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ORIGINAL ARTICLE

Superficial temporal artery pseudoaneurysm: what is the role of ultrasound?

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Abstract
Purpose The superficial temporal artery (STA) is one of the terminal branches of the external carotid artery; STA pseudoaneurysms are uncommon vascular lesion, generally subsequent to blunt or penetrating trauma that could represent a trick for radiologist, especially when the only anamnestic information is "palpable superficial swelling". In this article, we describe our ultrasonographic experience about STA pseudoaneurysm reporting several cases with different etiopatogenesis.
Methods Between January 2004 and March 2015 six patients (4F and 2M; aged 15–55 years, mean 36 year) presented at our department with superficial palpable swelling in temporal region (four with trauma history, two with iatrogenic cause) underwent to ultrasonographic study to assess the presence of STA pseudoaneurysm. Ultrasonographic findings suggestive of pseudoaneurysm was a well-defined, pulsatile, anechoic mass in B-mode, a swirling or disorganized pattern of blood flow in the lesion with demonstration of direct communication between arterial lumen and pseudoaneurysm at colour-Doppler and a typical to-and-fro waveform on pseudoaneurysm neck at pulsed-Doppler.
Results B-mode proves the presence of anechoic mass in five on six patients. Colour-Doppler demonstrates the presence of flow inside the lesion in five patients and a direct communication in all patients. To-and-fro typical waveform has been demonstrated in five patients. Ultrasound made diagnosis in all patients with a sensibility and specificity of 100 %.
Conclusion US is the imaging modality of choice, since it can provide detailed information about vascular anatomy without incurring the risks of invasive methods like angiography or radiation.

Keywords Pseudoaneurysm · Superficial temporal artery · Sonography · Colour Doppler

Riassunto
Scopo L'arteria temporale superficiale (STA) è uno dei rami terminali della carotide esterna. Gli pseudoaneurismi dell'STA sono poco frequenti, generalmente successivi a traumi chiusi o penetranti, potendo trarre in inganno il radiologo soprattutto quando l'unica informazione anamnestica è "rigonfiamento superficiale palpabile". In quest'articolo descriviamo la nostra esperienza ultrasonografica riguardo gli pseudoaneurismi dell'STA riportando diversi casi ad eziopatogenesi diversa.
Metodi Tra il Gennaio 2004 e Marzo 2015 6 pazienti (4F E 2M; Età 15–55 anni, media 36) giunti al nostro dipartimento per un rigonfiamento superficiale palpabile in regione temporale (4 con storia di trauma, 2 per cause iatrogene) vengono sottoposti ad esame ecografico per valutare la presenza di pseudoaneurismi dell'STA. I reperti ultrasonografici suggestivi per pseudoaneurisma sono stati: una massa ben definita, anecogena e pulsatile in B-mode, un pattern di flusso turbolento all'interno della lesione con la dimostrazione di una diretta comunicazione tra il lume

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arterioso e lo pseudoaneurisma al color-Doppler e un tipico spettro flussimetrico "to-and-fro" in corrispondenza del collo aneurismatico.
Risultati B-mode ha mostrato la presenza di una massa anecogena in 5 su 6 pazienti. Il color-Doppler ha dimostrato la presenza di flusso all'interno della lesione in 5 pazienti e una diretta comunicazione in tutti i pazienti. Lo spettro "to-and-fro" è stato dimostrato in 5 pazienti. L'ecografia ha permesso la diagnosi in tutti i pazienti con una sensibilità e specificità pari al 100 %.
Conclusioni L'ecografia rappresenta la modalità di imaging di scelta, fornendo informazioni dettagliate sull'anatomia vascolare senza incorrere nei rischi di metodiche invasive come l'angiografia o all'utilizzo di radiazioni.

Introduction

Superficial temporal artery pseudoaneurysms (STAPs) are vascular lesions of external carotid artery system; its first description was made by Thomas Bartholin in the seventeenth century [1] resulting from a blunt trauma, ever since about 350 cases have been described in literature [2]. In up to 90 % of cases STAPs are subsequent to blunt trauma and in the remaining 5–10 % are secondary to penetrating trauma or iatrogenic cause. STAP usually has the characteristic appearance of a cystic pulsatile mass in frontotemporal region entering in differential diagnosis with hematoma and abscess. Given their potential for rupture and haemorrhage, it is necessary to differentiate STAP from more common diagnoses so that subsequent complications can be prevented [3].

Imaging is necessary to confirm the diagnosis, especially in cases without a history of trauma. The most successful non-invasive modality is ultrasound, especially with the use of colour- and pulsed-Doppler so to exclude the other possible diagnosis; computed tomography (CT) angiography, magnetic resonance imaging (MRI) and angiography are other useful diagnostic modality for the diagnosis [4].

In this article, we describe our experience about STAP reporting several cases with different etiopatogenesis focusing on role of ultrasound, especially colour- and pulsed-Doppler findings, in their diagnosis.

Materials and methods

The medical files and imaging data of all patients who presented at our department for a palpable superficial swelling in frontotemporal region and underwent ultrasonographic (US) study between January 2004 and March 2015 were retrospectively reviewed. In total, 6 patients (four women and two man) underwent US study for suspected vascular lesion of superficial temporal artery (STA) subsequent to blunt trauma in three patients, two to iatrogenic cause (one subsequent to tensor threads Aptos facial lifting method and one to facial filler silicone oil injection) and one to penetrating trauma. The patient's ages ranged from 15 to 55 year old and the average age was 36 year old.

All patients presented a solitary painless mass in the fronto-temporal region accompanied by headache or ear discomfort with overlying skin intact, developed over a period included from 4 to 12 weeks (mean time presentation 6 weeks). Clinical examination revealed a pulsatile mass in four cases characterized by a bruit audible and fremitus palpable ceasing both with digital compression of proximal temporal artery. In two cases the patients showed a compressible, neither tender nor pulsatile subcutaneous swelling over the right temporal region without bruit and fremitus. Main characteristics of patients are summarised in Table 1.

US examination was performed with a MyLab 70 XVG GOLD scanner (Esaote, Genoa, Italy) using a linear multifrequency (7.5–12 MHz) transducer; a preliminary baseline sonography examination including a tissue harmonic imaging mode was carried out. This preliminary study allowed us to locate the lesion and to establish the best scanning approach for the subsequent colour and pulsed-Doppler study. The colour-Doppler gain was then adjusted until the pulsatile flow in the arterial lumen could be seen but the surrounding subcutaneous tissue remained virtually free of colour. All region of swelling, firmness or pulsation were systematically imaged by sliding the transducer along multiple planes parallel to the STA.

Diagnosis criteria was on B-mode the demonstration of "black hole sign", that is a superficial echo-free space that was usually roughly spherical and expanded with each systolic arterial pulsation, that can be comprised in a more large hyperechoic hematoma (Fig. 1a). Moreover, analysis of colour-Doppler signal allowed to demonstrate a swirling or disorganized pattern of blood flow within the mass, as a systolic colour jet of blood extending from the aneurysm neck into its lumen named as yin-yang sign (Fig. 1b) and to follow the communication between arterial lumen and the aneurysm sac, visible as a track of colour running through the soft tissues (Fig. 2). Finally, pulsed-Doppler showed on the aneurysm neck a to-and-fro bidirectional waveform, with direct flow into the aneurysm sac during systole and reversed flow from the aneurysm sac to the parent arterial lumen during diastole (Fig. 3).

Table 1 Main characteristics of patients

Case no.	Age (years)	Sex	Ethiology	Clinical presentation	Pre-sonography suspicion	Anatomical site	Artery involved	Aneurysm size (mm)	Aneurysm shape	Aneurysm patency	Aneurysm walls	Other imaging modalities
1	45	F	Iatrogenic (APTOS lifting threads)	Painless, pulsatile, palpable mass	No	Right temple	Frontal branch - superficial temporal artery	10 × 8 mm	Spherical	Yes	Thick	CT-angiography
2	15	M	Blunt trauma (punch)	Painful, non tender, pulsatile mass	Yes	Left temple	Frontal branch - superficial temporal artery	0.8 × 1 mm	Oval	Yes	Thin	Angiography
3	25	M	Blunt trauma (motor vehicle accident)	Tender, pulsatile mass	Yes	Left temple	Frontal branch - superficial temporal artery	21 × 16 mm	Oval	Yes	Thick	CT-angiography
4	55	F	Iatrogenic (facial filler silicon oil injection)	Painless, non-pulsatile, non-tender mass	No	Right temple	Frontal branch - superficial temporal artery	35 × 26 mm	Spherical	No	Thin	CT-angiography
5	40	F	Penetrating trauma (stab wounds aggression)	Painful, pulsatile mass	Yes	Right temple	Frontal branch - superficial temporal artery	55 × 40 mm	Oval	Yes	Thick	Angiography
6	38	F	Blunt trauma (punch)	Painful, non pulsatile, tender mass	Yes	Left temple	Frontal branch - superficial temporal artery	32 × 26 mm	Oval	Yes	Thin	Pathologic examination

Results

In all cases pseudoaneurysm involved the frontal branch of STA. Final diagnosis was confirmed by pathologic examination of the vessel body in one case and other imaging modality in five cases (CT three cases, angiography two cases). B-mode US imaging showed two spherical (1.5–3.5 cm diameter) and four large ovoid (0.8–5.5 cm diameter) pseudoaneurysms (mean diameter 4.2 cm); five patients presented the "black hole sign" while in one the swelling appeared hypoechoic with evidence of echogenic thrombus within cavity of the pseudoaneurysm.

Colour-Doppler demonstrates the presence of yin-yang sign in five patients; in one patient pseudoaneurysm is totally thrombized. The direct communication between arterial lumen and the aneurysm sac has been demonstrated in all cases with a specificity of 100 %. The to-and-fro sign at pulsed-Doppler analysis is present in five cases on six.

Ultrasound made diagnosis in all six patients with a sensibility and specificity of 100 %.

Discussion

The STA is one of the two terminal branches of the external carotid artery and supplies blood to the scalp. For its superficial course and its proximity to the underlying bony structures STA is vulnerable to every traumatic agent [5].

The anterior branch of the artery, that is interested in our cases, is more vulnerable, because during its tract is not cushioned by adjacent muscle, such as the temporalis muscle or the frontal muscle but it courses over the frontal osseous ridge in the galea aponeurotica, formed by the fusion line of the deep and superficial temporalis muscle fascia. This dense facial investment has a tethering effect in the gap between the temporalis and frontalis muscles and prevents the artery from displacing laterally and absorbing shock in response to traumatic forces [6].

Pseudoaneurysm is formed when there is a break in the vessel wall, so the extravasation of blood dissects the surrounding tissues, and an aneurysm sac, which retains a communication with the parent arterial lumen, is created. Then, the pseudoaneurysm wall is formed by organizing hematoma and fibrous tissue. Under the influence of high arterial pressure the sac usually tends to enlarge, with a sustained risk of its rupture and haemorrhage [7].

Pseudoaneurysms usually develop 1–8 weeks after injury to a vessel and are typically detected 2–4 months after trauma to the frontotemporal region [3].

Among the cases of post-traumatic STAP reported in the literature, 90–95 % have resulted from blunt trauma, while the remaining 5–10 % of cases resulted from penetrating

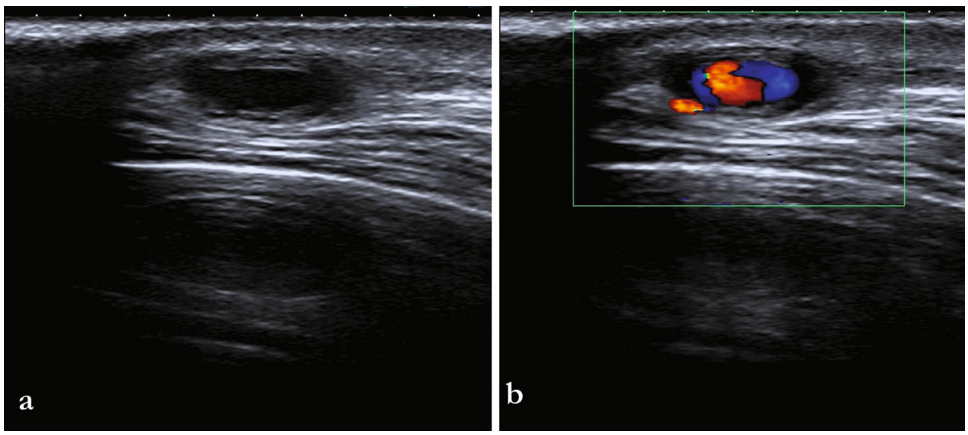

Fig. 1 B- and Doppler mode images of superficial swelling in left temporal region of a 25 years-old man with trauma history 6 months prior. **a** B-mode image shows an *oval*-shape hypo-anechoic lesion with mural mildly echogenic trombus. **b** Colour-Doppler US image demonstrating a bidirectional swirling flow ("yin and yang appearance") in the lesion consistent with a pseudoaneurysm

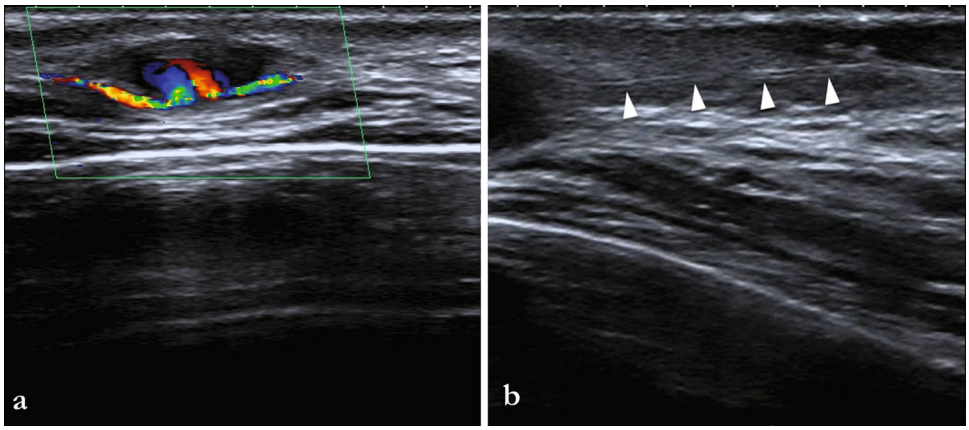

Fig. 2 B- and Doppler mode images of superficial mass in right temporal region of a 45-years-old female with history, 4 months prior, of an aesthetic procedure of facial rejuvenation (Aptos Thread-Lifting 2G technique). **a.** Colour-Doppler image show the anatomic relation between the aneurysm sac, its neck and the parent arterial lumen, as well as the patency of the arterial lumen distal to the aneurysm site; moreover it is possible to appreciate colour aliasing (turbulence) at the pseudoaneurysm neck is due to a high-velocity systolic jet. **b.** US image showing hyperechoic linear structures corresponding to the thin threads implanted to lift patient's brows (*arrowheads*)

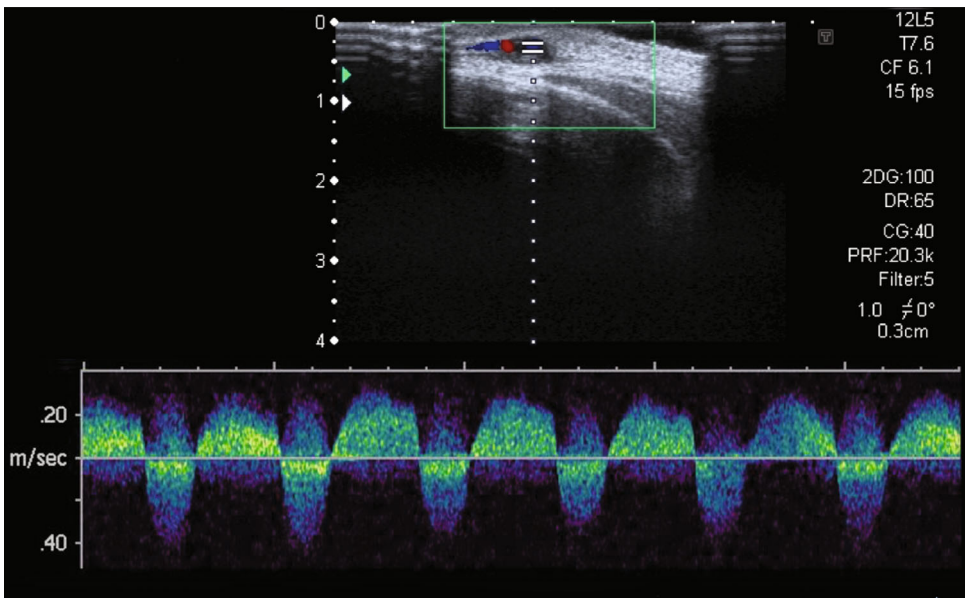

Fig. 3 Transverse duplex scan of a lump in the right temporal region of a 55 years-old woman with a history trauma 3 months prior shows a partially thrombosed STAP with a small amount of flow within the vascular structure. Sample volume is positioned in correspondence of pseudoaneurysm neck showing typical "to-and-fro" Doppler wave form depicted in lower half of scan. Note reversal of flow during diastole

trauma or iatrogenic cause [8]. However, the incidence of iatrogenic pseudoaneurysms has increased in recent years, likely because of the increasing use of percutaneous procedures and patients demands for minimally, as a matter of fact in recent years there have been reports of traumatic pseudoaneurysm formation after aesthetic surgery, including rhytidectomy, punch hair grafting, hair transplantation, rhinoplasty, augmentation mentoplasty, and orthognathic surgery [9].

Clinically, patients most commonly present with a solitary painless mass in the pre-auricural region accompanied by pulsations, headache, or ear discomfort; less frequent complaints include pain, visual disturbance, dizziness, haemorrhage and cosmetic defect. Clinical examination typically reveals a pulsatile mass in the frontotemporal region with thrill and bruit at auscultation. In some cases, pulsation may be absent if there is complete thrombosis of the aneurysmal sac. Its differential diagnosis is broad and includes hematoma, lipoma, cyst, abscess, angiofibroma, arteriovenous fistula, meningocele, and encephalocele [5, 6].

Generally imaging is necessary to confirm the diagnosis; the most successful non-invasive modality is Doppler Ultrasound that permits to define the anatomic relation between the aneurysm sac, its neck and the parent arterial lumen, as well as to assess the patency of the arterial lumen distal to the aneurysm site, without use of invasive procedure like angiography. Moreover, colour and pulsed-Doppler allow to describe real-time vascular behaviour of pseudoaneurysm because during systole the pressure is higher in the artery than in the pseudoaneurysm, leading to influx of blood into the pseudoaneurysm (the to-wave in pulsed-Doppler) and during diastole, the pressure and flow in the artery drop down to zero, and there may even be reversal of flow due to high resistance in the peripheral circulation, flowing back through the pseudoaneurysm neck as a result of the pressure gradient between the overdistended, high-pressure pseudoaneurysm and the low-pressure artery (the fro-wave in pulsed-Doppler). Occasionally, the neck is the only patent portion of the pseudoaneurysm if partial or total thrombosis has occurred. The radiologist should keep in mind that subcutaneous abscess or localized hematoma may transmit arterial pulsations and incorrectly suggest an aneurysm when thrill and bruit are absent [10, 11].

CT and MRI may be useful to see associated intracranial trauma, if there is a history trauma, but are not suggested for first-line imaging in sub-acute/chronic setting. The definitive diagnosis can be made with angiography, but, as this is an invasive test it is should be reserved for those to be treated directly [8].

STAP are not common, that could represent a trick for radiologist, especially when the only anamnestic information is “palpable superficial swelling”. In acute settings CT angiography is recommended, especially if there is a trauma history, allowing to see associated intracranial trauma. In the subacute-chronic settings like in our cases, US and Colour-Doppler are currently the imaging modality of choice allowing to differentiate between a pseudoaneurysm lesion and a simple soft-tissue hematoma, since it can provide detailed information about vascular anatomy without incurring the risks of invasive methods like angiography or radiation.

Compliance with ethical standards

Human and animal rights All ethical procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent All patients provided written informed consent to enrolment in the study and to the inclusion in this article of information that could potentially lead to their identification.

Conflict of interest The authors declare that they have no conflict of interest.

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