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● *Original Contribution*

COLOR DOPPLER ULTRASOUND IN DIAGNOSIS AND ASSESSMENT OF CAROTID BODY TUMORS: COMPARISON WITH COMPUTED TOMOGRAPHY ANGIOGRAPHY

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Abstract—A carotid body tumor (CBT) is a rare, non-chromaffin paraganglioma, and its diagnosis mainly depends on imaging modalities. The aim of this study was to investigate the ability of color Doppler ultrasound (CDU) in the diagnosis and assessment of CBT based on computed tomography (CT). We retrospectively reviewed the CDU and CT features of 49 consecutive CBTs and 23 schwannomas from 67 patients and compared these findings with surgical resection specimens. The mean size of CBT lesions on ultrasound scans and CT angiography (CTA) was 3.24 cm ± 0.82 cm (range, 1.6–5.2 cm) and 3.84 cm ± 1.08 cm (range, 1.8–6.8 cm), respectively, which had statistically significant difference ($t = 9.815, p = 0.000$). The vascularity of CBT lesions was richer than that of schwannoma lesions ($p < 0.05$). Intra-lesional vascularities feeding CBT mostly arose from the external carotid artery and had spectrum characteristics including low velocity and resistance. Peak systolic velocity (PSV) and resistance index (RI) of the vasa vasorum were 39.8 cm/s ± 19.8 cm/s and 0.54 ± 0.06, respectively. There was the correlation between CTA and CDU in identifying Shamblin type I CBT lesions, while CTA technique was superior for CDU, identifying Shamblin type II and III CBT lesions. Accuracy, specificity and sensitivity of CDU in diagnosing CBTs were 87.5% (63 of 72), 82.6% (19 of 23) and 89.8% (44 of 49), respectively. Both accuracy and sensitivity of CTA in diagnosing CBTs were 100%. CDU can be useful for assessment of Shamblin's type and intra-lesional blood flow of CBTs before its metastases, while CT imaging can reveal the relationship between lesions and adjacent arteries, as well as the involvement of the skull base. CDU combined with CT imaging can be used as an optimal detection modality for the assessment and management of CBT. (E-mail: ttyyus@sina.com) © **2016 World Federation for Ultrasound in Medicine and Biology.**

Key Words: **Carotid body tumor, Diagnosis, Color Doppler ultrasound, Computed tomography angiography.**

INTRODUCTION

A carotid body tumor (CBT) is a rare, non-chromaffin paraganglioma involving the carotid body chemoreceptor, which represents more than 50% of head and neck paraganglioma with an incidence of 1:30000 (Boscarino et al. 2014; Gad et al. 2014; Guercio et al. 2013). Although most CBTs are asymptomatic, slow-growing and benign, surgical excision as earlier as possible is advisable because they have malignant tendency to invade the adjacent vascular and neural structures (Martinelli et al. 2009; Sanl et al. 2012). Therefore, reliable and effective imaging methods applied for identifying primary CBTs and its metastases or recurrence are crucial. On account of abundant vascularity in CBTs and its proximity to nervous and vascular structures, fine-needle aspiration biopsy is not appropriate for the diagnosis of CBTs (Boscarino et al. 2014; O'Neill et al. 2011). Thus, diagnostic imaging modalities play a very important role in the diagnosis and differential diagnosis of this condition. Color Doppler ultrasound (CDU), computed tomography (CT), magnetic resonance imaging (MRI) and digital subtraction angiography (DSA) are requested for patients with suspected CBTs. DSA has been regarded as the gold standard for CBT diagnosis and treatment planning. However, DSA has been replaced by emerging imaging technology, such as CT angiography (CTA) and magnetic resonance angiography (MRA), which not only gives an accurate angiogram but also

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provides accurate information about regional extension of the tumor and eventual vascular encasement. CDU has been widely used since the development of color Doppler flow imaging has enhanced capabilities of diagnosing and assessing CBTs. There are many articles focused on surgical treatment so far. Little comprehensive comparison of CDU and CT features of CBTs is found in previous studies. In this study, we reviewed the CDU and CT features of CBTs and compared them with surgical resection specimens to discuss the role of CDU in the diagnosis and assessment of CBT.

MATERIALS AND METHODS

This was a retrospective study assessing results from 44 consecutive patients with 49 CBT lesions and 23 patients with 23 schwannoma lesions. All patients were treated with surgical resection at our hospital between October 2009 and September 2015. Four patients with CBTs had multiple lesions. For 49 cases of CBT, there were 20 (41%) tumors in 20 males and 29 (59%) in 24 females. Age of the patients with CBTs ranged from 36–82 y (mean, 45 y ± 18 y). There were 23 patients with 23 schwannoma lesions included in the study as control and whose mean age was 43 y ± 11 y (range, 38-62 y). CDU and CT imaging were performed for all patients as routine pre-operative assessment and CTA were performed as further evaluation. This observational study was approved by the university ethics committee and required neither patient approval nor informed consent for review of patient images and records. However, informed consent was obtained from all patients for CTA and surgery before each procedure.

CDU was performed with the HI VISION Preirus (Hitachi Medical, Tokyo, Japan) and LOGIQ 9 (GE Healthcare, Wauwatosa, WI, USA) ultrasound systems. The following ultrasound features of lesions were assessed: location, number, longest diameter, echogenicity, boundary and intra-lesional blood flow. The relationship of lesions and carotid bifurcation, internal and external carotid arteries, was evaluated, as well the changes of the carotid bifurcation angle and carotid artery morphology. Peak systolic velocity (PSV) and resistance index (RI) of intra-lesional vascularity feeding the tumor were calculated, those of the ipsilateral and contralateral internal carotid artery (ICA) and external carotid artery (ECA) were calculated simultaneously. Based on color Doppler flow imaging, we classified intra-lesional blood flow into four classes. Class I was defined as sparsely punctate blood flow. In class II, III and IV there were 1–2, 3–5 or ≥ 6 strip-like blood flows appearing in the region of lesions, respectively.

CT imaging was performed using a multi-slice spiral CT scanner (Somatom Sensation 64; Siemens Medical Solutions, Forchheim, Germany). Patients underwent CT supine with the head tilted so that the mandible was perpendicular to the table in order to minimize dental artifacts. The scan volume ranged from the skull base to C6 level, resulting in a typical scan length of about 15 cm. The scanning settings for CT were 120 kv, 200 eff. mAs and 64-mm × 0.6-mm slice detector configuration; table speed was 19.2 mm/s (pitch 1.0) and gantry rotation time was 330 ms. Axial images were reconstructed with a slice thickness of 1 mm and increment of 0.5 mm. CTA was performed after 80 mL of contrast agent (Ultravist 300; Schering, Berlin, Germany) was injected *via* an 18-gauge antecubital venous catheter with a power injector at a rate of 5 mL/s followed by a saline chaser bolus of 50 mL injected at the same flow rate. Adverse reactions or complications during and after the procedure were not found. Arterial phase as well as late phase image (t_{delay} = 80 s) was acquired in order to improve both the visualization of tumor vascularization and tumor extent. Multi-plane reconstruction (MPR), maximum intensity projection (MIP) and volume reconstruction (VR) images were obtained. All examinations were performed under breath hold and the patients were instructed to avoid swallowing during the examination.

We sent the resulting images to a dedicated imaging workstation for further evaluation. According to the classification criterion mentioned by Shamblin et al. (1971), CBT lesions were classified into three types: in type I the carotid artery is not or is minimally surrounded with the tumor; in type II, the tumor partially encases the carotid arterial structures; and in type III, there are larger tumors involving the carotid vessels. To investigate the difference in the longest diameter of CBT lesions between US and CTA, paired-samples t-tests were used. Independent-sample t-tests were used for comparison of hemodynamic parameters (PSV and RI) in CBT lesions and bilateral ICA and ECA. The chi-square test and Mann-Whitney U test were used for comparison of Shamblin's type and the CBT's intra-lesional blood flow classification, respectively. Any p values < 0.05 were considered statistically significant. Sensitivity, specificity and accuracy of the ultrasound scan were also calculated. All calculations were done using SPSS 17.0 for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS

A total of 44 patients with 49 CBT lesions were included in the final study. Forty patients had a single lesion, three patients had two lesions and one patient had three lesions, which were all bilateral. Those who had multi-focal lesions had familial history (three cases).

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