Cite as: Szymańska A, Szymański M, Gołąbek W, Drelich-Zbroja A, Jargiełło T: Doppler ultrasound appearance of neck tumors. J Ultrason 2018; 18: 96–102.

Submitted:
24.01.2018
Accepted:
16.04.2018
Published:
29.06.2018

Doppler ultrasound appearance of neck tumors

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DOI: 10.15557/JoU.2018.0014

Keywords
vascular malformation, paraganglioma, aneurysm, lipoma, Doppler ultrasound

Abstract

Aim: The purpose of this study was the evaluation of the sonographic appearance of neck tumors and determining the features useful in differential diagnosis. **Material and method:** The studied group consisted of 57 patients: 16 patients with carotid body tumors, 9 patients with neurogenic tumors, 8 patients with venous anomalies, 12 patients with neck cysts, 6 patients with lipomas, 5 patients with extracranial carotid artery aneurysms and 1 with a laryngocele. **Results:** All carotid paragangliomas were located within the carotid bifurcation and demonstrated rich low-resistance vascular flow, with higher maximum velocity and lower flow resistance parameters registered in the ipsilateral external carotid artery. In 7 out of 9 cases, neurogenic tumors were homogeneous, and in the remaining 2 cases – heterogeneous. Four schwannomas were hypervascular or showed moderate vascularity, and the rest of neurogenic tumors were hypovascular or avascular, with symmetrical maximum velocity and resistance values of carotid blood flow. Apart from one branchial cleft cyst with multiple fine internal acoustic reflexes, all other neck cysts were anechoic and avascular, and presented with posterior acoustic enhancement. The laryngocele presented as a well-demarcated, hypoechoic, homogeneous lesion located in the immediate proximity of the larynx, without signs of internal vascular flow. Lipomas were well-demarcated, homogeneous, hypoechoic tumors with regular margins, without signs of internal vascular flow. Venous malformations presented as irregular, hypoechoic spaces with venous blood flow, easily compressed by the probe. Extracranial carotid artery aneurysms were hypoechoic, well-defined spaces, which presented with slow internal, turbulent flow on Doppler study, and showed continuity with the carotid artery. **Conclusions:** Doppler ultrasound allows to visualize features characteristic for certain neck tumors. Solid or cystic structure, echogenicity, localization, as well as internal flow signals and vascularity pattern create a combination of ultrasound findings helpful in the differential diagnosis of lesions such as paragangliomas, venous malformations, neurogenic tumors, aneurysms, cysts and laryngoceles.

Introduction

Ultrasound (US) is widely used for the evaluation of neck structures. Their relatively superficial localization makes them easily accessible for US evaluation, whose additional advantages include high diagnostic accuracy, common use in clinical practice, a lack of ionizing radiation exposure for the patient, relatively low cost compared with other imaging modalities and the possibility for real-time biopsy monitoring.

In patients with neck lesions, a detailed clinical history and physical examination usually facilitate a preliminary diagnosis. The role of imaging studies is to narrow down and finalize the diagnosis, and determine the extent of the lesion. US examination is the modality of choice for the evaluation of cervical structures.

The aim of this study was to analyze the US appearance of neck lesions with the use of Doppler technique, and to identify the characteristic findings allowing for an effective differential diagnosis.

Material and Method

A total of 57 patients with neck lesions were evaluated, comprising 16 patients with carotid paragangliomas (PGLs), 9 with neurogenic tumors (including 3 neurofibromas, 5 shwannomas and 1 sarcoma neurogenes), 8 patients with venous malformations, 12 with neck cysts, 6 with lipomas, 5 with extracranial carotid artery aneurysms and 1 with laryngocele.

All patients were examined with LOGIQ 7 GE Healthcare Medical System device, with a 7.5–11 MHz linear transducer. In selected patients with extensive lesions, further examination was performed with a 3.5–4.0 MHz convex transducer. In all patients, the evaluated parameters included the location and contour of the lesion, its echogenicity, echostructure and compressibility. Also, 51 patients were examined with Doppler ultrasound (DUS) for the presence of vascular flow within the lesion and its position to cervical vessels. In vascular solid masses, flow velocity and resistance index values were identified in the tumor's vessels and carotid arteries.

All patients with solid tumors and neck cysts underwent surgery and the diagnosis was confirmed on the basis of histopathological exam. In patients with a venous malformation, magnetic resonance imaging (MRI) was performed to confirm a signal intensity pattern typical for this type of lesion. All extracranial carotid artery aneurysms were confirmed on CT or angiography.

Results

In all PGL patients, US scan showed the presence of a solid mass with regular margins and slightly inhomogeneous echogenicity, hypo- or isoechoic. All lesions were found in the carotid artery bifurcation, resulting with splaying of the internal and external carotid arteries of a varying degree, with the internal carotid artery dislocated posterolaterally. The maximal tumor diameter ranged from 2–5 cm. In color Doppler ultrasound (CDUS), all tumors presented with multiple flow signals characteristic for vascular pathologies (Fig. 1). In all patients investigated with color duplex DUS, the vascular flow within tumor vessels was characterized by low resistance, with mean resistivity index (RI) and pulsatility index (PI) being 0.5 and 0.7 respectively (Fig. 2). In 12 (approx. 75%) patients, the comparison of vascular flow parameters in both external carotid arteries showed higher velocity (mean V_{max} = 1.5 m/s) and lower resistance (mean RI = 0.6 and PI = 0.8) in the carotid artery on the side where the tumor was located compared with the contralateral artery (mean V_{max} = 1.0 m/s, mean RI = 0.8 and PI = 1.75) (Fig. 3).

All neurogenic tumors presented as a well-defined, ovoid, solid, hypoechoic mass, with moderate posterior enhancement. In 7 patients, the tumors had homogeneous structure, and 2 showed inhomogeneous echogenicity and ir-

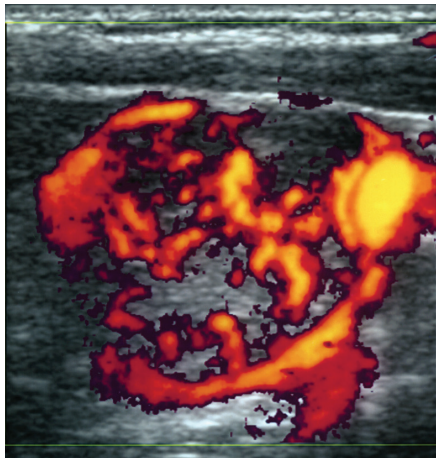

Fig. 1. *PDUS of a richly vascular carotid PGL*

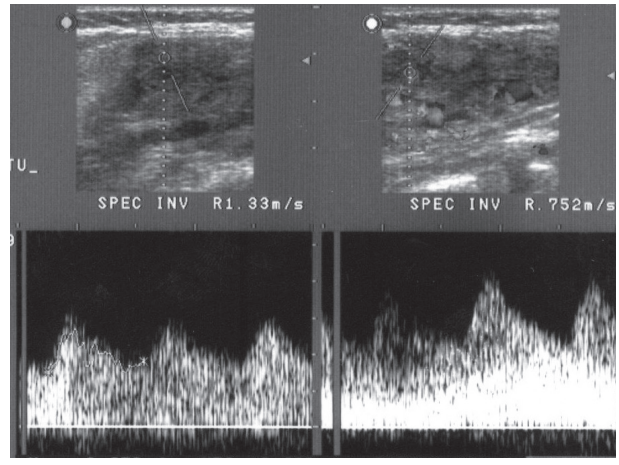

Fig. 2. *Low-resistance pattern of vascular flow within a PGL*

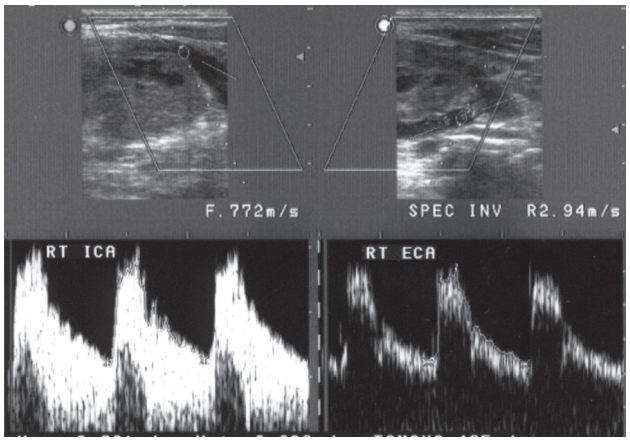

Fig. 3. *Low-resistance pattern of vascular flow within the ipsilateral external carotid artery compared to ipsilateral internal carotid artery*

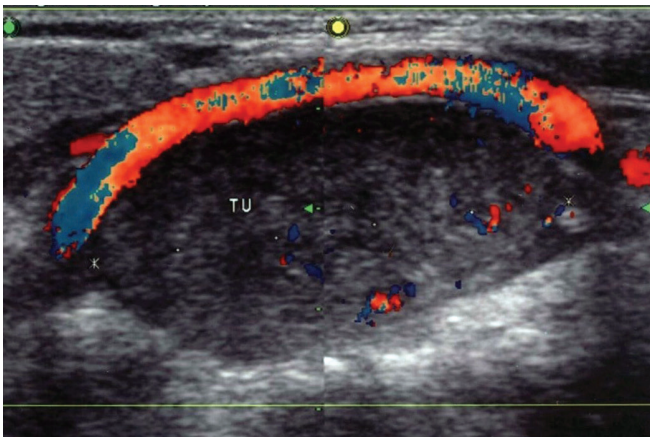

Fig. 4. *CDUS of a poorly vascular neurofibroma*

regular contour. The maximal tumor diameter ranged from 1.5–6 cm. Three tumors were located in the posterior neck triangle, and 6 medially to neck vessels. Color Doppler investigation revealed rich or moderate vascularity in 4 schwannoma patients. In the remaining tumors, vascular flow signals were scarce (Fig. 4). In spectral Doppler, vascular flow values and resistance index values were similar (mean V_{max} = 0.95 m/s, mean PI = 1.6 and RI = 0.65) in the ipsilateral vs. contralateral external carotid artery (V_{max} = 0.9 ms, PI = 1.65 and RI = 0.7).

Neck cysts in 2 patients presented as thyroglossal duct cysts and in 10 patients as branchial cleft cysts. All lesions were well-defined, thin-walled, with posterior acoustic enhancement and no vascular flow in a Doppler scan, with a diameter of 3–5 cm. Apart from one branchial cleft cyst, containing multiple fine, diffuse, internal reflexes, all the remaining lesions were anechoic (Fig. 5). All branchial cleft cysts were ovoid, had regular margins and were located alongside the sternocleidomastoid muscle. Thyroglossal duct cysts were found in the paramedian position, in the proximity of the hyoid bone, and had more irregular contours.

The laryngocele presented as a well-demarcated, hypoechoic, homogeneous lesion sized 2.5 × 3.5 cm, located in the anterolateral aspect of the neck, medially to the sternocleidomastoid muscle and neck vessels, next to the larynx. In a Doppler study, no vascular flow was visualized.

Lipomas were well-circumscribed, homogeneous, hypoechoic masses with regular contours and no vascular flow in Doppler evaluation. They were all located superficially, with a maximal diameter of 4 cm and 5 cm, respectively (Fig. 6).

Venous malformations presented as longitudinal and circular anechoic spaces of irregular shape and well-defined contours (Fig. 7). One lesion presented as tortuous hypoechoic vascular channels. All malformations were situated superficially, displayed acoustic enhancement and were readily compressible. In a Doppler study, they showed turbulent venous flow (Fig. 8).

Extracranial carotid artery aneurysms were well-demarcated, hypoechoic spaces with a maximal diameter of 3–5 cm, communicating with the internal (3/5) or external

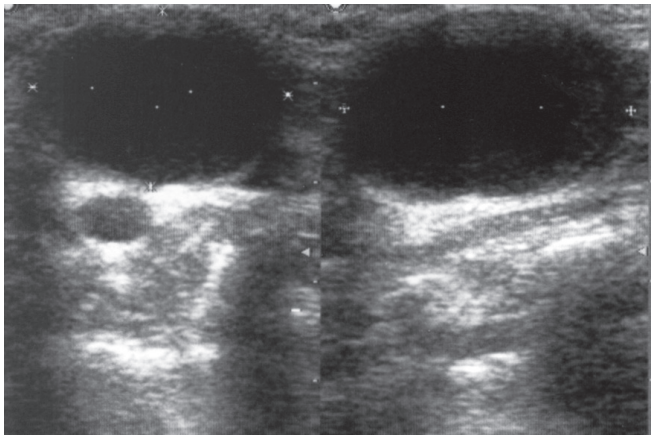

Fig. 5. *A well-defined, superficial, anechoic space with acoustic enhancement – typical branchial cleft cyst appearance*

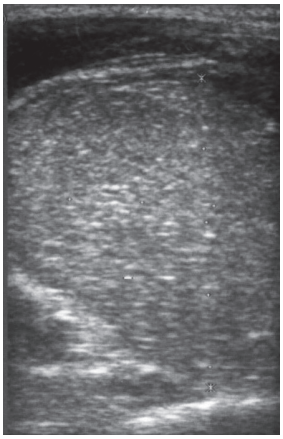

Fig. 6. *A well-defined, solid, homogeneous tumor with slight posterior enhancement – consistent with lipoma*

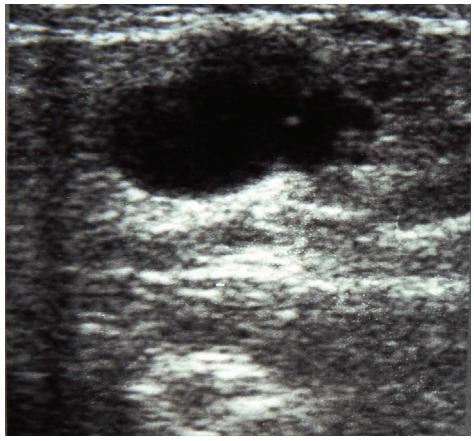

Fig. 7. *B-mode US of a venous malformation: superficial, well-defined, hypoechoic spaces of an irregular shape*

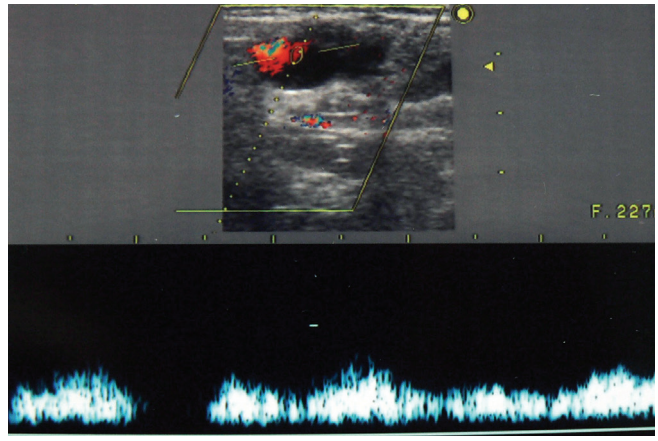

Fig. 8. *DUS of venous vascular flow in a venous malformation*

carotid artery (2/5) (Fig. 9). All lesions showed peripheral thrombi. In Doppler examination, their lumen displayed turbulent, slowed vascular flow.

Discussion

Neck tumors are commonly encountered in clinical practice, and are a very diverse group of lesions. Imaging studies play a very important role in noninvasive diagnostic workup, with US used as first-line modality. Multiplanar imaging with CT and MR can be used for further investigation, especially in the case of deep-situated and locally invasive masses, to confirm the diagnosis and accurately determine their extent prior to surgery[1]. Even though US appearance of many lesions is nonspecific, a comprehensive analysis of their characteristics in many cases facilitates a correct diagnosis, or at least allows to narrow down the differential workup.

The lesion's morphology is an important factor in its preliminary evaluation, allowing to differentiate solid masses from cystic lesions. The most common cystic formations are branchial cleft cysts, most of which arise from the remnants of the second branchial arch. They typically occur in children and young adults aged 20–40 years old[2]. On US, the cyst presents as a well-defined, round or ovoid, thin-walled lesion, most typically anechoic, with pronounced posterior enhancement[2,3]. Thyroglossal duct cysts are less common and occur at a younger age (16–25 years old)[4]. Their US appearance is influenced by previous inflammatory or hemorrhagic episodes which may lead to the presence of internal reflexes, mimicking a solid mass, as was the case in one of the patients in this study. Additionally, thyroglossal duct cysts may present with internal septa, thickened walls and a blurred margin[4,5].

The sonographic appearance of laryngocele resembles that of a non-complicated cyst, which may lead to a misdiagnosis[2]. In such circumstances, the localization of the lesion provides valuable insight. Branchial cleft cysts are situated superficially to neck vessels, along the medial and anterior border of the sternocleidomastoid muscle, whilst laryngoceles are clearly adjacent to the larynx (Fig. 10).

In the studied group, anechoic masses with acoustic enhancement included also extracranial carotid artery aneurysms and venous malformations. Doppler investigation

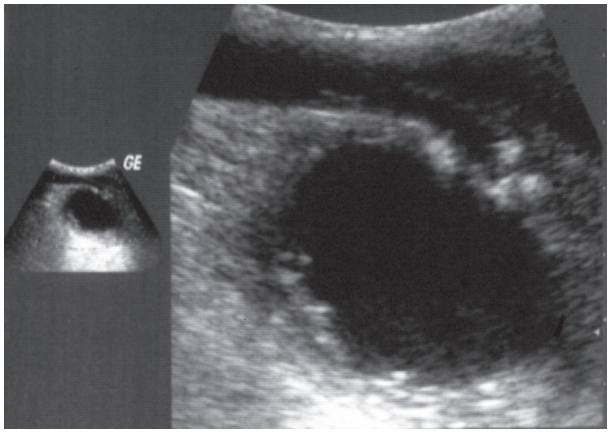

Fig. 9. *An extracranial carotid artery aneurysm presenting as a well-demarcated, hypoechoic space with peripheral thrombi, connected to the external carotid artery*

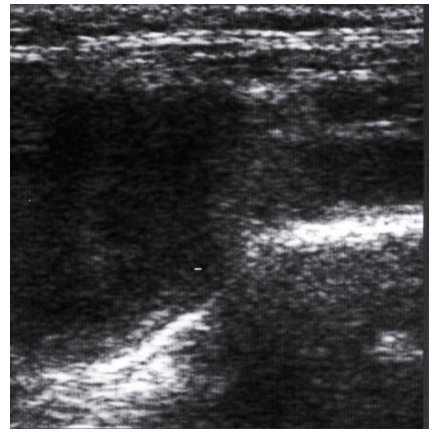

Fig. 10. *A well-defined, hypoechoic space with acoustic enhancement, adhering to the thyroid cartilage – an ultrasound appearance of a laryngocele*

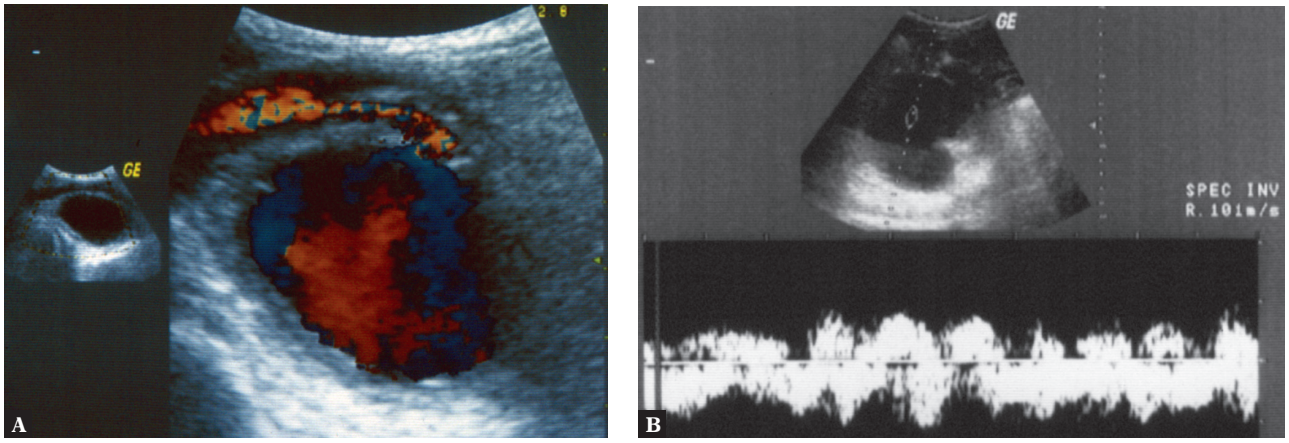

Fig. 11. *An external carotid artery aneurysm with visible turbulent vascular flow seen on CDUS (A) and PDUS (B)*

plays a key role in distinguishing these vascular anomalies from neck cysts, facilitating adequate further diagnostics and treatment[1]. Neck cysts do not show any vascular flow on a Doppler scan, whilst aneurysms present with multidirectional, tortuous flow, with turbulent spectral analysis (Fig. 11). Peripheral thrombi may also be noted. Additionally, in multiplanar evaluation it is usually possible to trace the course of the artery running through the lesion.

Venous malformations, as opposed to isolated, well pronounced anechoic foci, tend to present as hypoechoic, confluent areas of irregular shape. They may also present as tortuous, poorly demarcated vascular channels[6], as observed in one of our patients. Spectral Doppler reveals venous flow. They are also characterized by their compressibility, as the venous vessels without thrombi are obliterated with light pressure from the probe. Approximately 15% of venous malformations are found in the head and neck region. Fine, strong reflexes with a posterior shadow represent phleboliths and confirm the diagnosis, although they are not always present (approx. 20% of cases)[6].

The echostructure of solid neck tumors varies. Our results are supported by literature data showing that carotid PGLs and neurogenic tumors typically present as well-circumscribed, mostly homogeneous lesions, with or without posterior acoustic enhancement[7–9]. Also the lipomas investigated in our study had an US appearance of a homogeneous tumor. They are benign capsular lesions, usually located subcutaneously and to some extent compressible with moderate transducer pressure[10]. The most common neurogenic neck and head tumors include schwannomas and neurofibromas. Some authors state that schwannomas may undergo cystic degenerative changes, and both types of the tumors may show a lobular structure , without marked acoustic enhancement[7,8,11,12]. Such appearance was seen in two patients with neurofibromas in our group. Markedly inhomogeneous echogenicity is more commonly found in large tumors, as a result of degenerative changes[9]. A pathognomic, although not always present, feature of neurogenic tumors is their direct connection to the thickened nerve[7].

Doppler evaluation of the vascularity of solid neck masses is an important part of the differential workup, as it allows to identify highly vascular lesions, providing the surgeon with very important preoperative information. The presence of numerous, tortuous vessels with turbulent, low-resistance flow is highly indicative of a PGL[13,14]. Jin *et al*.[15] showed a statistically significant difference between the

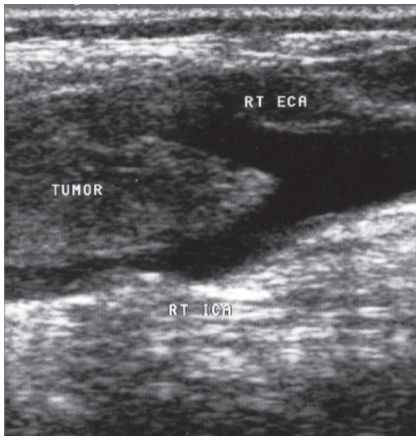

Fig. 12. *A hypoechoic PGL situated in the carotid bifurcation, splaying the proximal aspects of its branches*

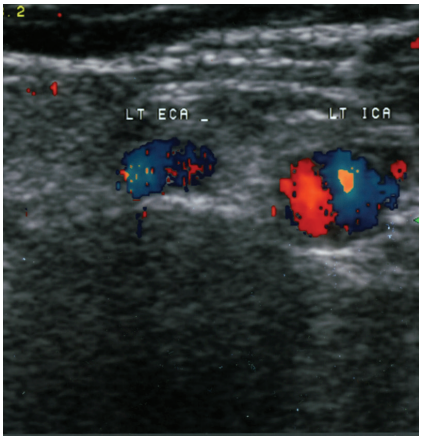

Fig. 13. *Sarcoma neurogenes: visible absence of vascular flow and the tumor's medial location to carotid arteries*

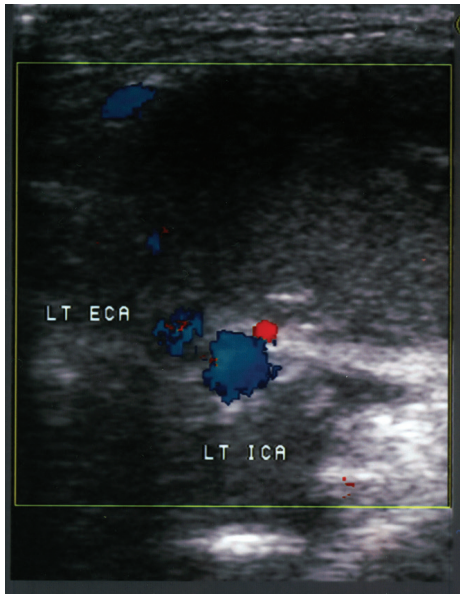

Fig. 14. *CDUS of a well-defined, avascular cyst, located superficially to neck vessels, with visible fine internal reflexes and acoustic enhancement*

vascularity of nerve sheath tumors and carotid PGLs to the advantage of the latter, as well as low RI values for these masses. A comparative analysis of the vascular flow in both external carotid arteries additionally aids the diagnosis, as the majority of PGL patients show a decreased RI in the ipsilateral external carotid artery, due to the presence of arteriovenous fistulas within the lesion[13,16]. The vascularity of neurogenic tumors seen on Doppler examination may range from minimal to abundant[7,8]. King *et al*.[8] and Kami *et al*.[7] state that schwannomas are highly vascular, and tumor vessels can be easily obliterated with light pressure from the probe. In our study, 5 schwannomas were moderately or richly vascular, without a decreased RI in the ipsilateral external carotid arteries.

In the case of a highly vascular neck tumor, analysis of its location may be helpful for differential diagnosis. A large majority of authors consider tumor location as an important predictor in the diagnostic workup[1,9,17,18]. The location in the carotid artery bifurcation, with the lesion splaying the proximal aspects of the internal and external carotid arteries (Fig. 12), and the internal carotid artery dislocated posterolaterally (wineglass bifurcation/lyre sign), is pathognomic for a PGL[12,19,20]. Characteristic findings include a solitary nodule in this location, or in the case of multiple paragangliomas, bilateral solitary nodules situated symmetrically in the carotid bifurcations. In our study, all PGLs were found in their typical location. Neurogenic tumors located in the proximity of carotid vessels were situated medially to the vascular bundle, dislocating it laterally (Fig. 13), whereas all branchial cleft cysts were situated superficially to carotid vessels (Fig. 14).

Conclusions

Ultrasound evaluation using colour and spectral Doppler modality visualizes certain characteristic features of given neck tumor types. Findings such as solid vs cystic content, characteristic echostructure and location, the presence of vascular flow and the pattern of vasculature make up various combinations forming ultrasound appearances helpful in the differential diagnosis of paragangliomas, venous malformations, neurogenic tumors, aneurysms, cysts and laryngoceles.

Conflict of interest

The authors do not declare any financial or personal links to other persons and organizations that could adversely affect the content of this publication and/or claim rights thereto.

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