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Imaging diagnosis of retroperitoneal ganglioneuroma in childhood

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Abstract *Purpose.* To demonstrate the typical appearance of retroperitoneal ganglioneuromas on CT and MRI.
Materials and methods. Retrospective analysis of diagnostic imaging (five CT scans, three MRI scans) in five children aged 3–15 years with the histological diagnosis of ganglioneuroma.
Results. The scans showed large (maximum 11 cm diameter), round or oval tumours with sharply defined margins. Intraspinal tumour involvement occurred in two cases. Comparing CT with MRI, MRI was more accurate in defining the intraspinal involvement. The ganglioneuromas were hypodense on unenhanced CT and showed moderate enhancement with administration of contrast medium. In three patients, CT demonstrated tumour calcification with a disseminated speckled pattern. On T1-weighted MRI the tumours were homogeneous and hypointense, showing marked enhancement after gadolinium administration. On T2-weighted scans the tumours were hyperintense.
Conclusion. At the time of diagnosis, retroperitoneal ganglioneuromas are generally large tumours that can be shown well by CT and MRI. The appearance on CT more readily suggests the diagnosis, but MRI is superior for documenting local or intraspinal tumour extension and lacks radiation load.

Introduction

Ganglioneuromas are rare, benign tumours of the peripheral and central nervous system. Contrary to neoplasms of the nerve sheath or paraganglioneric structures, they evolve from mature ganglion cells [1]. Among tumours of the autonomic nervous system, ganglioneuromas represent the most mature form. They can be distinguished from undifferentiated neuroblastomas and ganglioneuroblastomas, which contain elements of both malignant neuroblastoma and benign ganglioneuroma. Most commonly, ganglioneuromas derive from sympathetic nerve cells and are localized in the posterior mediastinum and the retroperitoneal space [2]. At the time of diagnosis, 60 % of the patients are under the age of 20 years with a slight female predominance [3]. Patients are often asymptomatic because ganglioneuromas grow slowly and are usually endocrinologically inactive [4].

The CT appearance of retroperitoneal ganglioneuromas is well described. At present, reports of the MRI appearance of these tumours, especially in childhood, are not available. Apart from one study of nine adult patients [5], which demonstrated MRI characteristics of retroperitoneal ganglioneuromas, there are only single case reports [6–8]. The aim of this study was to describe and compare the imaging findings of both CT and MRI in children with a histological diagnosis of retroperitoneal ganglioneuroma.

Materials and methods

Diagnostic imaging of the retroperitoneum with CT and MRI was analysed retrospectively in five children (four girls, one boy) between the ages of 3 and 15 years. All patients had the histological diagnosis of ganglioneuroma, which was made on the operative specimen. Initially, abdominal sonography was performed in all patients. Plain films of the abdomen or spine were not available. CT was performed in all patients before and after injection of contrast medium (1 ml/kg body weight, nonionic). Sequential 8-mm slices were obtained. MRI comprised T1-weighted (T1-W) and T2-weighted (T2-W) multiplanar spin-echo (SE) sequences, including contrast-enhanced (0.2 ml/kg Gd-DTPA) T1-W images. The size of the tumours was evaluated by planimetry in the maximum dimensions. CT attenuation was analysed in three of the five patients using the region-of-interest (ROI) modus. Dynamic studies or meta-iodo-benzyl-guanidine (MIBG) uptake studies were not performed. The evaluation criteria comprised size, shape, location and delineation of the tumours, as well as intraspinal involvement and their specific appearance on CT and MRI. Only tumours without intraspinal extension were treated by total excision; the remaining cases underwent subtotal excision.

Results

Clinically, two of the patients were asymptomatic and presented with a palpable abdominal mass during routine physical examination. Three children complained of nonspecific abdominal pain, encopresis and diarrhoea. Diseases that are frequently associated with ganglioneuroma, such as neurofibromatosis and multiple endocrine neoplasia (MEN) IIb, were not found in our group. In all five children, laboratory results were normal; in particular, there were no increased catecholamines in the 24-h urine and there were no increased tumour markers (AFP, beta-HCG, LDH) or secretion of vasoactive intestinal peptide (VIP). Initially, abdominal sonography was performed in all children. Subsequently, CT and MRI showed round or oval tumours with sharply defined margins located at pre- or paravertebral sites. In all cases the growth pattern was described as expansive with mass effect and encasement of the surrounding structures. Sonography failed to demonstrate intraspinal involvement of the tumours in the two cases in which it was present. The size of the tumours ranged from 3.8 to 11 cm and was estimated similarly by CT and MRI. By sonography, the tumour size was underestimated in all five cases with differences up to 20 % of the size described by CT or MRI.

The relevant findings on CT and MRI in all children are shown in Table 1. CT attenuation on unenhanced scans was predominantly low (27–36 HU). On enhanced CT there was only slight or inhomogeneously moderate uptake (45–77 HU). The enhanced CT scans revealed a tumour capsule in two cases. Three cases showed tumour calcifications with a discrete punctate pattern (Fig. 1 a). Two retroperitoneal ganglioneuromas showed intraspinal extension, which could be demonstrated by CT (Figs. 1 a, 2 a). Due to multiplanar imaging and improved tissue contrast in MRI the intraspinal extension was demonstrated more distinctly with this method than in CT. The ganglioneuromas showed intraspinal spread with local invasion, widening of the neuroforamina and a strictly extradural localisation. Consequently, the intraspinal component of the tumour was dumbbell shaped (Fig. 1 b,c).

MRI was performed in three children. In all cases, T1-W signal intensity of the tumours was equal or less than that of muscle and, therefore, classified as homogeneously low (Fig. 2 b). On T2-W scans the ganglioneuromas showed markedly high-signal intensity equal to that of water. On post-contrast T1-W images homogeneous, marked enhancement was evident. The degree and distribution of contrast enhancement on CT and MRI were not uniform. Inhomogeneous enhancement on CT was associated with marked enhancement on MRI in the same tumour (Fig. 2 a,c). Contrast enhancement on CT and MRI examinations improved the demarcation between tumour and surrounding tissue. For the evaluation of vascular encasement of retroperitoneal vessels, contrast enhancement was necessary in CT.

The histological and immunohistochemical analysis of all surgical specimens revealed benign mature ganglioneuromas without any poorly differentiated components in all cases. Currently there are no tumour recurrences or metastases in any child.

Discussion

Ganglioneuromas are rare benign tumours of the peripheral nervous system which preferentially are derived from the paravertebral sympathetic chain of the posterior mediastinum and retroperitoneum. Apart from these typical localizations, ganglioneuromas are found in the adrenal gland, skin, tongue, appendix and lymph nodes [9]. They present more often in childhood and adolescence and may remain asymptomatic for a long period of time. The development of clinical symptoms depends on the localization and size of the tumour. Endocrinological activity is rarely observed in patients with ganglioneuroma [4] and was not noticed in our patients. Ganglioneuromas can occur in all age groups but are usually seen before the age of 20 years [3]. More than half of the patients presenting with neuroblastoma are under the age of 2 years and more than 90 % under the age of 8 years. Boys are more frequently affected by neuroblastoma than girls [10]. The mean age of our patients was 7.6 years (Table 1) and four of the five children were girls. This shows that sex and age may be helpful in the diagnosis of neurogenic tumours.

The appearance in our US examinations was of a predominantly homogenous mass with hypodense echoge-

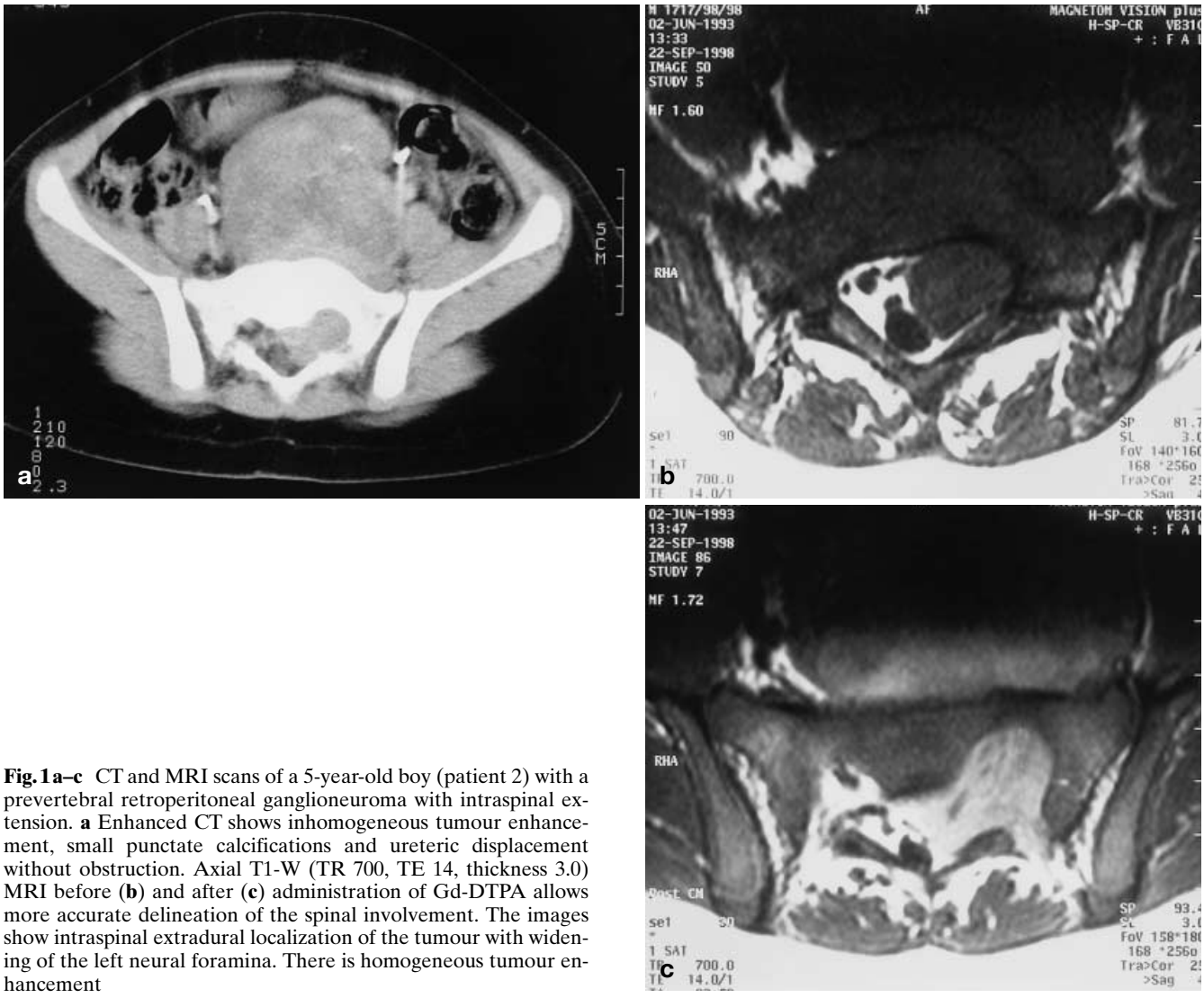

Fig. 1 a–c CT and MRI scans of a 5-year-old boy (patient 2) with a prevertebral retroperitoneal ganglioneuroma with intraspinal extension. **a** Enhanced CT shows inhomogeneous tumour enhancement, small punctate calcifications and ureteric displacement without obstruction. Axial T1-W (TR 700, TE 14, thickness 3.0) MRI before (**b**) and after (**c**) administration of Gd-DTPA allows more accurate delineation of the spinal involvement. The images show intraspinal extradural localization of the tumour with widening of the left neural foramina. There is homogeneous tumour enhancement

nicity and sharply delineated borders. Jasinski et al. [11] describe similar results, although they observed a unilateral paravertebral tumour more commonly than in our series. Extension across the midline, which was observed in three of our patients, is considered less typical for ganglioneuroma by these workers.

On CT, tumour calcifications were detected in three of our patients, having not been identified by US or MRI. This confirms that CT has a higher sensitivity for the detection of tumour calcifications. The detection of tumour calcification may be helpful to differentiate ganglioneuroma from neuroblastoma, the most common differential diagnosis of a retroperitoneal tumour in childhood. The appearance of tumour calcification in neuroblastoma is more often amorphous and of a rough pattern [12]. Intraspinal extension of ganglioneuromas is considered to be a rare manifestation [8]. However, the results of Armstrong et al. [12], who described this feature in two of ten cases, as well as our own results, demonstrate that intraspinal invasion may occur more frequently in retroperitoneal ganglioneuroma than considered previously. Due to the relatively frequent involvement of the spinal canal and the necessity for MRI, the value of an additional CT has to be considered critically.

Similar to previous reports in the literature, all tumours in this study showed low attenuation on unenhanced CT and slight or moderate enhancement on contrast-enhanced CT [5, 12, 13]. Histopathologically, ganglioneuromas are composed of an abundant amount of myxoid matrices and a relatively small amount of ganglion cells [10]. This seems to be the main reason for the low CT attenuation and pattern of enhancement. Neuroblastomas and phaeochromocytomas usually

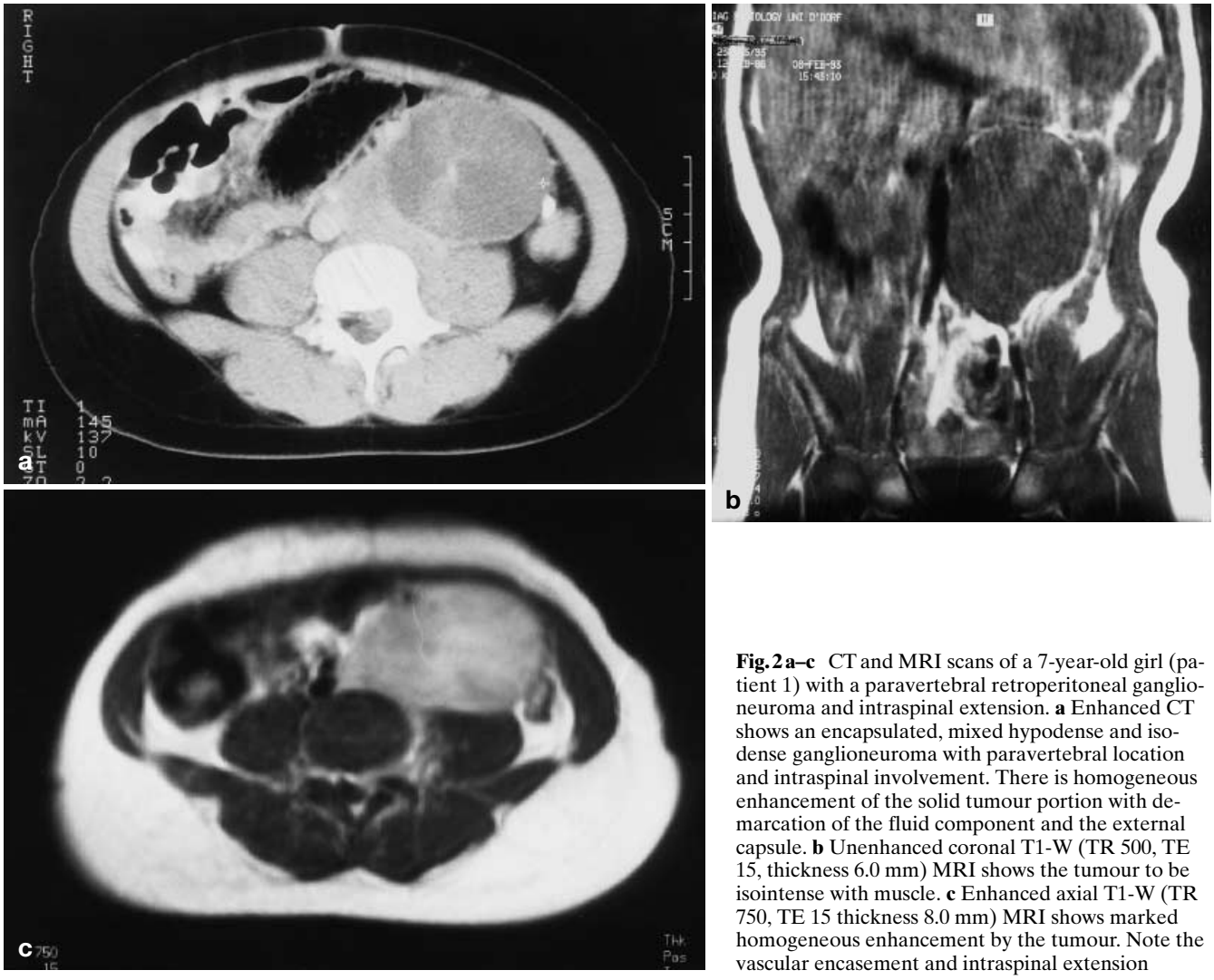

Fig. 2 a–c CT and MRI scans of a 7-year-old girl (patient 1) with a paravertebral retroperitoneal ganglioneuroma and intraspinal extension. **a** Enhanced CT shows an encapsulated, mixed hypodense and isodense ganglioneuroma with paravertebral location and intraspinal involvement. There is homogeneous enhancement of the solid tumour portion with demarcation of the fluid component and the external capsule. **b** Unenhanced coronal T1-W (TR 500, TE 15, thickness 6.0 mm) MRI shows the tumour to be isointense with muscle. **c** Enhanced axial T1-W (TR 750, TE 15 thickness 8.0 mm) MRI shows marked homogeneous enhancement by the tumour. Note the vascular encasement and intraspinal extension

show strong uptake of contrast medium on CT [14] and can, therefore, be distinguished from ganglioneuromas. However, poor contrast medium uptake appears to be typical for tumours of retroperitoneal localization because there was strong uptake of contrast medium in three patients with mediastinal ganglioneuromas [15].

According to the literature [5–8], the tumours are of homogeneous low intensity on T1-W MRI and markedly high signal on T2-W images. Similar to the results reported by Hallscheidt et al. [6], enhanced T1-W scans in our group showed predominantly strong enhancement. By contrast, Ichikawa et al. [5] described inhomogeneous enhancement and a lack of early enhancement (during the first 3 min after i.v. Gd-DTPA) in five patients who had dynamic MR examinations. This time-related distribution of Gd-DTPA in ganglioneuromas depends on the vascularity and capillary permeability of the tumour tissue. The high proportion of myxoid matrix and enlarged extracellular space in ganglioneuromas results in poor early enhancement on dynamic MRI and greater accumulation of contrast medium in non-dynamic MRI.

In conclusion, the appearance of retroperitoneal ganglioneuromas is more specific on CT than on MRI. A moderately enhancing encapsulated tumour on CT, showing fine speckled calcifications, is likely to be a benign ganglioneuroma. By contrast, a strongly enhancing tumour on MRI cannot be differentiated from other retroperitoneal tumours of childhood, especially neuroblastoma. The superiority of MRI in studying the regional and intraspinal extension emphasizes the value of this method in the diagnostic strategy of retroperitoneal tumours. Tumour extension across the midline and intraspinal tumour spread is more frequent in ganglioneuroma than previously considered.

Table 1 CT and MRI findings in the 5 children with ganglioneuroma

Patienten-No./sex/age (years)	Localisation	Shape	Margin	Size (cm)	Intraspinal tumor (yes/no)	CT findings calcification	Native	Enhancement	MRI-findings T1-W signal	T1-W + Gd-DTPA	T2-W signal
1/F/7	retroperitoneal, paravertebral	round	well defined, external capsule	6.9 × 5.8	yes	no	mixed hypodense/liquid density	slight, inhomogeneous	muscle-isointense	homogeneous, strong enhancement	marked hyperintense
2/M/5	retroperitoneal, prevertebral	oval	well defined	9.4 × 6.6	yes	punctate	hypodense	moderate, spotted	homogeneous hypointense	homogeneous, strong enhancement	hyperintense
3/F/3	retroperitoneal, prevertebral	round	well defined	4.1 × 3.8	no	no	hypodense	moderate, inhomogeneous	–*	–*	–*
4/F/8	retroperitoneal, paravertebral	polycyclic	well defined, external capsule	7.3 × 6.6	no	disseminated, speckled	mixed hypodense/intermediate	slight, inhomogeneous	hypointens	marked enhancement	marked hyperintense
5/F/15	retroperitoneal, prevertebral	oval	well defined	11 × 7.7	no	speckled	mixed hypodense/muscle density	slight, homogeneous	–*	–*	–*

* No MRI-examination performed

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