Ultrasound in sialadenitis

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Abstract The salivary glands are located superficially and are therefore easily accessible to ultrasound (US) examination, particularly if a high-frequency probe designed for small parts is used. Hence, US examination of these organs is widely applied particularly in non-neoplastic pathologies. In this way, it is possible to obtain adequate images without the use of ionizing radiation or complex instrumentation such as magnetic resonance imaging. However, US examination requires an expert clinical knowledge and familiarity with the normal and pathological US anatomy of the area. Limitations and pitfalls linked to US examination of this area should also be kept in mind.

Keywords Salivary glands · Sialadenitis · Ultrasound

Riassunto Le ghiandole salivari si localizzano in regioni superficiali e sono quindi, complessivamente, di facile accessibilità per lo studio ecografico, in particolare con sonde per piccole parti ad alta frequenza. Per questa ragione l'indagine ecografica di questi organi è molto diffusa ed in particolar modo nelle patologie non neoplastiche. E' così possibile ottenere un adeguato imaging senza utilizzo di radiazioni ionizzanti o di strumentazioni complesse e di poco agevole impiego come la risonanza magnetica (RM). Questo tuttavia presuppone un preciso inquadramento clinico e richiede una semeiotica ecografica strutturata. Vanno inoltre considerati i limiti ancora condizionanti l'indagine ecografica.

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Introduction

Sialadenitis is one of the most commonly encountered pathologies among those affecting the head and neck region. The salivary glands can be affected by various types of inflammatory pathologies of which some are easily diagnosed (parotitis caused by paramyxovirus) while other diseases require more complex diagnostic procedures. Computed tomography (CT) is considered the gold standard in the study of inflammatory diseases of the salivary glands unlike neoplastic diseases which are more accurately studied using MR imaging. X-ray sialography is progressively being abandoned due to the invasiveness of the procedure, although this method is significantly more accurate than MR imaging of the salivary glands [1].

In Europe, US imaging is commonly performed in the study of the salivary glands. US yields a high sensitivity in the diagnosis of inflammation affecting the glands and provides a valid contribution to the clinical investigation. US is mandatory as a first-line examination, and in many cases US provides a definitive differential diagnosis with a high diagnostic confidence.

Anatomy

The salivary glands are divided into two groups: the major salivary glands and the minor salivary glands. Both groups are embryologically derived from the epithelium of the floor of the mouth.

The major salivary glands are pairs of extramural glands, i.e. the parotid glands situated in a specific cervical loggia and the submandibular and sublingual glands situated in the floor of the mouth. They are connected to the oral cavity through the excretory ducts. The parotid glands, which are the largest of the salivary glands, are enclosed by

a separate fascia, which penetrates the glands thereby forming changeable lobes. The capsule is very thin at the parapharyngeal space, the conchal cartilage and the tragus. The parotid glands consist of a prismatic body and two extensions: the anterior portion resting on the deep masseter muscle and the deeper extension which reaches the lateral wall of the pharynx passing between the prestyloid muscles and the stylomandibular ligament. Stensen's excretory duct originates from the apex of the anterior extension and runs superficial to the masseter muscle, pierces the buccal fat and the buccinator muscle to open opposite the upper second molar in the oral cavity. A group of gland lobes, referred to as the accessory parotid gland, are situated along its course.

The facial nerve (with a highly variable course) and the external carotid artery pass through the gland. The parotid gland consists of parotid lobules, which produce a serous secretion, and a supportive fibrous tissue known as the stroma. The stroma contains areas of lymphoid tissue, which may be converted into groups of lymph nodes.

The submandibular glands are located in the submandibular space beneath the floor of the mouth and they have a mesial extension called the "hook". Wharton's excretory duct arises from this extension running at the base of the lingual frenulum to open into the sublingual caruncle. The submandibular glands have a lobular structure similar to that of the parotid glands and they produce a serous and mucous secretion.

The sublingual glands are a group of glands situated in the sublingual space, surrounded by the lingual fossa, the floor of the mouth and the mylohyoid muscle. The glands have multiple, small, excretory ducts, or one single duct referred to as the duct of Rivino or Bartolini's duct. The structure of the glands is mixed and the secretion is mainly of a mucous nature.

There are a number of small minor salivary glands located in the lips, palate, cheeks and at the base of the tongue. The minor salivary glands residing around the circumvallate and foliate papillae have taste perception functions.

The major salivary glands are closely connected to the lymphatic system. There are areas of lymphoid tissue in the glands and areas of salivary tissue outside the glands. The parotid lymph nodes can be divided into intraglandular and extraglandular lymph nodes. Extraglandular lymph nodes (superficial parotid or preauricular nodes) drain the lymphatic flow from the temporal region and frontal part of the galea capitis. It is a group of small lymph nodes (3–5 mm) located between the superficial fascia and the gland. The pretracheal lymph nodes belong to this group. The second group of extraglandular lymph nodes is located between the lower pole of the parotid gland and the anterior portion of the sternocleidomastoid muscle, but it is sometimes situated along the external jugular vein.

The intraglandular lymph nodes are a group of small lymph nodes (3–5 mm) located along the course of the retromandibular vein, generally in a deep location compared to the course of the facial nerve. These lymph nodes drain lymph from the Eustachian tube, the external auditory canal and the deep regions of the face. The intra- and extraglandular lymph nodes do not exceed 9 mm in diameter under physiological conditions.

Under physiological conditions, the submandibular gland does not generally present intraglandular lymph nodes as the capsule was formed earlier during organogenesis [2]. It is surrounded by numerous lymph nodes belonging to level Ia. They drain lymph from the oral cavity and may frequently be enlarged as a result of inflammation in the mouth. At the posterior pole of the gland one of these lymph nodes may mimic glandular enlargement generally referred to as Kuttner's tumor.

US anatomy and scanning technique

Computed tomography is currently considered the gold standard for the assessment of salivary gland inflammation. However, CT requires administration of contrast medium and involves significant exposure to ionizing radiation in a region of the body which contains tissues and organs presenting high radiosensitivity (the thyroid and the lens of the eyes).

In contrast, US is easily performed, inexpensive and widely available and this method is therefore a valid alternative to CT particularly in Europe and Japan [3, 4]. US imaging permits differentiation between glandular lesions and extraglandular lesions, assessment of glandular lesions located in the superficial structures and differentiation between cystic lesions and solid lesions, all with a high reliability (98 % confidence interval). Dilatation of the salivary ducts is easily visible at US examination, which also permits an accurate assessment of anomalies caused by intraglandular lithiasis. US can provide an initial differentiation between expansive lesions of benign or malignant nature and allows the study and characterization of most lymph node stations in the neck. US is furthermore useful for guiding biopsies, abscess drainage and botulinum toxin injection in the case of salivary hypersecretion.

US examination of the salivary glands is performed with a linear probe (7.5–18 MHz); narrow focal zones are studied using high-resolution transducers. The examination is performed with the patient in supine position and the head extended. The glands should be studied in both axial and longitudinal planes, and color Doppler should be performed for a first and sometimes definitive characterization of the findings.

The parotid gland is characterized by thin, uneven echoes of a higher intensity compared to the adjacent

muscles. There is a strong absorption of echoes hindering visualization of the deep regions, particularly in the retropharyngeal space. Identification of the capsule is difficult, especially in elderly patients due to progressive fatty infiltration. In about 30 % of the cases, the facial nerve can be identified using high-frequency probes (13–18 MHz); it appears as a hyperechoic binary structure. Under physiological conditions the ducts cannot be studied.

The submandibular glands present an echo pattern similar to that of the parotid glands, without absorption of posterior echoes but with a more accurate visualization of the capsule. The deeper region situated under the mylohyoid muscle can often be visualized in its entirety. Wharton's duct is visible only if dilated.

The sublingual glands can be visualized by placing the probe under the chin. They present an echo pattern similar to that of the parotid glands, and because of their small size they are visible only if affected by pathology. The excretory ducts are never visible. The use of a probe with frequency up to 18 MHz may be useful.

Sialosis

Sialosis, also known as sialadenosis, is a non-inflammatory condition characterized by bilateral enlargement of the salivary glands, most often the parotid glands. This condition has a multifactorial etiology and is generally not associated with autoimmune diseases such as sarcoidosis and Sjögren's syndrome, although the clinical symptoms are similar. The most common causes of sialosis are alcoholism, bulimia, achalasia, diabetes mellitus, hyperlipidemia, obesity and malnutrition. The use of certain drugs such as diuretics, thiourea and iodinated contrast media may induce sialosis.

Histological analysis shows acinar enlargement and absence of inflammatory cells. Clinical examination reveals bilateral glandular enlargement with no sign of inflammation, and a slow and progressive evolution. Diagnosis is based on the patient's clinical history, US examination (to exclude different pathologies) and possibly biopsy of the parotid gland [5]. In some cases the parotid gland is so enlarged that US examination requires a low-frequency probe for the evaluation of the deep portion [6].

Acute inflammation

The most common cause of acute inflammation of the salivary glands is mumps virus, and diagnosis does not require imaging techniques. When the parotid glands are infected with mumps virus they appear round, hypoechoic and hypervascular at color Doppler US. US is performed mainly

to exclude the presence of abscess or calculi. Bacterial infections may also involve the salivary glands. These infections are frequent in elderly patients with poor oral hygiene. The parotid glands are affected in 80 % of the cases.

The most frequently found pathogens are *Streptococcus aureus* and *Viridans*. US is the imaging method of choice in these cases; X-ray sialography is contraindicated because it may aggravate the inflammation [7]. US permits prompt exclusion of the presence of calculi. The glands appear enlarged, hypoechoic and heterogeneous; in some cases inflammation is focal only and it may be difficult to distinguish the inflammatory lesion from a nodule. The skin overlying the gland is thickened and edematous (Figs. 1, 2, 3), and the involved parenchymal region of the gland is often markedly enlarged. Parotid inflammation often evolves into abscess. Abscesses appear as hypoanechoic multilocular or star-shaped tortuous masses. The hypoanechoic area may contain small, moving hyperechoic foci representing gas microbubbles caused by pus.

Organized abscesses may be surrounded by a hyperechoic halo, but color Doppler imaging can facilitate

Fig. 1 Acute parotitis. The gland is mildly enlarged and appears hypoechoic with an inhomogeneous echostructure and moderate hypervascularization at color Doppler US

Fig. 2 Acute parotitis. The gland appears hypoechoic and hypervascularized at color Doppler

Fig. 3 Acute parotitis. The gland is markedly enlarged and appears hyperechoic with hypoechoic striae due to lymphedema

Fig. 4 Parotid abscess. US shows a large hypoechoic formation, which is tortuous and irregular (a), surrounded by hypervascularization at color Doppler US (granulation tissue) (b)

differentiation between the parenchymal region of the gland and areas affected by abscess (Fig. 4a, b).

Granulomatous inflammation

Cat Scratch disease is a form of granulomatous inflammation mainly diagnosed in children. The disease is caused

by *Bartonella henselae* bacteria and is characterized by enlarged regional lymph nodes, sometimes with pus (30 %). US appearance of the parotid glands affected by Cat Scratch disease is characteristic due to the presence of enlarged lymph nodes within the gland, whereas the parenchyma is sometimes almost normal (Fig. 5a, b).

Tuberculosis can involve the salivary glands by dissemination through the blood circulation or the lymphatic system. The patient can present with acute onset of sialadenitis causing pain and diffuse swelling or, more commonly, with a subacute evolution mimicking a neoplastic lesion. US appearance of this nodule-like mass shows a slow-growing, well-defined solid hypoechoic lesion which may subsequently turn into abscess or fistula. The lack of radiological evidence of pulmonary tuberculosis may make diagnosis difficult. Specificity of fine needle biopsy (FNAC) is 93 %, but sensitivity is 80 %. Histologic analysis is often necessary to achieve a definitive diagnosis.

Multiple enlarged intraglandular and locoregional lymph nodes are always present and they may sometimes be the only finding when the periparotid areas are affected [8, 9].

Sarcoidosis is a systemic inflammatory disease that affects the parotid glands in 10–30 % of the cases. In some patients parotid involvement may be the initial or the only sign of the disease. When sarcoidosis is associated with uveitis and facial nerve paralysis it is referred to as Heerfordt's syndrome. This disease is generally characterized by progressive, bilateral, painless enlargement of the parotid glands, which are multinodular and hard on palpation (Fig. 6a–c); it may mimic neoplastic disease. US image shows various features ranging from the presence of multiple hypoechoic nodules to diffuse hypoechogenicity and no intranodular fluid or necrosis, while color Doppler US may show diffuse hypervascularization.

Chronic inflammation

Chronic inflammation is caused by chronic bacterial infection. In most cases the infection becomes chronic due to incomplete resolution of an acute process. The parotid glands are affected more frequently than the submandibular glands. The most frequently involved pathogens are *Streptococcus viridans*, *St. pneumoniae*, *St. pyogenes*, *Staphylococcus aureus* and *Escherichia coli*. Some drugs (diuretics, atropine and some antidepressants) cause reduced salivary flow and may promote chronic inflammation.

Glands affected by chronic inflammation are characterized by sialectasis and reduced salivary secretion. This creates a vicious circle between reduced salivary secretion and parenchymal damage, often in the presence of calculi and ductal stenosis [10]. US shows glands of normal or reduced dimensions characterized by the presence of

Fig. 5 Cat scratch disease. US shows enlarged hypo-anechoic lymph nodes within the gland, fluid collection (a) and hypervascularization of the lymph nodes at color Doppler US (b)

multiple oval hypoechoic areas, uniformly distributed in the gland parenchyma [11]. The image shows a varying degree of sialectasis, also with cysts and saliva collections separated by hyperechoic septations, which present increased vascularization at color Doppler US [12] (Fig. 7a, b). Parenchymal calcifications are frequent findings. The progression of the disease leads to gland atrophy and residual parenchymal fibrosis (Fig. 8a, b).

In children and adolescents a form of chronic recurrent parotitis is often diagnosed; this condition occurs as a consequence of parotitis caused by mumps virus (paramyxovirus), and it is characterized by episodes of self-limiting pain and swelling at varying intervals. US shows enlarged glands characterized by multiple rounded hypoechoic areolae of 2–4 mm in diameter with well-defined margins and focal thin ductal dilatations. This morphologic finding is characteristic of chronic recurrent parotitis, but it is not specific [13]. X-ray sialography may be therapeutic in these patients.

Chronic sclerosing sialadenitis is also referred to as “Kuttner’s tumor”. It is a chronic inflammation with a focal tumor-like presentation. US image shows a nodular, intra-glandular lesion with well-defined margins; it is hypoechoic

Fig. 6 Sarcoidosis. US shows multiple small hypoechoic nodules (a) with hypervascularization of the gland at color Doppler US (b) and power Doppler US (c)

and inhomogeneous due to the presence of hypoechoic areolae and hyperechoic striae (Fig. 9). This type of lesion affects only the submandibular gland. “Kuttner’s tumor” can cause sialectasis. The presence of sialectasis associated with a hypoechoic submandibular nodule and a “radial”

Fig. 7 Chronic parotitis. US reveals large saliva collections separated by hyperechoic septations in the anechoic areas (a) which present with increased vascularization at color Doppler US (b)

pattern of blood flow signals at color Doppler US suggests chronic sclerosing sialadenitis. However, FNAC is often required to achieve a definitive diagnosis [14].

Miscellaneous

Sjögren's syndrome is a disease in which lymphocytes invade and destroy the exocrine glands. It is the second most common autoimmune syndrome after rheumatoid arthritis and it affects the salivary glands in 40–80 % of the cases. This results in a higher incidence of lymphomas in the parotid glands and a higher incidence of salivary stones. Diagnosis of Sjögren's syndrome is based on physical examination and laboratory findings. MR sialography or X-ray sialography is employed to establish the degree of salivary gland involvement. In the early stage, US image is normal, but later there will be enlargement of

Fig. 8 Chronic sialadenitis. The submandibular gland is involuted showing hypoechoic alterations and calcifications (a), dilatation of the salivary ducts (b)

Fig. 9 "Kuttner's tumor". Poorly defined hypoechoic nodule with mild dilatation of the salivary ducts

the glands and widespread structural irregularities (Fig. 10a, b). In a more advanced stage US shows sialectasis and marked hypervascularity on color Doppler US [2]. Similar changes may affect the lacrimal glands.

HIV parotitis shows painless swelling of both parotid glands. In about 70 % of the cases US image shows multiple small hypoechoic areas which are a sign of lymphoid infiltration. In the remaining 30 % US shows a characteristic pattern with multiple large bilateral cysts that may contain calcifications (Fig. 11).

Exposure to radiation also in low doses [15] may cause acute sialadenitis with painful swelling and possible evolution into a chronic condition characterized by the

Fig. 10 Sjögren's syndrome. The submandibular gland is enlarged and inhomogeneous (a) with large vessels at power Doppler (b)

Fig. 11 HIV parotitis. US shows multiple cysts of varying size and intracystic calcifications

presence of necrotic hypoechoic areas which are difficult to differentiate from neoplastic changes. Also in this case, the presence of sialectasis may help to differentiate the lesion from a neoplastic disease.

Conclusions

The use of US imaging in non-neoplastic pathologies of the salivary glands is increasingly common, as the equipment is widely available and well tolerated by the patients. US imaging yields a high sensitivity thanks to the development of high-frequency transducers, but specificity is still low as there are several overlaps between different diseases. A

further definition of the US patterns is required and US outcome should be integrated with color Doppler US and possibly elastographic findings. However, there are several conditions in which US examination yields high diagnostic confidence, such as sialosis, abscess and HIV parotitis. In addition to this, US guidance is useful in invasive procedures (drainage), minimally invasive procedures (extracorporeal shock wave lithotripsy) and in differential diagnostic procedures.

Conflict of interest The authors have no conflict of interest to declare.

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