53.5 years). Disease courses were between 3 days and 17 years (mean: 27.5 months). The institutionalreview board approved the study protocol, andwaived the informed consent requirement due to thestudy design. Enhanced CT revealed moderate to marked enhancement and 50-100 Hu increases in CT values.

Surgical treatment

Microsurgical treatment under general anesthesia was offered to all patients and most tumors had poor blood supply with crisp or tenacious textures in contrast with non-CMs. Adjuvant radiotherapy was given to subjects with sub-total resection.

Statistical analysis

Data were analyzed with SPSS13.0 (SPSS Inc., Chicago, IL) and differences were considered statistically significant when $P<0.05$.

Results

Symptoms and signs of CMs appear in **Table 1**. All patients received a CT scan and scan data are available in **Table 2**. Calcifications can appear in any tumor aspect, but commonly ap-

Table 1. Symptoms and signs associated with 58 CM cases

Symptoms	Cases (N)	Signs	Cases (N)
Headache	31	Papilledema	22
dizziness	9	Mild hemiplegia	10
Nausea, vomiting	8	Superficial sensation decrease	5
Convulsion	10	Ataxia	5
Vision decrease	7	Nystagmus	2
Hyposmia	5	Visual field defect	1
No Symptoms	8	Hoarseness	1

Table 2. CT findings in 58 CM cases

Tumors	Cases (N)
Locations	
Cerebral convex	13
Cerebellar tentorium	6
Superior sagittal sinus	5
Cerebral falx	5
Middle cranial fossa	5
Olfactory groove	4
Cerebral ventricle	4
Cerebellopontine angle	4
Petro-clivus	4
Sphenoidal crest	3
Posterior cranial fossa	2
Multiple	2
Tuberculum sellae	1
Size (cm)	
<3	12
3-7	38
>7	8
Boundary	
Clear	58
Unclear	0
Peritumoral edema	
No	2
Mild (<2 cm)	52
Medium (2-4 cm)	4
Severe (>4 cm)	0
Shapes of calcified focuses	
Focal	
Stippled	18
Nodular	16
Cauliflower-like	8
Scattered	
Lamellar	5
Annular	4
Island-like	2
Diffuse	2
Complete	3

peared in the center. CT values of tumor calcifications ranged from 80-600 Hu and calcification shapes were varied (**Figure 1A-H**).

Surgical results

Simpson Grade I-II resection was achieved in 52 cases and III in 6 according to Simpson criteria [7]. Postoperatively, there were no complications and only one death occurred after an intracranial infection.

Pathological results

Histopathological examinations of specimens revealed benign meningiomas (WHO Grade I) in all cases according to 2007 WHO diagnostic criteria [8]. Pathological sub-types included 19 cases of transitional meningioma, 18 meningothelial, 13 fibroblastic, 7 psammomatous, and 1 angiomatous CM.

Follow-up results

Clinical and radiographic follow-ups were completed for 57 cases and the range duration of follow-up was 36-68 months (mean: 48 months). Finally, all neurological defects disappeared and no recurrence of tumors was found.

Discussion

Incidence of CMs

The incidence of CMs was 3-20% in the literature [2, 3, 5], and this variation may be explained by different image diagnostic techniques. Earlier images were based on skull x-rays which identified 15-18% of CMs detected with CT because calcifications were visible in only 2-5% of x-ray films [9]. Also diagnostic criteria for calcifications have been historically different. CT values for tissues exceeding 80 or 100 Huwere thought to be CMs according to the literature, but some CM's were 80 Hu [1, 3, 10]. Finally, CMs were often not specifically described as a unique diagnosis when meningiomas were diagnosed.

Mechanism of meningioma calcification

How CMs occur is presently uncertain but may be due to alkaline phosphatase (AP) abundance and activity because tumoral calcification is

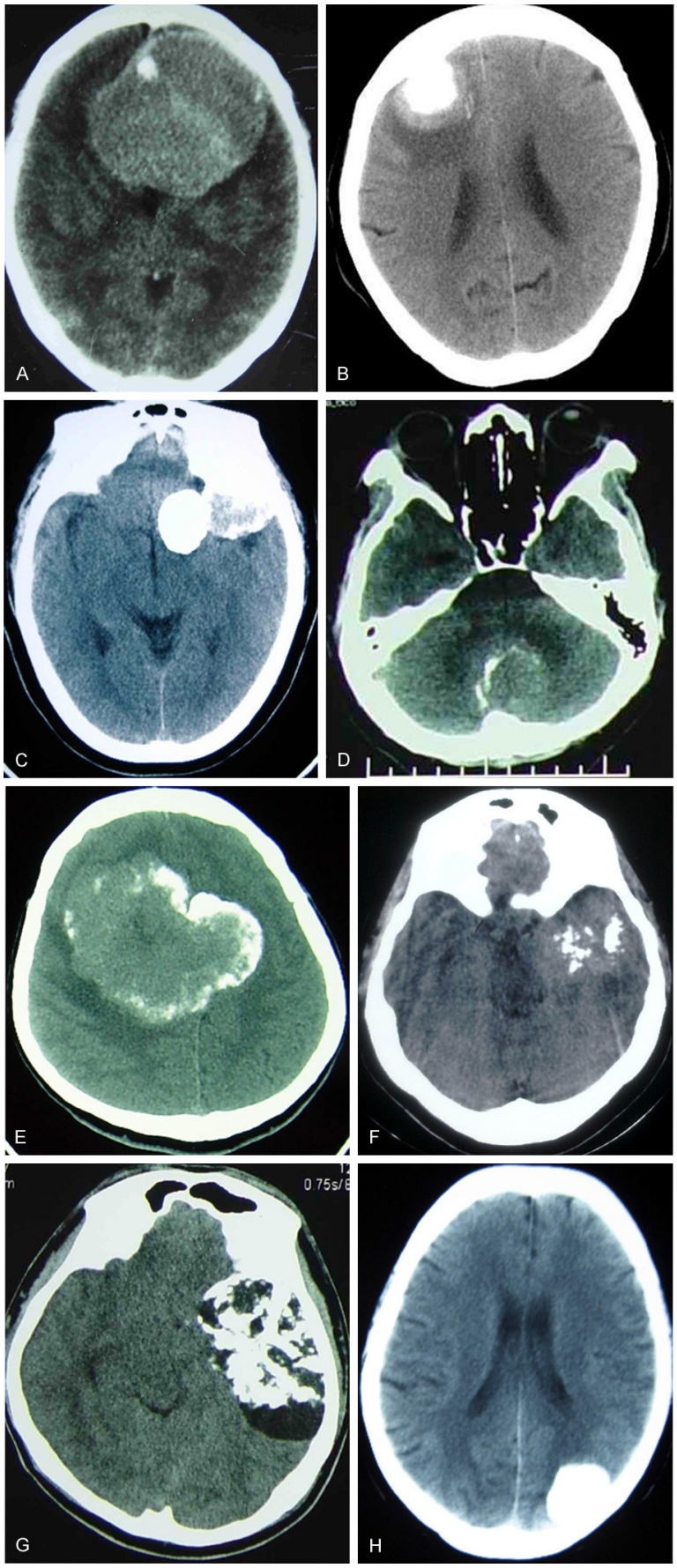

Figure 1. CT imaging of meningioma with different calcification forms. A. Stippled calcification; B. Nodous calcification; C. Cauliflower-like calcification; D. Lamellar calcification; E. Annular calcification; F. Island-like calcification; G. Diffuse calcification; H. Complete calcification.

dystrophic [11, 12]. Manipulation of tumor blood supply alters intratumoral pH, which increases local AP, which in turn increases intratumoral phosphoric acid by hydrolyzing lysosomal phosphatase from necrotic tumor cells. Calcium phosphate precipitation produces calcifications. Acidic environments can dissolve calcium phosphate.

Meningiomas can secrete glycosidoproteins that can also cause calcification. For example, osteopontin, a secretory phosphorylating glycosidoprotein, is more abundant in meningiomas and Hirota and colleagues reported that osteopontin was related to meningioma and breast cancer micro-calcifications [13]. Osteopontin is necessary for the formation of psammoma bodies which are small (50-70 μm diameter) concentric calcified structures [14] that appear due to dystrophic calcification metabolic products released by tumoral cells.

Clinical characteristics

According to our findings, CMs appeared more frequently in subjects older (mean 53.5 years) compared to meningiomas (mean 49.7 years) ($P< 0.05$). Roser and co-workers reported that older patients accounted for 57.1% of CMs [15]. Also, CMs were 2.6 times more frequent in females than in males, which was slightly higher than published ratios

(1:2 for females:males) [2, 5, 15]. CMs also frequently were found in the cerebral convexity, falx, tentorium and the middle cranial fossa, and were uncommonly located in thesellar region and rarely in the pineal body area. CMs were asymptomatic in 14% of subjects and this was significantly higher that reported for meningiomas (7.8%) [16] ($P<0.05$). Asymptomatic meningiomas in our group were frequently completely calcified and calcifications occurred chiefly intratumourally and rarely in the meningioma wall.

Calcifications were diversely shaped and were categorized into 4 groups: focal, scattered, diffuse or complete. Usually, focal calcifications were manifested by stippled, nodular or cauliflower-like high-density areas in meningiomas on plain CT images. Scattered calcifications were lamellar, annular or island-like high-density areas. Among them, stippled and nodular calcifications were most common and diffuse or complete calcifications were rarer. Complete CMs accounted for only 2.2% of all CMs [17], but we 5.2% of our subjects had complete CMs.

We observed no mild peritumoral edema and this may be explained by slow growth, less invasion and a poor blood-supply which was noted in most samples, especially meningiomas with complete or diffuse calcifications. Calcification occurred frequently in some subtypes and 26% of CMs were transitional and fibroblastic [17]. In our samples, calcification occurred in transitional (32.8%), meningothelial (31%) or fibroblastic (22.4%) meningiomas, and rarely in meningeal sarcomas, or malignant or atypical meningiomas. Obvious calcifications were present in psammomatous meningiomas.

Treatment and prognosis

CMs are thought to be slow growing and not very invasive [5] and Nakasu reported a mean doubling time of 27 months and 41 months for focal or diffuse meningiomas calcifications, respectively, and tumor cell proliferation was low [18]. Masaki reported 19 CM cases of which 84.2% had no apparent growth and this was less than reported for non-CMs [19]. Some CMs were asymptomatic meningiomas and were found during CT scans for head injuries or general examinations. At this time, treating CMs in older patients is not standardized [16, 19] but we suggest that surgery may be a first-line treatment for symptomatic CMs.

Operative indications and surgical techniques for treating CMs are identical to non-CMs and less invasion and poor blood-supply allow for easy removal of CMs. Rarely, CM removal requires a rongeur or a grinding drill and adjuvant radiotherapy can inhibit or prolong tumor recurrence for subjects who received sub-total resection.

In our group, 89.6% of CMs were removed completely due to less invasiveness and 1.7% of subjects died during surgery. For patients with successful surgery, no recurrence was noted during the 3-6 year follow-up. In comparison, total CM removal rates of overall meningiomas were 50-83%, and operative deaths were as high as 9% with recurrence in 15-20% of subjects [5].

Prognosis for CM was better than for meningiomas in our series and this may be attributed to less tumor cell proliferation and better tumor removal. Hidetoshi's group studiedcorrelations between dye indices of monoclonal antibodies against cell proliferation associated nuclear antigen (MIB-1) and tumor proliferative potential in 342 meningioma cases (117 CMs) using logistic regression analysis and found that calcifications reduced tumor proliferation [10]. Nakasu and co-workers reported that diffusely calcified meningiomas had smaller dye indices for MIB-1 (0.57%) in contrast with non-CMs (1.75%) and focally calcified meningiomas (0.92%) [18]. Thus, because calcified tumor cells die consistently, tumoral calcifications may contribute to less meningioma recurrence [12, 20].

Disclosure of conflict of interest

None.

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