Sonography of the salivary glands and soft tissue lesions of the neck

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Topography and sonographic anatomy of the salivary glands

The three pairs of salivary glands can be easily identified within the neck with ultrasound. The parotid gland is located in the retromandibular fossa as a triangular, echogenic structure. The submandibular gland is situated under the body of the mandible, abutting the posterior free edge of the mylohyoid muscle. The sublingual glands lie deep to the mylohyoid muscle, they are identified in the sublingual space lying lateral to the genioglossus muscle.

Sonographic anatomy

Parotid gland
Sonographically the parotid gland is a triangular, uniformly hyperechoic structure in the retromandibular fossa [Figure 1].

Figure 1 Transverse section of the normal left parotid gland

The majority of the parotid gland can be easily assessed by ultrasound however the deep portion of the gland may be seen with difficulty and the portion of the parotid gland which lies medial to the mandible cannot be identified with consistency. The masseter muscle is located deep to the anterior part of the superficial parotid, lateral to the ramus of the mandible. The inferior portion of the parotid gland may be referred to as the cervical lobe. Within the parenchyma the retromandibular vein is often identified, lying lateral to the external carotid artery. The plane of the retromandibular vein through the parotid can be used to differentiate between the superficial and deep part of the parotid gland [(1)]. Small, bean-shaped or oval, hypoechoic structures within the gland are commonly identified they, represent reactive, hyperplastic lymph nodes. Normal minor, peripheral non dilated intraglandular ducts are not visualized by ultrasound. The main duct (Stenson’s-duct) is sonographically identifiable as either a tubular structure with high resolution transducers (>10mhz) or is identified as a single echogenic line. The facial nerve is not visualized sonographically [(2)].

Color Duplex Doppler
Salivary glands are well-perfused. The arterial supply and their associated veins can be displayed by color Doppler sonography. The retromandibular vein can be used to differentiate
superficial and deep lesions of the parotid gland (venous plane). Color Doppler sonography is used to assess the vascularisation of salivary gland diseases [(3)].

it is not possible to use colour flow patterns or specific Doppler characteristics to diagnose specific pathological entities within the salivary glands However, the peak systolic velocity of the intra -parenchymal arteries increases after stimulation (vitamin C or lemon stick). The lack of detectable increase in peak systolic velocity after stimulation can be used in the assessment of Sjögren’s syndrome.

**Submandibular gland**

The submandibular gland is triangular shaped, with a homogeneous echogenic structure, identified at the posterior border of the mylohyoid muscle. The facial artery and vein are located posterior to or within the gland, the facial artery passing superiorly behind the submandibular gland, over the inferior body of the mandible. Non dilated intraglandular ducts are usually not identified, but may be seen as faintly visible narrow, confluent tubules. Wharton’s duct (main duct) is identified between the mylohyoid and hyoglossus muscles, colour flow imaging may help in differentiating it from the adjacent lingual vessels.

**Sublingual gland**

Sonographically the sublingual gland is distinguished from the genioglossus muscles as a echogenic mass lying lateral to the genioglossus, deep to the mylohyoid. There may be a direct communication with the submandibular gland situated dorsally. The ducts lead to the sublingual caruncle, in the anterior part of floor of the mouth, they cannot be identified with ultrasound.

**Pathological changes in the salivary glands**

**Acute inflammations of the salivary glands**

Acute bacterial sialadenitis usually arises as a consequence of a bacterial, ductogenic, ascending infection and often affects older patients [Figure 2].

**Figure 2** Enlarged submandibular gland. Hypervascularisation is visualized on Power Doppler Typical inflammation of the submandibular gland is visualized

The main indication for ultrasound is to assess whether an obstructive sialadenitis with ductal dilatation is present or whether there is a cystic mass ie abscess formation has developed.
Enlarged intraglandular, hypoechoic lymph nodes should not be confused with small abscesses. The oval shape of the lymph nodes and the eccentric echogenic hilum with its associated hilar bloodflow pattern helps to identify lymph nodes. Purulent abscess formation can present as a heterogeneous mass or is sometimes identified as a frankly cystic collection. Pus within an abscess can be relatively echogenic. Color Doppler sonography demonstrates a reactive hypervasculality in the surrounding parenchyma.

Using palpation under sonographic control (sonopalpation) occasionally motion of the pus/debris within the abscess can be visualized. Ultrasound contrast media can be used to delineate the liquefaction of an abscess. Ultrasound-guided aspiration of a possible abscess can prove or exclude the diagnosis of an abscess. The ability to obtain accurate bacteriology can aid management. Viral infections, such as for example Mumps usually show bilateral hypoechoic enlargement of the parotid glands. Typically hypervasculality is found on color Doppler Sonography.

**Chronic inflammation of the salivary glands**

**Chronic (recurrent) sialadenitis**

Typically unilateral in presentation; causes include recurrent bacterial infection. Strictures or stenoses of the ducts may be precipitating factors. The gland is less swollen than in acute sialadenitis and is heterogeneous in appearance, duct dilatation may be detected. Salivary duct strictures are more accurately visualized by sialography than by ultrasound. Ultrasound is used primarily to exclude a causal sialolithiasis [Figure 3].

Intra-or periglandular, moderately enlarged lymph nodes with hyperechoic hila can be detected in chronic sialadenitis. Küttner’s tumor is a chronic sclerosing sialadenitis of the submandibular gland. Typical appearances are those of an ill-defined heterogeneous submandibular gland; special care should be taken to recognize the intra glandular ducts and vessels in order not to confuse the abnormal submandibular gland with a tumour.

In children chronic cystic parotitis can be diagnosed sonographically, small hypoechoic lesions are visualized within the echogenic parenchyma. Usually this disease is self limiting.

**Figure 3** Left parotid gland in a child: Multiple cystic lesions are found in a gland with a normal echogenic background of the parenchyma: Chronic cystic parotitis was diagnosed
**Sjögren's Syndrome**

Sjögren's syndrome is an autoimmune disease. The clinically significant xerostomia is caused by a myoepithelial sialadenitis with fibrosis. In most cases, the changes are more apparent in the parotid glands, in mild Sjögren's syndrome it may be difficult to detect the changes in the submandibular glands. Once the disease progresses the changes are identified in both the parotid and submandibular glands. Chronic sialadenitis and Sjögren's disease demonstrate a similar appearance sonographically, however chronic sialadenitis is usually unilateral whereas Sjögren's affects the salivary glands symmetrically i.e bilateral changes are identified. The glands are enlarged, heterogeneous in echotexture, with multiple small hypoechoic areas within. The appearances are sometimes likened to a “currant cake” appearance or “leopard” skin appearance [Figure 4] [(4)].

Enlarged intra-or extraglandular lymph nodes are a frequent finding in Sjögren's disease. If an enlarged lymph node mass is identified then consideration of a biopsy is recommended, because there is an increased risk of non-Hodgkin's lymphoma in Sjögren's syndrome. It is recommended that when a hypoechoic mass of more than 1 cm is identified within a salivary gland that displays signs of Sjögren's disease-a histological evaluation should be performed.

**Figure 4**  
Transverse section of the right parotid gland in a patient with Sjögren's syndrome: The gland is markedly hypoechoic with multiple hypoechoic areas, moderate hypervascularisation is present

Color Doppler shows increased blood flow during the acute stages of inflammation. However during the fibrous stages of the disease the blood flow measured by peak systolic velocities in pulsed Doppler sonography does not increase after stimulation with a lemon stick or Vitamin C.

**Epithelioid sialadenitis**

The epithelioid cell (granulomatous) inflammation of salivary glands with intra-and periglandular lymph nodes is an extra-pulmonary manifestation of sarcoidosis. In sarcoid infiltration- symmetrical enlarged parotid glands can be found. Typically, the enlarged salivary glands are painless, and contain multiple small nodules within. A facial palsy or fever
may be present. Hypoechoic lymph nodes or intraglandular hypoechoic conglomerates may be identified. The appearances can mimic chronic infection or lymphoma.

**Tuberculosis of the salivary glands**

Tuberculosis of the salivary glands often exhibit a pseudotumorous appearance in sonography. Parotid tuberculosis may be confused with a malignant ill defined hypoechoogenic tumor. Therefore, histological evaluation is usually recommended. The diagnosis can be made with the detection of acid-fast rods in the parotid biopsy material [(5)].

**Post-Radiotherapy sialadenitis**

Following irradiation of head and neck cancers, there is often an associated sialadenitis. Sonographically in the acute stage, the glands are diffusely hypoechoic, and are often moderately enlarged. In the chronic form the gland is small and frequently ill-defined, ie poorly demarcated from the surrounding soft tissues. Ultrasound can be very useful in solving the common clinical problem of a submandibular mass, post-radiotherapy in a patient who has been treated for head and neck cancer. It can differentiate between a lymph node recurrence and a post-radiotherapy sialadenitis.

**Sialolithiasis**

Salivary gland calculi are distributed primarily within the submandibular gland and its associated Wharton's duct (more than 80% of patients); in approximately 10% of patients, the stones are found in the parotid gland or in the associated Stenson's duct. Salivary calculi of the sublingual gland are rare. Symptomatic salivary stones occur when there is an obstruction of the ductal system. The key feature to differentiate is whether there are stones within the main duct of the salivary glands, within the small intraglandular ducts or within the salivary gland parenchyma. Common sites are the genu of the main submandibular gland (the bend that occurs as the duct passes around the posterior border of the mylohyoid) or within the intraglandular ducts of the submandibular gland [(2)]. Calculi of the parotid gland usually arise in the periphery of the duct system or within the glandular parenchyma. Salivary stones are typically echogenic structures with posterior acoustic shadowing [Figure 5, 6]. In case of very small stones <2-3 mm the posterior shadowing may be absent, or may be weak. In symptomatic sialolithiasis there is usually an accompanying ductal dilatation and sonographically evident inflammatory change within the salivary gland.

*Figure 5 Longitudinal section of the submandibular: duct: Multiple stones are seen (Steinstrasse)*
Figure 6 Longitudinal section of a moderately dilated submandibular duct (Wharton’s duct) A stone is located in the anterior portion of the duct

Ductal dilatation is visualized as a tubular hypoechoic branching of the intraglandular ducts, associated inflammatory changes result in an hypoechoic swelling of the gland. Ultrasound is a sensitive imaging modality in the detection of salivary stones, there are quoted accuracies of 90%. About 20% of salivary stones are radio-lucent on radiography – with ultrasound it is possible to identify these stones and to identify their precise location. In experienced hands, ultrasound is now the primary imaging method for sialolithiasis.

Tumors of the salivary glands
About 95% of salivary gland tumors are primarily epithelial in origin. Salivary tumours are predominantly benign (80%). About 70% of the tumors are located in the parotid gland, 10% in the submandibular gland, and the remainder in the sublingual and minor salivary glands. The size of the salivary gland is inversely related to the likelihood of any tumour detected being malignant ie if a tumour is detected in a sublingual gland there is a higher probability that this tumour is malignant as compared to a tumour detected in the larger parotid gland [(6)].

Pleomorphic adenoma
Pleomorphic adenoma is the most common salivary tumour, it is also known as a mixed cell tumour. The parotid gland is the most common location of the mixed cell tumor, about 60% of all parotid gland tumors are mixed cell tumors. They are benign and often slow growing tumours. Often patients may present with findings of a firm mass in the parotid gland which has been present for many years. Women are affected slightly more often than men. Clinically, the findings are of a firm, nodular, painless mass. Most tumors are superficial to the facial nerve, which is not infiltrated. So-called "Iceberg tumors," which are tumours which arise within the deep portion of the parotid gland and extend into the parapharyngeal space may cause swallowing problems. Sonographically mixed tumors are homogeneous, and relatively hypoechoic. They have a so-called "pseudo-cystic" appearance with enhanced sound wave transmission with posterior acoustic shadowing identified They are sharply
bordered, the contour is often lobulated - this is regarded as a typical finding [Figure 7]. Rarely, cystic change and areas of calcification can be identified. In long standing cases - malignant transformation is a possibility.

**Figure 7** Longitudinal scan of the parotid gland: A sharply bordered hypoechoic lesion is visualized in the superficial portion of the parotid gland; A pleomorphic adenoma was diagnosed (note the pseudocystic appearance with acoustic enhancement identified deep to the tumour).

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**Adenolymphoma (Wharthins tumor)**

Adenolymphoma (also known as cystadenolymphoma) is the second most common, benign salivary gland tumor. In 90% of cases they are located in the superficial parotid, often in the caudal portion or tail of the parotid gland. The tumours have a predominantly male distribution - typical presentation is in an elderly male. Adenolymphoma is usually (compared to pleomorphic adenoma) a rather softer, partially cystic ovoid mass. Histologically, the tumour is composed of epithelial, glandular tissue with prominent associated lymphoreticular tissue. In up to 30% a multilocular tumour may be present. In approximately 10 to 15% of cases the tumour may be bilateral. Sonographically, the tumors are sharply bordered ie well-defined, hypoechoic, and frequently contain a cystic component [Figure 8]. They are usually ovoid in shape and may contain areas of calcification.

**Figure 8** Transverse section of the caudal part of the parotid gland A sharply bordered hypoechogenic lesion with cystic parts is visualized: An Adenolymphoma was diagnosed on histology.
Non-epithelial tumors of salivary glands

Within this relatively rare group of tumors (5% of salivary tumours), lymphangiomas and hemangiomas make up just over 50% of these tumours. Hemangiomas are also classified as a venous vascular malformations. On ultrasound, hemangiomas are typically well-defined hypoechoic lesions that may be compressible. The echostructure of hemangiomas depends on the size of the lacunar spaces, this may vary considerably. The majority of hemangiomas are hypoechoic compared with the surrounding soft tissues.

Arterio-venous malformations display color flow and arterial Doppler signal, they may be highly vascular lesions, especially when AV shunts are present. In thrombosed vascular malformations, no colour flow may be identified. In low flow lesions, again no colour flow may be identified.

The cystoid lymphangiomas reveal no vascularisation.

A Lipoma is typically ovoid in shape, usually moderately compressible and has the typical feathered echostructure of adipose tissue. Fine echogenic striae are identified within the mass, these striae are typically orientated parallel to the transducer [Figure 9] [(7)].

Figure 9  Transverse section of the parotid gland. A hypoechoic lesion with a feathered structure is visualized: Parotid lipoma was diagnosed in CT. Longitudinal section of the parotid gland (a). A hypoechoic lesion with echogenic striae within is visualized in the parotid gland: Parotid lipoma (b).
Lipomas are commonly located in the parotid area. The higher the fibrous content of the lipoma, the greater the echogenicity detected on ultrasound. Pure lipomas are relatively hypoechoic. The remaining non-epithelial salivary tumors are schwannomas and neurofibromas (About 7% of non-epithelial salivary gland tumors are sarcomas.).

**Epithelial, malignant tumors of the salivary glands**

Carcinoma represents approximately 86% of malignant salivary tumors. The adenoidcystic carcinoma (formerly called cylindroma) are the most common carcinomas of the salivary glands (35%). Adenoidcystic carcinoma occurs relatively frequently in the minor salivary glands of the palate and pharynx. Sonographically, the tumor is usually a well-defined, round, hypoechoic mass [Figure 10].

**Figure 10** Longitudinal section of the floor of the mouth. A slightly ill-defined lesion is seen in the region of the sublingual gland. Adenoidcystic carcinoma was diagnosed histologically.

In about 20% of the tumors, the margin is ill-defined and irregular. Histology often demonstrates perineural infiltration which cannot be shown by sonography. If a malignant salivary gland tumor is suspected either on ultrasound criteria or cytology following an ultrasound guided biopsy, other imaging procedures such as CT or MRI may be indicated. In particular, if ultrasound is unable to define the extent of the mass, particularly if it is extending into the deep part of the parotid, further imaging e.g. MRI is indicated to define any extension into the parapharyngeal space. This cannot be detected with ultrasound.

**Acinar cell carcinoma** (3% of parotid gland tumors) is typically round in outline and possesses a pseudo capsule which manifests itself on ultrasound as a well-defined margin ie it may have the same ultrasound appearances as a pleomorphic adenoma. A low grade malignant mucoepidermoid carcinoma (preferred site: parotid gland), may also exhibit the same appearances.

The mucoepidermoid carcinoma, accounts for approximately 30% of all malignant salivary gland tumors. High grade mucoepidermoid carcinoma are usually ill defined lesions whereas low grade tumors may present as a sharply bordered benign looking tumour on imaging.

**Intraglandular metastases**

Tumours of the skin in the facial region and scalp e.g. squamous cell carcinoma, may metastasise to lymph nodes within the parotid gland. In malignant melanoma of the scalp - metastases to the lymph nodes of the parotid gland are frequently found.
Squamous cell carcinoma metastases may exhibit necrosis within the Intra parotid lymph nodes. Melanoma metastases typically present as rounded hypoechoic lymph nodes within the parotid gland. Systemic diseases such as malignant lymphoma will also manifest themselves as Intra parotid lymphadenopathy. Typically multiple conglomerates of hypoechoic masses are found in the parotid gland. If a central hilum is present, this may help to identify these as Intra parotid lymph nodes. Usually, lymphoma is not localized solely within the salivary glands, but also other (cervical) lymph nodes groups are affected.

**Pseudo-tumours of the salivary glands**

**Retention cysts** show a smooth outline and are anechoic on ultrasound. Other cysts include cysts of the first branchial arch. The cyst fluid in these cysts is often echogenic. An unusual type of salivary gland cyst is the so-called ranula, This is a cystic mass arising from the sublingual gland in the floor of the mouth, due to obstruction of the ducts of the sublingual gland.

Cysts may also be present in **AIDS related lymphoepithelial cysts** [(8)]. Usually bilateral swelling of the parotid glands is present **Hypertrophy of the masseter muscle** is present if a thickness of more than 14 mm in the non-contracted state (transverse diameter) can be measured by ultrasound. **Sarcoidosis and tuberculosis** can also present as pseudo-tumor (histology is often required to make a definite diagnosis). Lesions of the skin such as sebaceous cysts and other subcutaneous masses are accurately localized sonographically in the subcutaneous tissues.

**Ultrasound guided biopsy of the salivary glands**

Recent literature states that ultrasound guided core biopsy of the salivary glands is a safe and accurate investigation particularly for the histological diagnosis of tumors [(5;9)]. However while some surgical authors fear that tumor seeding may occur following biopsy there is no significant evidence base to contradict the view that ultrasound guided FNA and ultrasound guided core biopsy for salivary tumors is a safe, cost effective and accurate procedure with minimal risk of complications.

**Soft tissue lesions of the neck**

A detailed knowledge of the anatomy of the soft tissues of the neck is mandatory for the proper sonographic assessment of the neck. The lesions of the thyroid and parathyroid glands are not covered in the following review

**Cervical cysts**

**ThyroGLOSSAL duct cysts**

ThyroGLOSSAL duct cysts can arise along a line from the foramen caecum in the base of the tongue to the pyramidal lobe of the thyroid gland. They are usually found in the region of the hyoid bone and at this level are typically mid line, and are sometimes multilocular. In an infrahyoid location they are typically located off mid line ie paramedian. Ultrasoundographically thyro-glossal duct cysts may be identified as anechoic masses with posterior acoustic enhancement. However debris in cysts may simulate a pseudo solid, hypoechoic structure
Figure 11. Following infection, these cysts are usually heterogeneous in echotexture. If the thyroglossal duct cyst is closely related to the hyoid bone or is abutting the hyoid bone—this should be reported as this is important information for the surgeon, if he is planning for surgery. Rarely a papillary carcinoma can arise in thyroglossal duct cysts.

**Figure 11** Longitudinal section of the pre-epiglottic space. A ovoid cystic lesion is seen caudal to the hyoid bone: Thyroglossal duct cyst.

**Branchial cleft cysts**

These cysts are to be found in the lateral neck and usually arise from the 2nd or 3rd branchial cleft. The second branchial cleft cyst is the most common congenital cyst presenting in the neck. Usually they are located antero-lateral to the carotid bifurcation. Cervical cysts from the first branchial cleft arches can be localized in the parotid region. The echogenicity of the branchial cleft cysts varies. Some of these cysts are anechoic. Most, however, contain finely dispersed, homogeneous echogenic material, the presence of cholesterol crystals aggregates contributing to the echogenic and 'pseudo solid' appearance [Figure 12] [(10)]. In some cases, the mobility of the contents of the cyst can be documented by sonopalpation. Less commonly a fluid/fluid level is detectable. In super added infection, the fluid within the cyst is typically echogenic and the cyst wall is irregularly thickened. When infection is present there may be associated enlarged regional lymph nodes. No colour flow Doppler signals are found in branchial cleft cysts. If colour flow is identified this indicates a solid lesion, A metastatic squamous cell carcinoma lymph node mass should be considered as a differential diagnosis.
Figure 12  Longitudinal section of the carotid triangle A ' pseudo solid ' homogenous lesion is visualized. Typical branchial cleft cyst.

Dysontogenetic tumors

Epidermoid and dermoid cysts are predominantly located in the midline. The floor of the mouth is regarded as a typical location. Lateral locations, e.g. the parotid glands, are rare. Larger teratomas are sometimes diagnosed in uteri. Dysontogenetic cysts often are very echogenic. This is due to the high acoustic impedance of the contents of hair, skin, and fluid and sebaceous material. Calcification is typically seen in teratomas.

Lipomas

Lipomas are typically localized within the subcutaneous tissues; however they may occasionally be intra-muscular, they are iso- or hyper-echoic with a striped or feathered structure. Lipomas are usually ovoid in shape [Figure 13]. While typically located superficially, occasionally cervical lipomas may identified within the deeper tissues of the neck [(11)]. Multiple lipomata of the neck is sometimes present in patients with alcoholism (Madelung’s disease).

Figure 13  An ovoid isoechoic lesion with feathered structure is seen: Typical appearances of a cervical lipoma
**Carotid body tumor**

Carotid body tumors are typically located within the carotid bifurcation [Figure 14]. Arteriovenous shunting with high diastolic flow is often identified in these paragangliomas. The blood supply arises from the external carotid artery [(12)]. These non-chromalphil paragangliomas may also originate from the vagal ganglia or the ganglia of the internal jugular vein. However, the jugular glomus tumors cannot be delineated by sonography due to their superior location i.e., just inferior to the skull base.

*Figure 14 Transverse section of the carotid bifurcation (BLUE). A vascular solid tumor is seen between the ICA and ECA.*: Carotid body tumor

**Neurogenic tumors**

Neurogenic tumors (neurofibromas and schwannomas), arise from the multiple nerves present within the neck [Figure 15], they frequently arise from the branchial plexus or the vagus nerve. The diagnosis can be made when a nerve is identified entering and leaving an ovoid solid lesion. Neurogenic tumors are moderately vascularized on Colour Doppler.

*Figure 15 Longitudinal section of the brachial plexus. Typical neurogenic tumor (schwannoma) arising from the fascicles of the brachial plexus.*

The differential diagnosis of highly vascularized solid extrathyroidal lesions include ectopic thyroid gland, paraganglioma or lymph node metastasis (especially thyroid cancer, or
lymphoma) and neurogenic tumors. In children an ectopic thymus, and a vascular malformation should be considered.

**Hemangiomas and lymphangiomas**

Large hemangiomas and lymphangiomas [Figure 16] can be diagnosed prenatal by ultrasound. Postnatally - they predominantly occur in the first two years of life. The echogenicity of hemangiomas varies depending on the histology (capillary, mixed or cavernous). Echogenicity is dependent on the size of the cystic cavities. If these cavities are small, the echogenicity of the lesion is increase. Typically, hemangiomas are easily compressible. Associated phleboliths are sometimes detected. Arteriovenous shunts with high diastolic flow may be detected. A lack of detectable blood flow does not exclude a hemangioma, because either the flow may be too slow to be detected by Color Doppler or because the vascular channels are thrombosed.

Figure 16  Transverse section of the masseter muscle reveals a hypoechoic, compressible vascular mass : diagnosis - hemangioma

**Lymphangiomas (also known as cystic hygroma)** are usually found in the early years of life. They are hypoechoic multicystic lesions with thin septae, and are trans spatial (ie occupy multiple spaces/compartments within the neck) in location with an absence of identifiable colour Doppler flow signal [Figure 17] [(13)].

Figure 17 Hypoechoic, septated, compressible lesion with no detectable flow on Colour Doppler assessment Lymphangioma of the neck was histologically proven.
Cervical lymph nodes

In the majority of patients, lymph nodes will be identified within the neck on ultrasound. However because of the low acoustic impedance differences between lymph nodes and the surrounding soft tissues - normal lymph nodes may be difficult to detect [(14)]. The impedance contrast between lymph node and the surrounding fatty tissue is low, increasing the difficulty of the detection of normal lymph nodes [(15)]. The typical sonographic appearance of a reactive lymph node is that of an ovoid, well-circumscribed hypoechoic lesion. In addition to the oval or elongated (sausage or bean shaped) configuration, an eccentric, echogenic hilus is characteristic of a benign reactive lymph node [Figure 18].

Figure 18 A longitudinal image of a reactive lymph node with an eccentric hilum.

The echogenic hilus is due to hilar blood vessels, the parallel arrangement of lymphoid sinuses within the medulla of the lymph node and fat in the vicinity of the hilum. The longitudinal ie long axis diameter of reactive lymph nodes can be ≥ 20 mm. The short axis diameter in the upper internal jugular group can be up to 10 mm, in other sites, it is usually <8 mm. The longitudinal diameter ie long axis measurements of lymph nodes in the neck is variable. Children typically have multiple detectable lymph nodes and in contrast to adult cervical lymph nodes- they are more bulky (i.e. more rounded or ovoid in shape) in appearance. This is due to the fact that children have a greater volume of lymphatic tissue as compared to adults.

Inflammatory lymph nodes

Viral infections or bacterial infections are common causes of cervical lymphadenopathy. Most infections cause painful lymphadenopathy. In these cases, imaging is not usually carried out. If there is clinical concern ultrasound can be used for follow up to assess response during anti-inflammatory therapy.

An annotated diagram of the neck lymph nodes identifying where the lymph nodes are located, can be helpful for documentation. Another indication for ultrasound assessment is to diagnose or exclude abscess-formation. In the early stages cystic change is identified within lymph nodes in developing suppurative lymphadenitis. Abscesses are usually hypoechoic but may contain echogenic pus. Color flow imaging may be useful in identifying areas of necrosis with a corresponding lack of colour flow detectable within. Lymph nodes are usually enlarged in a bacterial or viral lymphadenitis. Their short axis diameter is often > 10 mm. The shape is ovoid to round [Figure 19].
Inflammatory or reactive lymph nodes usually possess smooth or sharp borders. In some cases, there is an eccentric bulging of the lymph cortex. The hyperechoic hilum may be lost, it is not universally identified in benign lymph nodes. On colour Doppler flow imaging - inflamed lymph node have a hilar vascular supply with a regular branching pattern of the intranodal vessels [Figure 20]. Precise quantification of the increased perfusion using color Doppler or power Doppler is not necessary.

**Figure 20 An ovoid lymph node with a benign hilar blood flow pattern is seen in lymphadenitis**

**Tuberculous lymphadenitis**

In the acute stage, the ultrasound appearances are non-specific. Ovoid to round hypoechoic enlarged lymph nodes are found, differentiation from other nodal adenopathies in the acute stage is not possible. After several weeks, the appearances change and ultrasound examination shows an ill-defined, heterogenous node. The surrounding fascia is indistinct or blurred, matting of the nodes may be present [Figure 21] [(16)]. Fistula formation is a typical manifestation of tuberculous lymphadenopathy, fistula are identified as connecting hypoechoic structures [(17)]. In the subacute stage, lymph nodes are hyperechoic and heterogeneous in echotexture. The lymph nodes are often poorly vascularized or have no demonstrable colour flow. In the chronic and post-treatment phase echogenic or calcified areas can be found within the lymph nodes.
Lymph node metastases

Cervical lymph node assessment and staging in head and neck cancers is an important indication for Ultrasound imaging. About 90% of cervical lymph node metastases are due to squamous cell carcinoma. Other common primary tumors that metastasise to cervical lymph nodes are: thyroid, breast, lung, stomach and melanoma. It should be noted that the retropharyngeal lymph node group cannot be evaluated by sonography. These nodes, however, are only usually involved in pharyngeal cancers, or after neck dissection or following radiotherapy.

An important criterion for metastatic lymph nodes is a round shape [Figure 22] [(17;18)].

Figure 21 A hypoechoic lesion undergoing necrosis with an associated fistula. Diagnosis - tuberculosis.

Figure 22 A rounded lymph node with multiple peripheral arteries is visualized in a squamous cell carcinoma lymph node metastasis.
Many authors have emphasized the importance of the ratio of longitudinal to short axis diameter. A L/S index of > 2 corresponds to a benign lymphadenopathy with an accuracy of 84%, an index of <1.5 was found in 71% of the cases with a metastasis. The short axis diameter is an important criterion in its application to the shape of the node – the rounder the node the more likely it is to be malignant. In patients with a known primary tumour – a short axis diameter of greater than 8mm is considered suspicious for a metastasis [(19)].

In the carotid triangle or the upper internal jugular chain a short axis diameter of up to 10 mm may be caused by reactive lymph nodes. However the evaluation of the echo structure, shape and architecture is perhaps the more important criteria for malignant infiltration, in particular in squamous cell lymph node metastatic disease.

Many authors have also used Colour Doppler and Power Doppler to evaluate lymph node metastases [(20)]. A benign colour flow pattern represents a predominantly central blood flow pattern with a hilar vessel communicating with multiple branches [(21)], whereas a chaotic network of the intranodal vessels is considered as typical for metastatic nodes [Figure 23]. Areas of vascular sparing and multiple peripheral arteries (feeder or sub capsular arteries) are regarded as suspicious for metastatic disease. The areas of vascular sparing are said to correlate with areas of necrosis [(22)].

Figure 23 Rounded lymph nodes with areas of vascular sparing - squamous cell carcinoma metastases

While the sensitivity of ultrasound for the detection of lymph node metastases is good, the specificity of ultrasound alone is limited. However ultrasound-guided fine needle aspiration and ultrasound guided core biopsy allows excellent differentiation between inflammatory/reactive and metastatic lymph nodes. Non palpable lymph nodes can be routinely sampled under ultrasound guidance.

In clinically-negative necks of head and neck cancer patients (N0), the use of ultrasound and ultrasound guided FNA is capable of reducing the number of neck dissections performed. It should be remembered that micrometastases may not be detected [(23)].

Sonography is used in the evaluation of possible infiltration of the great vessels in the neck. In particular, infiltration of the wall of the carotid artery is of significant clinical importance. Detectable contact between tumor and artery wall of more than 3,5 cm is highly suggestive of infiltration of the deep layers of the artery wall. Sono-palpation ie a gentle bouncing motion with the probe is recommended in assessing the internal jugular vein to assess for tumour infiltration of the vein. A normal vein will be easily compressible, sonopalpation ensures that the operator identifies a patent internal jugular vein [(24)].
Ultrasound of the liver …. CFD

Ultrasound can also be used to document the effect of radio-and chemotherapy for lymph node metastases. Squamous lymph node recurrences tend to arise predominantly in the first two years post diagnosis. In selected patients, ultrasound follow-up examinations are necessary to enable the diagnosis of subclinical metastasis. The recommended period of scanning intervals in the first year is between 6 to 12 weeks (depending on the capacity of the ultrasound service). Post neck dissection, tumor recurrence does not follow the established lymph node routes of spread in the untreated neck. A diligent search for contralateral metastases and skip metastases is required.

**Malignant lymphoma**

While on histology Non-Hodgkin's lymphoma and Hodgkin's lymphoma can be distinguished, ultrasound can not make that differentiation. In most cases of malignant lymphoma at least one or more lymph node groups is affected and in particular the posterior cervical triangle region is commonly involved [Figure 25]. There is often a conglomerate of enlarged lymph nodes. As with sarcoidosis, a so-called facet forming sign may be present. The nodes are round or polygonal in shape and are usually sharply defined. Extranodal infiltrations is rare in lymphoma. In aggressive forms of lymphoma, perinodal fluid collections or oedema is detected and associated matting may be present. The lymph nodes are often very hypoechoic, the so-called “pseudocystic” sign [(25)]. Often small, moderately echogenic structures (a stippled or reticular appearance) are found within the lymph node. In some cases a moderate posterior acoustic enhancement is visualized, again in keeping with the 'pseudocystic' sign [(26)]. Necrosis in the strict sense is uncommon in lymphoma. Occasionally echogenic vessel walls of intranodal vessels will be detected. This is called a small-vessel-sign Because the architecture of the node is infrequently disrupted in lymphoma, the hilus of the lymph node may still be visible [Figure 24] [(27)].

**Figure 24** small vessel sign in malignant lymphoma.

![Small vessel sign in malignant lymphoma](image)

**Figure 25** A conglomerate of nodes is visualized. In the posterior triangle of the neck in malignant lymphoma

![Conglomerate of nodes](image)
In color Doppler sonography malignant lymphomas often demonstrate a plethoric benign type hilar bloodflow pattern, ([28]) with a regular branching of the intranodal vessels [Figure 26]. The chaotic vessel network identified in metastatic squamous cell carcinoma is not typically demonstrated. On colour flow imaging, one can not distinguish inflammatory nodes from lymphoma.

**Figure 26** Power Doppler demonstrates a plethoric hilar flow pattern in non Hodgkin Lymphoma

**Unusual cervical lymphadenopathies**

These following conditions may mimic lymphoma; **Rosai Dorfmann disease** is a histiocystosis of the lymph nodes in this disease the hilar structures are often preserved, however completely hypoechoic nodes may also be present. **Kimuras disease (eosinophilic hyperplastic lymphogranuloma)** ([29]) and Kikuchi's disease are lymphadenopathies that also present with enlarged hypoechoic lymph nodes. ([26]).

**Summary**

High-resolution ultrasound is now the primary imaging method for the evaluation of the soft tissues of the head and neck region. In lymph node assessment, it is able to demonstrate the morphology of the lymph nodes and is an accurate tool for staging the neck in patients with head and neck cancer. Ultrasound guided biopsy is a safe and cost-effective technique allowing either a cytological or histological diagnosis to be obtained. Other lesions in the neck show a typical sonomorphology which allows a good and effective imaging triage with ultrasound eg, branchial cleft cysts, lipomas, carotid body tumors etc,. For salivary gland masses, ultrasound is frequently the first and often the only imaging procedure that is required. Ultrasound can efficiently diagnose the majority of salivary tumours, it allows an ultrasound guided biopsy to be performed and can identify those cases that may require further imaging.
With a knowledge of the key anatomy in the head and neck and an ability to detect the various signs that can be used to diagnose the common conditions that present within the neck, ultrasound has a significant role to play in head and neck imaging.

References


