Sudan University of Sciences and Technology

College of Post Graduates

Evaluation of Salivary Glands of Snuff-users Using Ultrasonography

تقويم الغدد اللعابية لدى متعاطي السعوط باستخدام التصويربالموجات فوق الصوتية

A Thesis Submitted in Partial Fulfillment Of The Requirements Of The Master Degree in Diagnostic Ultrasonography.

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May 2019

Dedication

Every challenging work needs self-efforts as well as guidance of elders specially who were very close to our heart.

My humble effort I dedicate to my dear father, loving and kind mother, sisters, uncles, brothers and grandmother. Whose affection love, encouragement and prays of day and night make me able to get such success and honor.

To my beloved husband who has offered support, counsel, encouragement and confident in my ability to get this done.

Also to the sweet angles my children and every one helped me a lot to achieve this work.

Acknowledgment

I would like to express my deep thanks to Dr. Ahmed Abu-kunna for his guidance and assistance who helped me to complete this study. I will always appreciate it.

I am also indebted to the management of the college of medical radiological sciences in Sudan University of Sciences Technology, and the radiology department of the military hospital –Omdurman, who let me use their ultrasound units.

I am very grateful to the people who have accepted to take the tests on them, they are the base of this research and deserve all thanks.

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Abbreviations

AP	Anterioposterior
Ca	Calcium
CAMP	Cyclic adenosine monophosphate
CL	Chlorine
FNAC	Fine-needle aspiration cytology
GI	Gastrointestinal
HCO3	Hydrogen carbonate
H2O	Water
K	Potassium
ML	Mediolateral
SPSS	Statistical Package for the Social Sciences
SUST	Sudan University of Science and Technology

Abstract

The aim of this study was to evaluate the salivary glands of the snuff users using ultrasound in terms of size, blood flow, echogenicity, echotexture and any other pathological changes.

The data were collected by ultrasonic salivary gland examination of 27 adult sniffers (research group) and 26 adult non-users (comparison group). The tests were conducted in the ultrasound unit at the college of Medical Radiological sciences at Sudan University of Science And technology from August to December 2018.

The study found that the average size of salivary glands of snuff users was greater than the average size of non-abusers. Blood supply and tissue characteristics were normal and the study found that no difference between the group of snuff users and non-users.

The study concluded that ultrasound plays an important role in the assessment of salivary glands, and can be used - because of its availability and ease - as a periodic check to assess the salivary glands of snuff users and other types of tobacco.

مستخلص

هدفت هذه الدراسة الي تقييم الغدد اللعابية لمتعاطي (السعوط) باستخدام الموجات فوق الصوتية من حيث الحجم، التغذية الدموية ، خصائص النسيج بالإضافة الي أي تغيرات مرضية أخري. تم جمع البيانات عن طريق اجراء فحص الغدد اللعابية بالموجات فوق الصوتية ل27 من الأشخاص البالغين الذين يتعاطون السعوط(مجموعة البحث)، و26 من الأشخاص البالغين من غير المتعاطين (مجموعة المقارنة)، وتمت الفحوصات في وحدة الموجات فوق الصوتية بكلية علوم الأشعة الطبية بجامعة السودان للعلوم والتكنولوجيا في الفترة من أغسطس إلي ديسمبر 2018.

وجدت الدراسة أن متوسط حجم الغدد اللعابية لمتعاطي السعوط كان أكبر من متوسط الحجم لغير المتعاطين. التغذية الدموية وخصائص النسيج كانت طبيعية ولم تجد الدراسة اختلافاً يذكر بين مجموعة المتعاطين وغير المتعاطين.

خلصت الدراسة الي أن الموجات فوق الصوتية تلعب دوراً مهماً في تقييم الغدد اللعابية ، كما يمكن أن تستخدم – بسبب توفرها وسهولة اجرائها – كفحص دوري لتقييم حجم الغدد اللعابية لمتعاطي السعوط والأنواع الأخرى من التبغ.

Chapter one

1.1 Introduction

Salivary glands comprise the parotid, the submandibular and the sublingual glands, as well as the small subsidiary glands. The largest, the parotid , drains by it is duct into the mouth at the level of the second upper molar tooth. The submandibular consist of superficial part and deep part, it is duct open alongside the fraenum of the tongue. The sublingual glands lies on the floor of the mouth and drains directly by a series of small ducts. This direct contact of salivary glands and the mouth , where snuff is placed, increases the possibility of salivary glands being affected by snuff components.

The ingredients of snuff include :

- Polonium 210 (nuclear waste)
- N-Nitrosamines (cancer-causing)
- Formaldehyde (embalming fluid)
- Nicotine (addictive drug)
- Cadmium (used in batteries and nuclear reactor shields)
- Cyanide (poisonous compound)
- Arsenic (poisonous metallic element)

(https://www.fda.gov)

There are some studies that indicate the effect of snuff on saliva in terms of change in pH or change in secretion, but the effect of snuff on the salivary glands itself needs to be clarified.

Ultrasound imaging of salivary glands gives important information on any changes in size, tissue and blood supply. In addition to the detection of tumors and stones.

1.2 Problem statement:

The use of snuff may affect salivary glands at different levels, some users may be affected in the near term and show symptoms directly, and others may be affected over time and after long periods of abuse.

Periodic examination of the condition of the mouth in general and salivary glands in particular remains important in both cases.

This study attempted to highlight the role that ultrasound can play in evaluating the salivary glands of snuff users. This role may reduce the need for more expensive and time-consuming tests.

1.3 Objectives:

The general purpose of this study was to evaluate the salivary glands of snuff users using ultrasound, this general purpose achieved through a set of specific objectives:

To measure the size of the salivary glands.

To identify echotexture and echogencityof salivary glands.

To detect the pathological changes.

To evaluate the blood flow of the salivary glands.

1.4 Outlines:

The thesis consists of five chapters, chapter one is an introduction, chapter two is a literature review, chapter three mentions the material and methods used to complete the study, chapter four represents the results and chapter five include the discussion, conclusion and recommendations.

Chapter two

(Literature Review)

2.1 Introduction:

The salivary glands are exocrine glands that produce saliva .beside the hundreds of minor salivary glands located throughout the palate, nasal ,laryngeal and oral cavity, there are three pairs of major salivary glands. The largest of these three are parotid glands which are located in front and just beneath the ears. the second are submandibular glands which are situated beneath the lower jaw. the third pair are sublingual glands which can be found under the tongue in the floor of the mouth,The major function of the these glands is to secrete saliva, which plays a significant role in lubrication, digestion, immunity, and the overall maintenance of homeostasis within the human body.

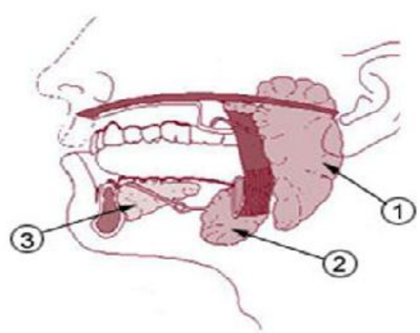


Fig.2.1: parotid(1),submandibular(2) and sublingual(3)

glands.(Wikipedia.org).

2.2 Developmental anatomy:

Early work suggests that development of the salivary glands begins during the sixth to eighth embryonic week when oral ectodermal outpouchings extend into the adjacent mesoderm and serve as the site of origin for major salivary gland growth. The development of major salivary glands is thought to consist of three main stages .The first stage is marked by the presence of a primordial anlage (from the German verb *anlagen*, meaning to lay a foundation or to prepare) and the formation of branched duct buds due to repeated epithelial cleft and bud development. Ciliated epithelial cells form the lining of the lumina, while external surfaces are lined by ectodermal myoepithelialcells . The early appearance of lobules and duct canalization occur during the second stage. Primitive acini and distal duct regions, both containing myoepithelial cells, form within the seventh month of embryonic life.The third stage is marked by maturation of the acini and intercalated ducts, as well as the diminishing prominence of interstitial connective tissue. The first of the glands to appear, during the sixth gestational week, is the primordial parotid gland. It develops from the posterior stomodeum, which laterally elongates into solid cords across the developing masseter muscle. The cords then canalize to form ducts, and acini are formed at the distal ends. A capsule formed from the ambient mesenchyme surrounds the gland and associated lymph nodes.

Small buds appear in the floor of the mouth lateral to the tongue during the sixth week of embryonic life and extend posteriorly around the mylohyoid muscle into the submandibular triangle. These buds eventually develop into the submandibular glands. A capsule from the surrounding mesenchyme is fully developed around the gland by the third gestational month .During the ninth embryonic month, the sublingual glandanlage is formed from multiple endodermal epithelial buds in the paralingual sulcus of the floor of the mouth. Absence of a capsule is due to infiltration of the glands by sublingual connective tissue. Intraglandular lymph nodes and major ducts also do not generally develop within sublingual glands. Upper respiratory ectoderm gives rise to simple tubuloacinar units. They develop into the minor salivary glandsduring the 12th intrauterine week.

2.3 Anatomy:

2.3.1 Parotid gland:

The paired parotid glands are the largest of the major salivary glands and weigh, on average, 15–30 g. Located in the preauricular region and along the posterior surface of the mandible, each parotid gland is divided by the facial nerve into a superficial lobe and a deep lobe .The superficial lobe, overlying the lateral surface of the masseter, is defined as the part of the gland lateral to the facial nerve. The deep lobeis medial to the facial nerve and located between the mastoid process of the temporal bone and the ramus of the mandible.

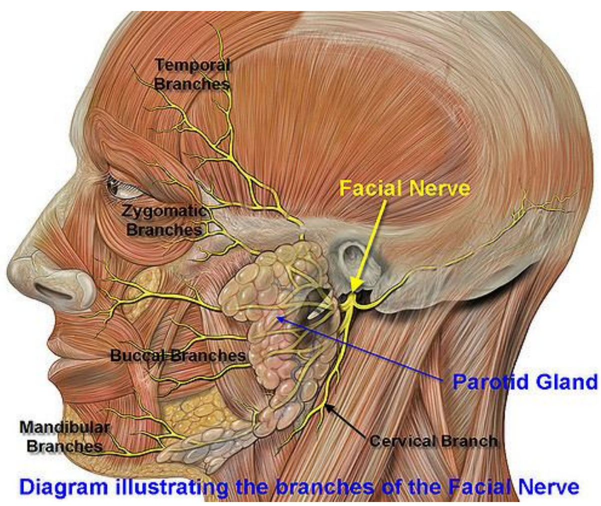


Fig.2.2: facial nerve branches.(www.rosellodiazcarandell.com)

The parotid gland is bounded superiorly by the zygomatic arch. Inferiorly, the tail of the parotid gland extends down and abuts the anteromedial margin of the sternocleidomastoid muscle. This tail of the parotid gland extends posteriorly over the superior border of the sternocleidomastoid muscle toward the mastoid tip.

The deep lobe of the parotid lies within the parapharyngeal space. An accessoryparotid glandmay also be present lying anteriorly over the masseter muscle between the parotid duct and zygoma. Its ducts empty directly into the parotid duct through one tributary. Accessory glandular tissue is histologically distinct from parotid tissue in that it may contain mucinous acinar cells in addition to the serous acinar cells.

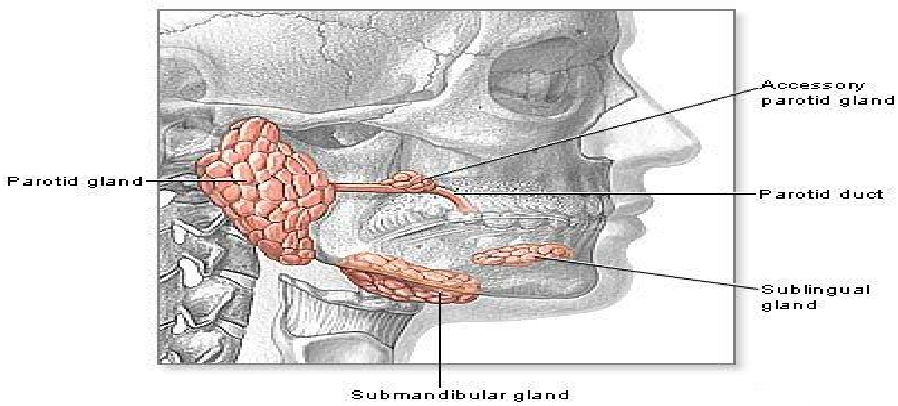


Fig.2.3: accessory parotid gland and parotid duct.(www.google.com/amp/s/pinterest.com)

2.3.1.1 Fascia:

The deep cervical fascia continues superiorly to form the parotid fascia, which is split into superficial and deep layers to enclose the parotid gland. The thicker superficial fascia is extended superiorly from the masseter and sternocleidomastoid muscles to the zygomatic arch. The deep layer extends to the stylomandibular ligament (or membrane), which separates the superficial and deep lobes of the parotid gland. The parotid fascia forms a dense inelastic capsule and, because it also covers the masseter muscle deeply, can sometimes be referred to as the parotid masseteric fascia.

2.3.1.2 Stensen's Duct:

The parotid duct, also known as Stensen's duct, secretes a serous saliva into the vestibule of the oral cavity. From the anterior border of the gland, it travels parallel to the zygoma, approximately 1 cm below it, in an anterior direction across the masseter muscle. It then turns sharply to pierce the buccinator muscle and enters the oral cavity opposite the second upper molar tooth.

2.3.1.3. Arterial Supply:

The blood supply to the parotid gland is from branches of the external carotid artery, which courses superiorly from the carotid bifurcation and parallel to the mandible under the posterior belly of the digastric muscle. The artery then travels medial to the parotid gland and splits into two terminal branches. The superficial temporal artery runs superiorly from the superior portion of the parotid gland to the scalp within the superior pretragal region. The maxillary artery leaves the medial portion of the parotid and supplies the infratemporal fossa and the pterygopalatinefossa The transverse facial artery branches off the superficial temporal artery and runs anteriorly between the zygoma and parotid duct to supply the parotid gland, parotid duct, and the masseter muscle.

2.3.1.4 Venous Drainage:

The retromandibular vein, formed by the union of the maxillary vein and the superficial temporal vein, runs through the parotid gland just deep to the facial nerve to join the external jugular vein.

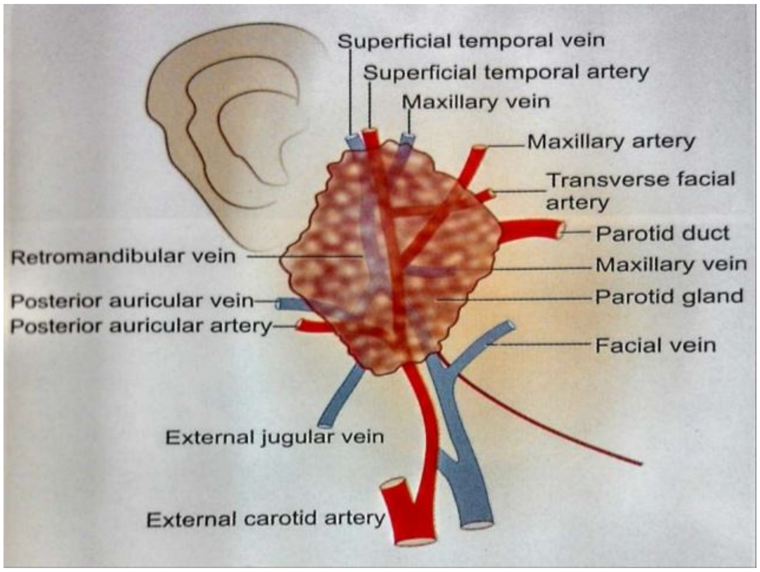


Fig.2.4: venous drainage of parotid gland.(www.slideshare.net)

2.3.1.5. Lymphatic drainage:

Drain into parotid nodes(superficial and deep)which, in turn, drain directly or indirectly into superficial and deep cervical nodes.

2.3.1.6. Innervation:

The parotid gland receives sensory and autonomic innervations. the autonomic innervation controls the rate of saliva production. Sensory innervations is supplied by auriculotemporalnerve(gland)and the great auricular nerve(fascia).

The parasympathetic innervation to the parotid gland has acomplex path. It begins with the glossopharyngeal nerve(cranial nerve IX).this nerve synapses with otic ganglion (a collection of neuronal cell bodies).

The auriculotemporal nerve then carries parasympathetic fibres from the otic ganglion to the parotid gland. parasympathetic stimulation causes an increase in saliva production.

Sympathetic innervation originatesfrom the superior cervical ganglion,part of the paravertebral chain. fibres from this ganglion travel along the external carotid artery to reach the parotid gland. Increased activity of the sympathetic nervous system inhibits saliva secretion via vasoconstriction.

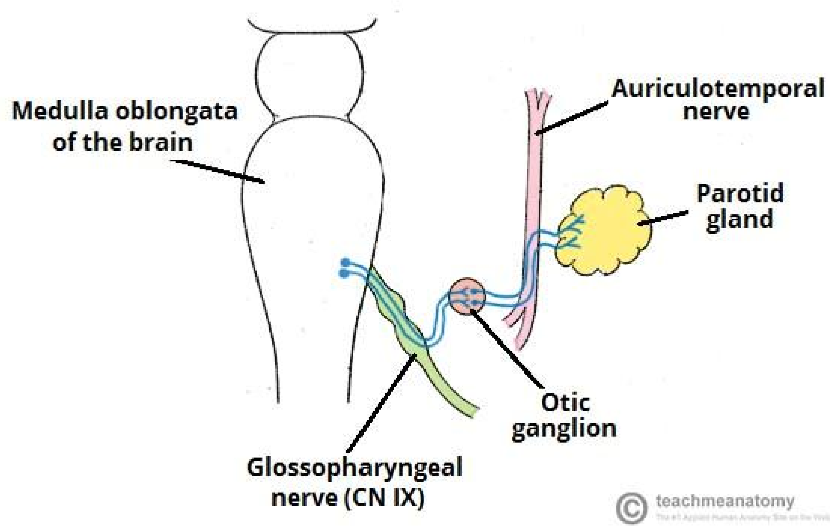


Fig.2.5: innervation of parotid gland.(http://teachmeanatomy.info)

2.3.2 Submandibular Gland:

The submandibular gland (in older texts, this gland was sometimes referred to as "the submaxillary gland") is the second largest major salivary gland and weighs 7–16 g. The gland is located in the submandibular triangle, which has a superior boundary formed by the inferior edge of the mandible and inferior boundaries formed by the anterior and posterior bellies of the digastric muscle. Also lying within the triangle are the submandibular lymph nodes, facial artery and vein, mylohyoid muscle, and the lingual, hypoglossal, and mylohyoid nerves.

Most of the submandibular gland liesposterolateral to the mylohyoid muscle.

2.3.2.1 Fascia:

The middle layer of the deep cervical fascia encloses the submandibular gland. This fascia is clinically relevant because the marginal mandibular branch of the facial nerve is superficial to it, and care must be taken to preserve the nerve during surgery in the submandibular region.

2.3.2.2. Wharton's Duct:

The submandibular gland has both mucous and serous cells that empty into ductules, which in turn empty into the submandibular duct. The duct exits anteriorly from the sublingual aspect of the gland, coursing deep to the lingual nerve and medial to the sublingual gland. It eventually forms Wharton's duct between the hyoglossus and mylohyoid muscles on the genioglossus muscle. Wharton's duct, the main excretory duct of the submandibular gland, is approximately 4–5 cm long, running superior to the hypoglossal nerve while inferior to the lingual nerve. It empties lateral to the lingual frenulum through a papilla in the floor of the mouth behind the lower incisor tooth.

2.3.2.3. Arterial Supply:

Both the submandibular and sublingual glands are supplied by the submental and sublingual arteries, branches of the lingual and facial arteries. The facial artery, the tortuous branch of the external carotid artery, is the main arterial blood supply of the submandibular gland. It runs medial to the posterior belly of the digastric muscle and then hooks over to course superiorly deep to the gland. The artery exits at the superior border of the gland and the inferior aspect of the mandible known as the facial notch. It then runs superiorly and adjacent to the inferior branches of the facial nerve into the face. The lingual artery branches inferior to or with the facial artery off the external carotid artery. It runs deepto the digastric muscle along the lateral surface of the middle constrictor and then courses anterior and medial to the hyoglossusmuscle.Venous Drainage The submandibular gland is mainly drained by the anterior facial vein, which is in close approximation to the facial artery as it runs inferiorly and posteriorly from the face to the inferior aspect of the mandible. The common facial vein is formed by the union of the anterior and posterior facial veins over the middle aspect of the gland. The common facial vein then courses lateral to the gland and exits the submandibular triangle to join the internal jugular vein.

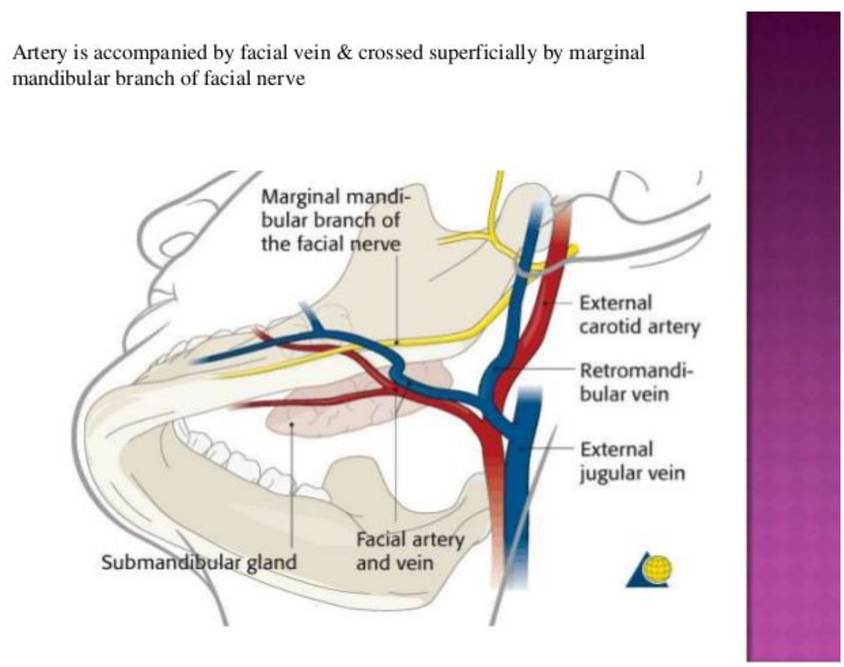


Fig.2.6: submandibular gland blood supply.

2.3.2.4. Lymphatic Drainage:

The prevascular and postvascular lymph nodes draining the submandibular gland are located between the gland and its fascia, but are not embedded in the glandular tissue. They lie in close approximation to the facial artery and vein at the superior aspect of the gland and empty into the deep cervical and jugular chains.

2.3.2.5 Innervation:

The submandibular glands recevive autonomic innervation through parasympathetic and sympathetic fibres, which directly and indirectly regulate salivary secretions respectively.

Parasympathetic innervation originates from the superior salivary nucleus through pre-synaptic fibres, which travel via the chorda tympani branch of the facial nerve. The chorda tympani then unifies with the lingual branch of the mandibular nerve before synapsing at the submandibular ganglion and suspending it by two nerve filaments.

Post-ganglionic innervation consists of secretomotor fibers which directly include the gland to produce secretions, and vasodilator fibers which accompany arteries to increase blood supply to the gland,increased parasympathetic drive promotes saliva secretion. Sympathetic innervation originates from the superior cervical ganglion, where post-synaptic vasoconstrictive fibers travel as a plexus on the internal and external carotid arteries, facial artery and finally the submental arteries to enter each gland. increased sympathetic drive reduces glandular blood flow through vasoconstriction and decreases the volume of salivary secretions, resulting in a more mucus and enzyme-rich saliva.

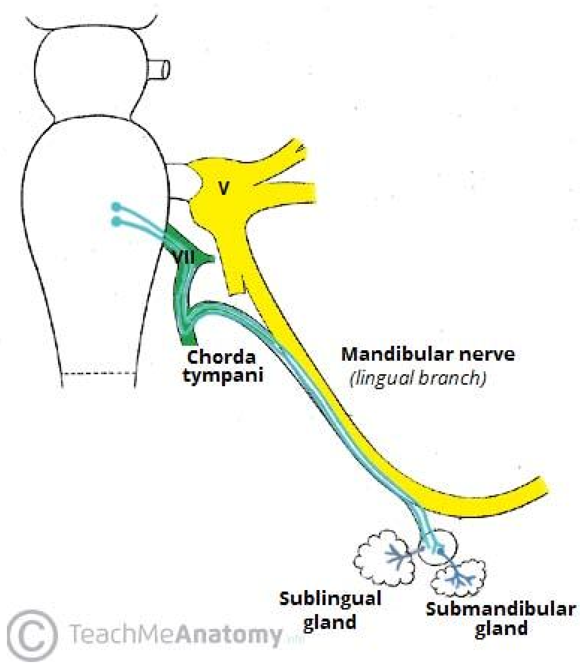


Fig.2.7: sublingual and submandibular innervation.

(http://teachmeanatomy.info)

2.3.3. Sublingual gland

The smallest of the major salivary glands is the sublingual gland, weighing 2–4 g, it lies as a flat structure in a submucosal plane within the anterior floor of the mouth, superior to the mylohyoid muscle and deep to the sublingual folds opposite the lingual frenulum . Lateral to it are the mandible and genioglossus muscle. There is no true fascial capsule surrounding the gland, which is instead covered by oral mucosa on its superior aspect. Several ducts (of Rivinus) from the superior portion of the sublingual gland either secrete directly into the floor of mouth, or empty into Bartholin’s ductthat then continues into Wharton’s duct.

2.3.3.1. Arterial supply and venous drainage:

Blood is supplied to the sublingual gland by the submentaland sublingual arteries, branches of the lingual andfacial arteries, respectively. The venous drainage is through the sublingual and submentalviens which drain into lingual and facial veins,both then draining into the internal jugular vein.

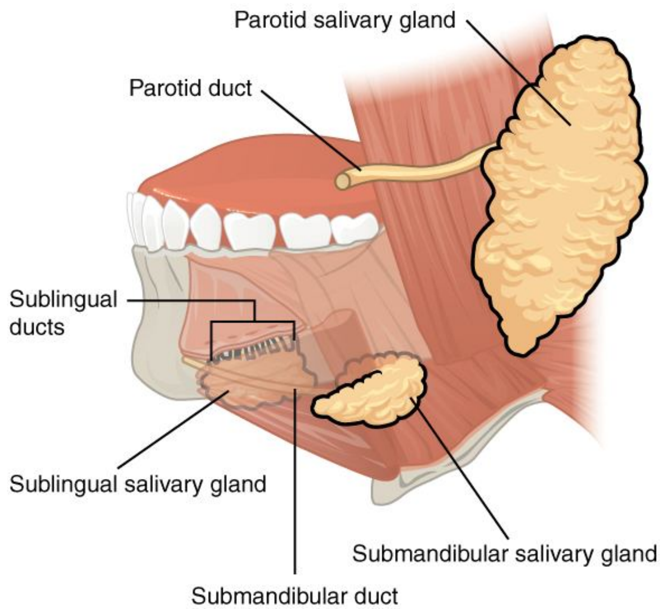


Fig.2.8: ducts of salivary glands.

2.3.3.2. Innervation and lymphatic drainage:

Both the sympathetic and parasympathetic nervous systems innervate the sublingual gland. The presynaptic parasympathetic (secretomotor) fibers of the facial nerve are carried by the chorda tympani nerve to synapse in the submandibular ganglion.

Postganglionic fibers then exit the submandibular ganglionand join the lingual nerve to supply the sublingual gland. Sympathetic nerves innervating the gland travel from the *cervical ganglion* with the facial artery. The sublingual gland is mainly drained by the submandibular lymph nodes.

2.3.4. minor salivary glands:

About 600 to 1,000 minor salivary glands, ranging in size from 1 to 5 mm, line the oral cavity and oropharynx. The greatest number of these glands are in the lips,tongue, buccal mucosa, and palate, although they can also be found along the tonsils, supraglottis, and paranasal sinuses. Each gland has a single duct which secretes, directly into the oral cavity, saliva which can be either serous,mucous, or mixed.

2.4. Histology:

Salivary glands are made up ofsecretoryacini(acini-means a rounded secretory unit)and ducts.there Are two types of secretions-serous and mucous.theacini can either be serous, mucous, or mixture of serous and mucous.

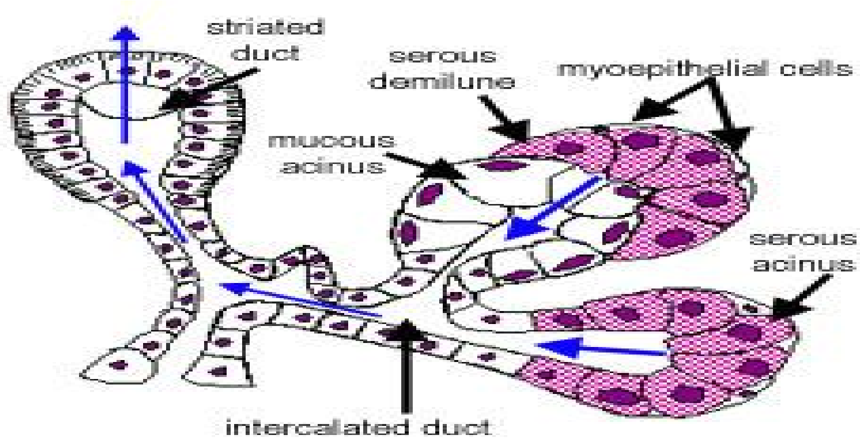


Fig.2.9: **diagram of part of salivary gland showing a serous acinus and mixed serous-mucous acinus.**

(http://www.histology.leeds.ac.uk**)**

A serous acinus secretes proteins in an isotonic watery fluid.

A mucous acinuss secretes secretesmucin– lubricant.

In a mixed serous-mucous acinus, the serous acinus forms a serous demilune around mucous acinus, as shown in the diagram.

The secretory units merge into intercalated ducts, which are lined by simple low cuboidal epithelium, and surrounded by myoepithelial cells. These ducts continue on as striated ducts. These have a folded basal membrane, to enable active transport of substances out of the duct. Water resorption, and ion secretion takes place in the striated ducts, to make saliva hypotonic (reduced Na,Cl ions and increased carbonate, and potassium ions).The striated ducts lead into interlobular (excretory) ducts, lined with a tall columnar epithelium. The glands are divided into lobules by connective tissue septa. Each lobule contains numerous secretory units, or acini.

2.5. Physiology:

2.5.1. functions of saliva:

a. Initial starch digestion by α-amylase (ptyalin) and initial triglyceride digestion by lingual lipase

b. Lubrication of ingested food by mucus.

c. Protection of the mouth and esophagus by dilution and buffering of ingested foods.

2.5.2. composition of saliva:

Saliva is characterized by:

(1) High volume (relative to the small size of the salivary glands) (2) *High K* +and HCO3 concentrations.

(3) Low Na+andCl−concentrations.

(4) Hypotonicity.

(5) Presence of α-amylase, lingual lipase, and kallikrein.

The composition of saliva varies with the salivary flow rate:

(1) At the lowest flow rates,saliva has the lowest osmolarity and lowest Na+, Cl−, and HCO3− concentrations but has the highest K+ concentration.

(2) At the highest flow rates(up to 4 mL/min), the composition of saliva is closest to that of plasma.

•The composition of saliva varies with flow rate

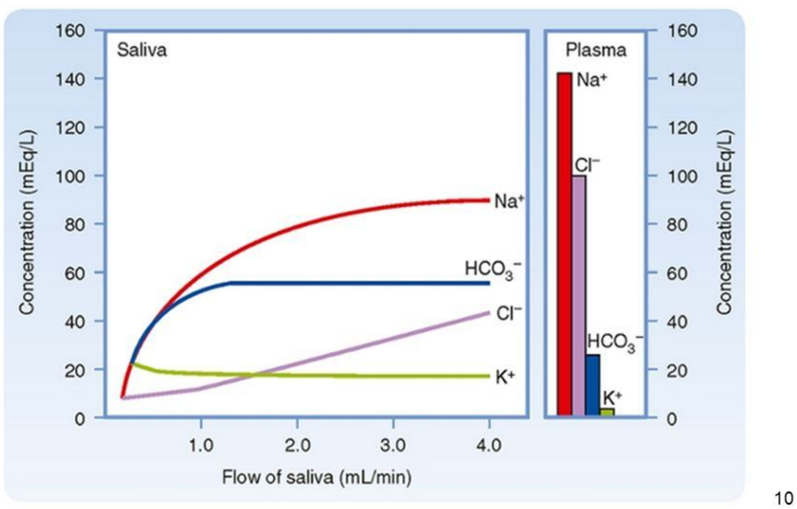


Fig.2.10: composition and flow of saliva.

The structure of each gland is similar to a bunch of grapes. The acinus (the blind end of each duct) is lined with acinar cells and secretes an initial saliva. A branching duct system is lined with columnar epithelial cells, which modify the initial saliva.When saliva production is stimulated, myoepithelial cells, which line the acinus and initial ducts, contract and eject saliva into the mouth.

a. **The acinus**: Produces an initial saliva with a composition similar to plasma.
This initial saliva is isotonic and has the same Na^+, K^+, Cl^-, and HCO_3^-concentrations as plasma.

b. **The ducts**: Modify the initial saliva by the following processes:
(1) The ducts reabsorb Na^+ and Cl^-, therefore, the concentrations of these ions are lower than their plasma concentrations.

(2) The ducts secrete K^+ and HCO_3^- therefore, the concentrations of these ions are higher than their plasma concentrations.

(3) Aldosterone acts on the ductal cells to increase the reabsorption of Na^+ and the secretion of K^+(analogous to its actions on the renal distal tubule).
(4) Saliva becomes hypotonic in the ducts because the ducts are relatively impermeable to water. Because more solute than water is reabsorbed by the ducts, the saliva becomes dilute relative to plasma.

(5) The effect of flow rate on saliva composition is explained primarily by changes in the contact time available for reabsorption and secretion processes to occur in the ducts.Thus, at high flow rates, saliva is most like the initial secretion from the acinus it has the highest Na^+ and Cl^- concentrations and the lowest K^+ concentration.

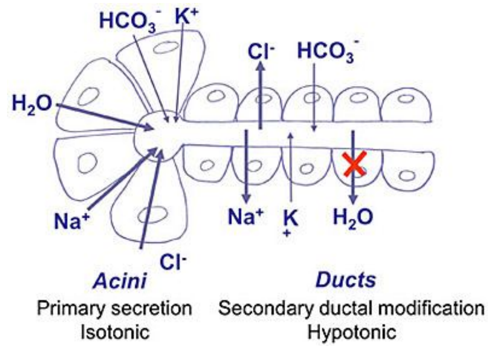


Fig.2.11: modification of saliva by ductal cells.(http://tankonyvtar.hu)

At low flow rates, saliva is least like the initial secretion from the acinus; it has the lowest Na+ and Cl−concentrations and the highest K+ concentration.

The only ion that does not "fit" this contact-time explanation is HCO3, HCO3 secretion is selectively stimulated when saliva secretion is stimulated.

2.5.3. Regulation of saliva production:

Saliva production is controlled by the parasympathetic and sympathetic nervous systems (not by GI hormones).

Saliva production is unique in that it is increased by bothparasympathetic and sympathetic activity. Parasympathetic activity is more important, however.

a. Parasympathetic stimulation:

(cranial nerves VII and IX) increases saliva production by increasing transport processes in the acinar and ductal cells and by causing vasodilation.

Cholinergic receptors on acinar and ductal cells are muscarinic. The second messenger is inositol 1,4,5-triphosphate (IP3) and increased intracellular [Ca2+].

Anticholinergic drugs (e.g., atropine) inhibit the production of saliva and cause dry mouth.

b. Sympathetic stimulation:

increases the production of saliva and the growth of salivary glands, although the effects are smaller than those of parasympathetic stimulation.
Receptors on acinar and ductal cells are b-adrenergic.

The second messenger is cyclic adenosine monophosphate (cAMP).

c. Saliva production:

is increased (via activation of the parasympathetic nervous system) by food in the mouth, smells, conditioned reflexes, and nausea.

2.6. Ultrasonographic anatomy:

All salivary glands are homogeneous and increased echogenicity relative to adjacent muscle on ultrasound. This increased echogenicity is related to the fatty glandular tissue composition of the gland,. The normal sizes of the salivary glands have been evaluated There does not seem to be any gender-related differences, but the size of the glands increase significantly with body weight.

2.6.1. Parotid Gland:

The parotid gland is located in the retromandibular fossa. Anatomically, the superficial lobe and deep lobe are separated by the plane of the facial nerve.
On US, the nerve cannot be visualized and thus the anatomic lobes cannot be distinguished. Some refer to the caudal portion of the parotid gland as the superficial lobe, but we prefer referring to structures visualized

around or within the gland for orientation, which avoids confusion with the anatomic definition of the parotid lobes.

In most cases, the retromandibular vein is visualized without difficulty; however, normal intraglandular salivary ducts and the main duct (Stensen's duct) are generally not seen, even with high-frequency transducers.

A dilated Stensen's duct may be visualized, running superficially along the masseter muscle through the corpus adiposumbuccae and then turning medially through the buccinator muscle.

In this anterior region, accessory salivary tissue can often be seen. The echostructure is usually homogeneous and the echogenicity comparable to that of the thyroid gland (fig .12).Lymph nodes can be seen within the gland, and are located in the anatomic superficial lobe.

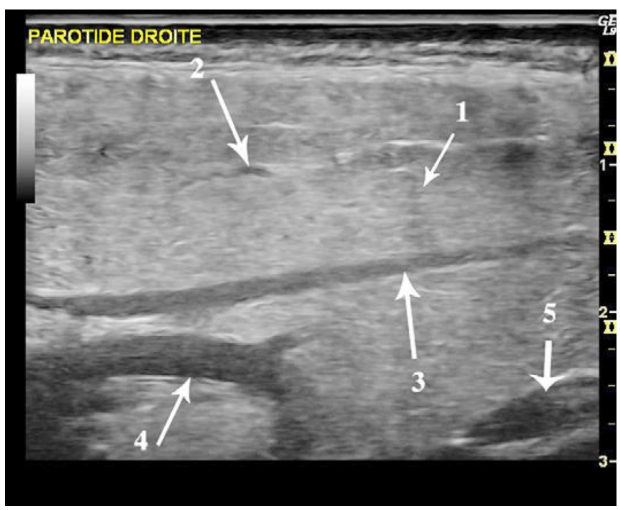


Fig.2.12: Longitudinal sonogram of a normal parotid gland. 1: parenchyma, 2: small duct,3: retromandibular vein, 4 and 5: external carotid artery. (Philips Katz et al.)

2.6.2. Submandibular Gland:

The submandibular gland is located anterior and caudal to the parotid gland. Sometimes the salivary tissues of both glands can be found adjacent to each other without any intervening facia, but their echostructure is different: the submandibular gland is more hypoechoic than the parotid gland. The other anatomic structures in the submandibular region are the mandible, the mylohyoid muscle, the anterior belly of the digastric muscle, and the facial vessels. The facial artery runs posterior to or even within the submandibular gland. On a typical oblique section of the submandibular gland, the palatine tonsil can also be visualized as hypoechoic area in a cranioposterior position relative to the submandibular gland. Normally, the submandibular glands have a triangular shape with a posterior base. Normal intraglandular ducts are only rarely visualized. After stimulation with lemon, they may be more easily seen. The main submandibular duct (Wharton's duct) originates from the deep portion of the gland and ascends anteriorly to the caruncula in the floor of the mouth.

The main duct can be differentiated from the lingual vessels by color Doppler .

2.6.3. Sublingual Gland:

The sublingual glands are localized in the floor of the mouth, cranial to the mylohyoid muscle, medial to the mandible and lateral to the geniohyoid muscle. In some cases the salivary tissue can even extend posteriorly to the submandibular gland.4 The sublingual glands have multiple small excretory ducts that are not visible with US. The glands appear more echogenic than the hypoechoic muscles of the floor of the mouth.

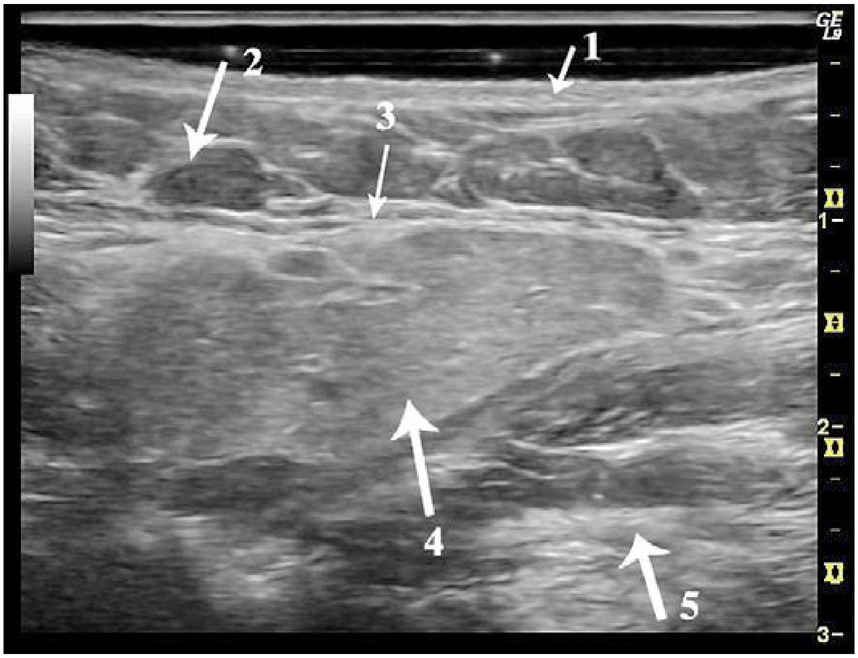


Fig.2.13: Transverse sonogram of right normal submandibular gland. 1: skin, 2: fat, 3: fascia, 4:parenchyma, 5: mylohyoid muscle. (Philips Katz et al.)

Fig.2.14: Transverse sonogram of right normal sublingual gland: 1: parenchyma, 2: anterior belly digastric muscle, 3: floor of the mouth. (Philips Katz et al.)

2.7. Ultrasonographic pathology:

2.7.1 inflammatory diseases:

Inflammatory diseases Infection of a salivary gland is called sialitis, which can be further divided into infection of the gland itself, or sialadenitis, and infection of the salivary duct or ducts, termed sialodochitis.

Viral Sialadenitis: Endemic parotitis or the mumps, caused by a paramyxovirus, is the most frequent acute infection,. Usually, the clinical presentation is sufficient for a definitive diagnosis.5 In 75% of cases both parotid glands are enlarged. Cervical lymph nodes are also always enlarged.

On US, the parotid glands are enlarged with a more rounded shape and a hypoechoicstructure, Sometimes the salivary ducts are enlarged and visible.

Color Doppler demonstrates diffuse hyper vascularization.

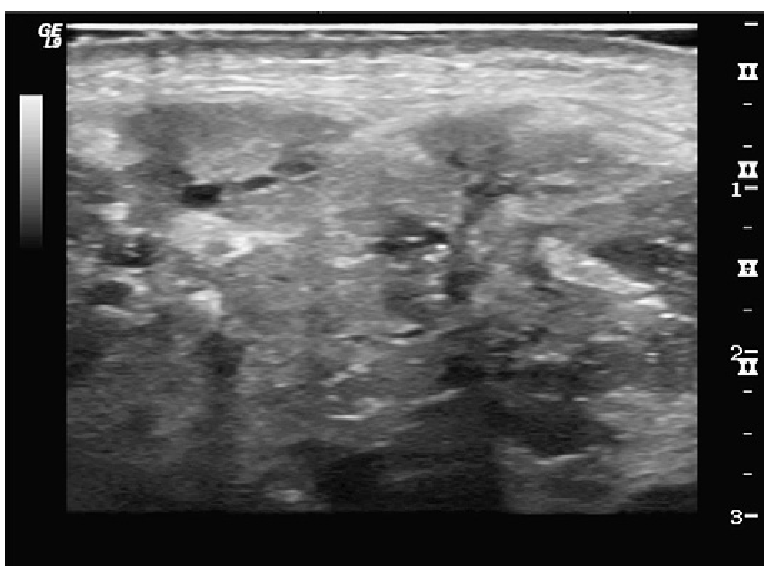


Fig.2.15: Longitudinal ultrasound of a parotid gland: Unilateral heteroechogenic aspect of the parenchyma with duct dilatation and swelling of the gland.(Philips Katz et al.)

Bacterial Sialadenitis:

Acute bacterial parotitis:

Acute bacterial parotitis is as common in adults as in children. Clinical presentation is typically unilateral, with sudden pain and swelling and increased pain at each meal (salivary colic, even in the absence of lithiasis).

US is the only radiographic examination indicated, revealing salivary duct dilatations,hypoechoic parenchyma, and enlarged intraglandular lymph nodes.

on color Doppler is visible Hypervascularization because of the inflammation,(Fig.16).

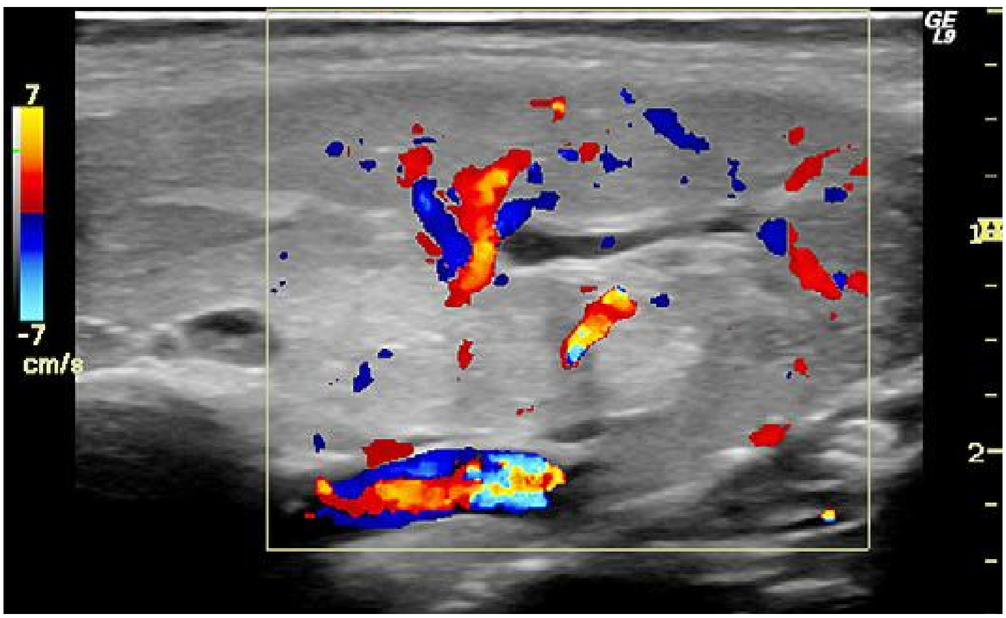


Fig.2.16: Longitudinal ultrasound of parotid gland. Color Doppler reveals hyperemia. (Philips Katz et al.)

Acute sialoadenitis:

The main goal of US in inflammatory diseases is to rule out lithiasis or other ductal obstructions.In severe infections, intraglandular liquid spaces, implying abscess formation,may be observed and are more frequent in diabetic patients. Air may also be seen.as well as moving, echoic debris within an abscess , US guidance is particularly useful for needle aspiration or drainage of the abscess (Fig. 17).

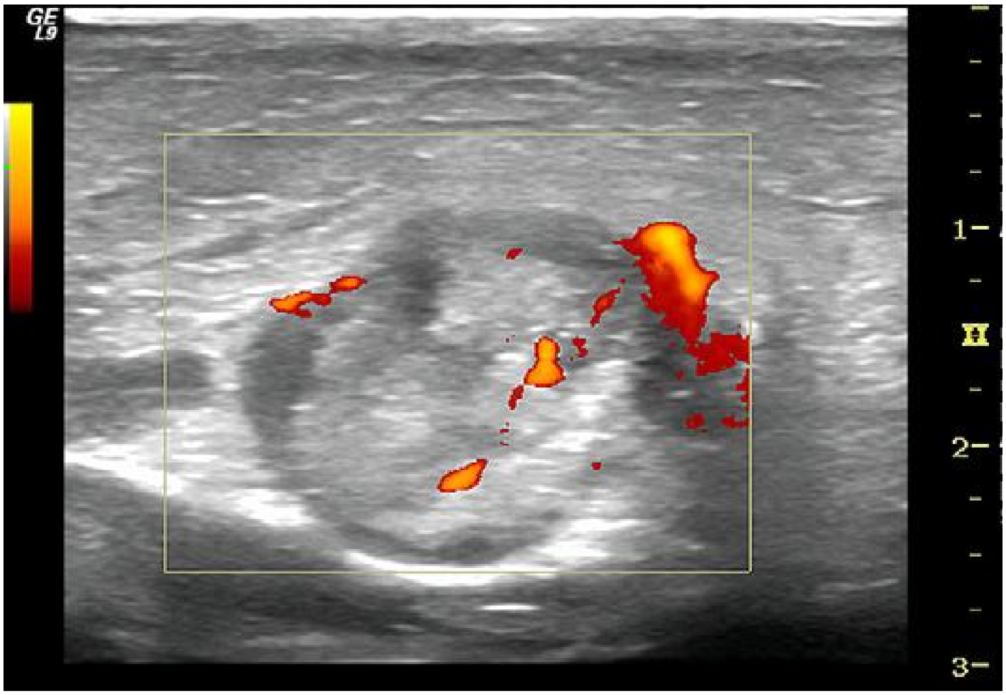


Fig.2.17: Transverse sonogram and Doppler of a left parotid. Typical aspects of parotid abscess. (Philips Katz et al.)

Chronic parotitis:

In chronic inflammation, the glandular modifications seen on US are often less prominent than in acute diseases. An atrophic hypoechoic gland may be seen, but the size of the gland is variable. Sometimes ductal ectasia is found (Fig. 7); however, sialography is superior to US for visualizing chronic inflammatory obstructions of the saliary ducts.

Tuberculousparotitis:

Tuberculosis of the salivary glands is rare, with parotitis mimicking a malignant tumor,Moderate pain, or no pain at all, may be present.

On US, there are heterogeneous, hypoechoic, poorly-defined lesions, with regional lymphadenopathy (Fig. 19).

The lymph nodes themselves have poorly defined margins as well (Fig. 20).

US-guided fine-needle aspiration (FNA) cytology is diagnostic showing specific granulomatous lesions with giant cells and necrosis.

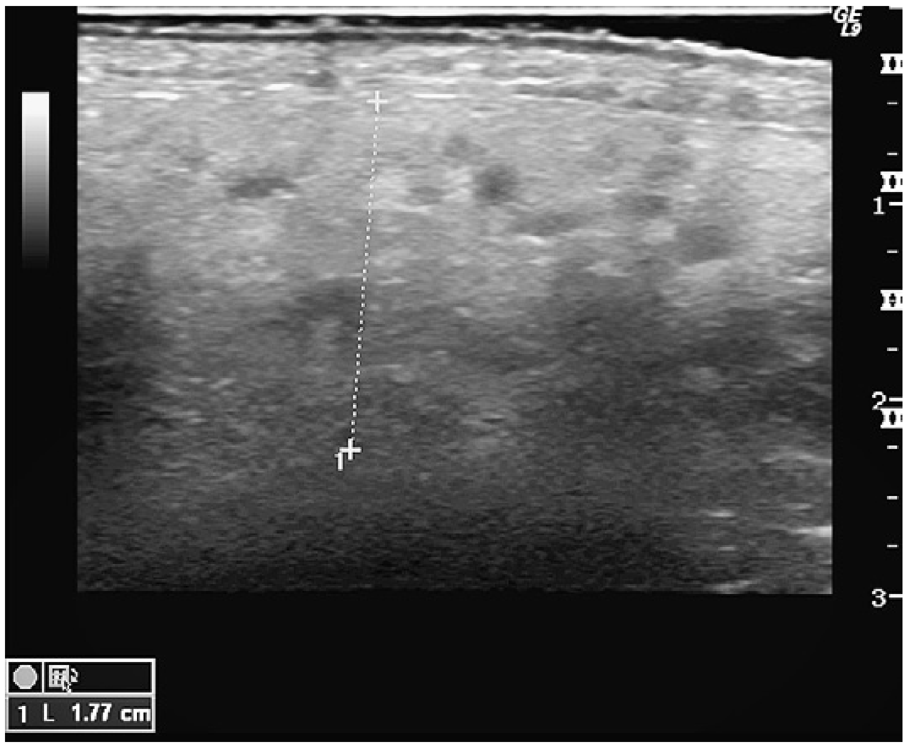


Fig.2.18: Longitudinal sonogram of left parotid on an adult. Heteroechogenic structure with small hypoechogenic nodules.Chronic parotidis. (Philips Katz et al.)

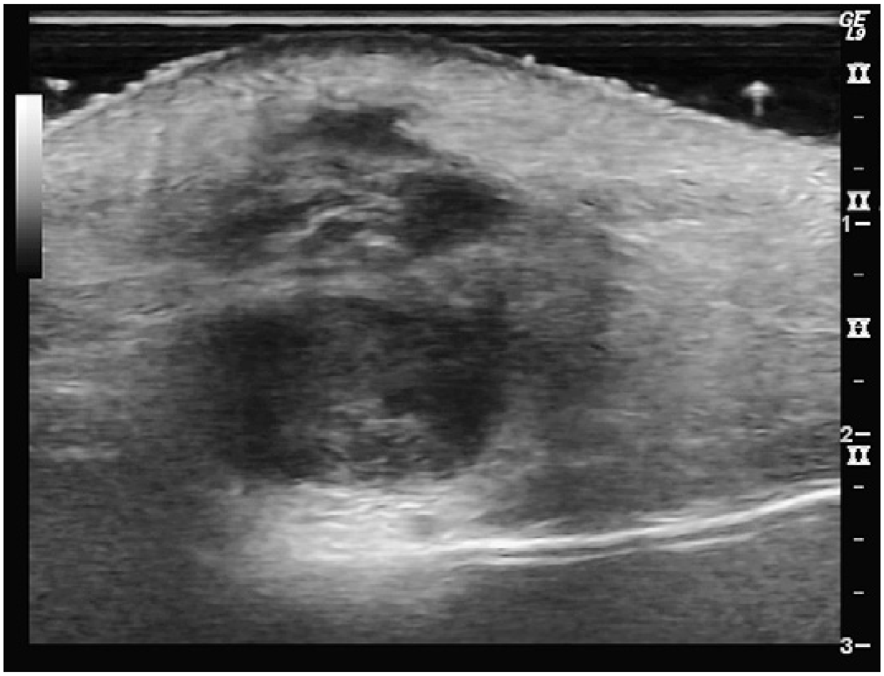


Fig.2.19: Longitudinal sonogram of parotid on an adult. Big lesion inside the parenchyma badly delimitate with heteroechonic aspect mimic a tumor: tuberculosis. (Philips Katz et al.)

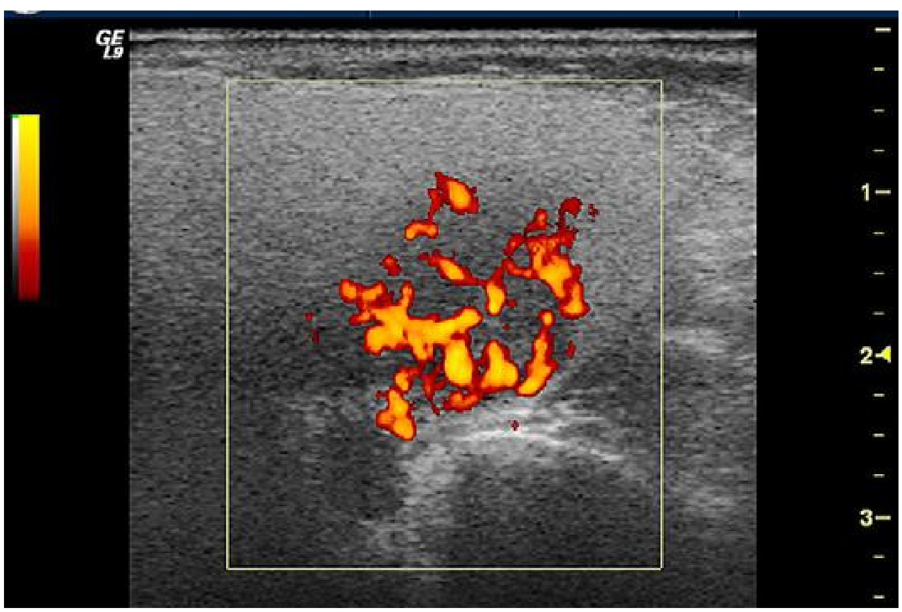


Fig.2.20: Color Doppler of parotidis tuberculosis. Hyperemia inside the lymph node. (Philips Katz et al.)

Sialodochitis with Sialolithiasis:

More than 80% of salivary concretions are localized in the submandibular gland or in Wharton’s duct. Approximately 15% of cases of sialolithiasis occur in the parotid gland or in Stensen’s duct. Sublingual lithiasis is rare. Salivary calculi usually cause symptoms only if an obstruction of the ductal system occurs. For therapeutic purposes it is important to differentiate lithiasis of the main duct from those of the intraglandular ducts.

Typical locations for lithiasis are at the anterior bend of Wharton’s duct and at the confluence of the intraglandular ducts.

Sometimes intraoral transducers are used to localize submandibular stones. Lithiasis of the parotid system is often located in the ducts in the periphery of the gland or deep in the parenchyma. Sonographically, lithiasis typically appears as a bright curvilinear echo complex with posterior shadowing (Figs. 21) In lesions smaller than 2 mm, this shadow may be missing.

Fig.2.21: Transverse ultrasound of right submandibular gland. Heteroechogenic aspect of the gland with a white hyperechogenic structure,.Silalolithiasis (6.7 mmdiameter). (Philips Katz et al.)

Sjogren's syndrome:

Sjogren's syndrome (SS) is an autoimmune disease with chronic inflammation of the major salivary glands, the lacrimal glands, and arthritis. The exocrine glands are infiltrated by lymphocytes and plasma cells. The incidence of Sjogren's disease in women is seven to nine times higher than in men.Definitive diagnosis is made by biopsy of the minor salivary glands of the lips. sonographically In the acute stage, swelling and hypoechoic transformations are found Often the glands are heterogeneous because of inflammation, enlarged lymph nodes, and myoepithelial hyperplasia the peripheral ductal system may be dilated; furthermore, multiple small cysts are found(fig.22), The sonographic changes correlate with histological involvement With time, the glands become small, hypoechoic, heterogeneous, and difficult to delineate. Color Doppler shows hyper vascularization.

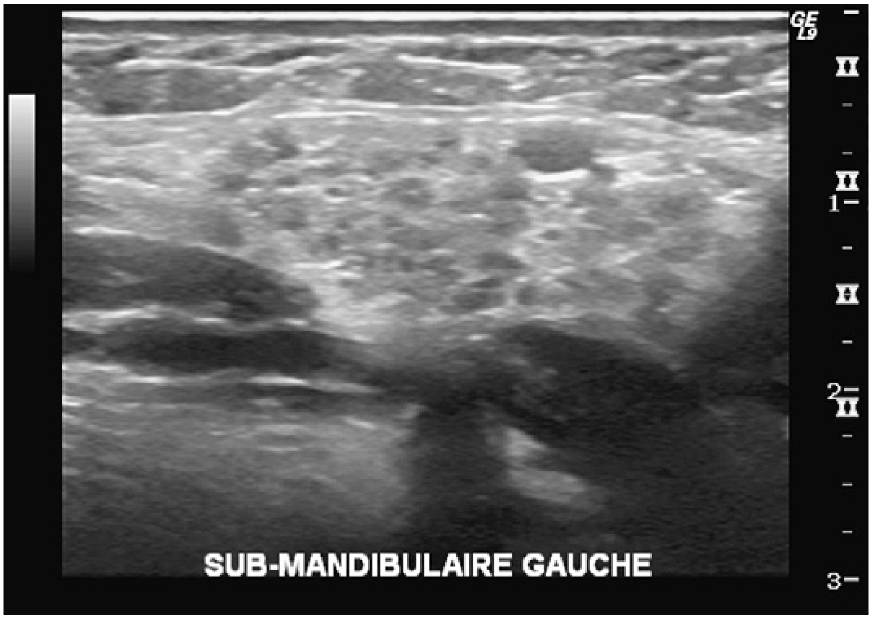


Fig.2.22: Transverse ultrasound of left submandibular gland. Typical aspect of Sjogren's syndrome, with many hypoechogenic nodules inside the parenchyma(Philips Katz et al.).

2.7.2.Salivary gland tumors:

2.7.2.1. Benign Tumors of the Glandular Epithelium:

Pleomorphic adenoma: Pleomorphic adenoma is the most frequent tumor of the salivary tissue (24%– 71%).In approximately 80% of cases the tumor is located in the superficial partof the parotid gland. Sonographically, the tumor is well circumscribed and usually is homogeneous and hypoechoic. A well-defined, lobulated margin is regarded as typical (Figs.23).

When calcifications are found in parotid tumors, Color Doppler most often demonstrates moderate vascularization.

Cystadenolymphoma (Warthin's tumor): Papillary cystadenomalymphotosum (Warthin's tumor) is the second most frequent salivary gland tumor. The tumors are most often located in the caudal partof the parotid gland and may be bilateral. On US the lesion is usually more heterogeneous than pleomorphic adenomas (Fig.24) and have well-defined borders.

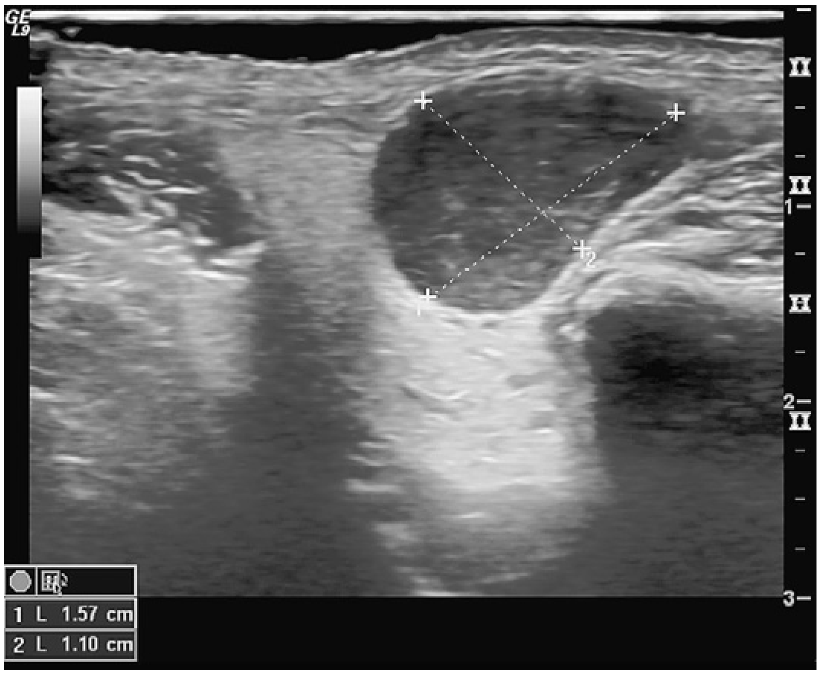


Fig.2.23: Transverse sonogram of right parotid gland. Homogeneous hypoechogenic tumor well delimitate inside the parenchyma. Histology demonstrated pleomorphic adenoma. (Philips Katz et al.)

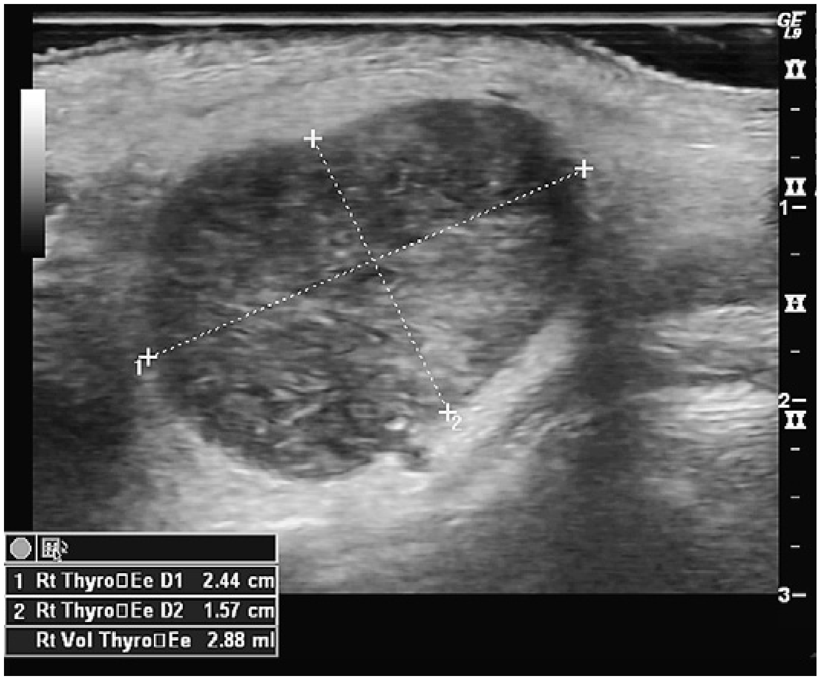


Fig.2.24: Transverse sonogram of right parotid gland. Hypo to isoechogenic lesion with several cystic areas, but well deliniated. FNAC reported papillary cystadenomalymphotosum or Whartin's tumor.. (Philips Katz et al.)

2.7.2.2. Malignant Epithelial Tumors:

Mucoepidermoid carcinoma: mucoepidermoid carcinoma is the most frequent malignant tumor of the salivaryglands. Malignant tumors smaller than 2 cm in diameter usually have ahomogeneous structure and present with smooth borders; therefore, especially low-grade malignant tumors are often incorrectly diagnosed as benign lesions by imaging. High-grade malignant tumors and larger lesions mostly show irregular borders and a typical heterogeneous echo pattern. Frequently, irregular zones of necrosis are found. These tumors are most often correctly assessed as malignant tumors by US.

Acinar cell carcinoma: 3% of tumors is typically round in outline an have a pseudo capsule on ultrasound as awell-defineed margin it same appearance as a pleomorphic adenoma(fig .25). color Doppler usually shows a higher degree of vascularization as compared withthe normal parenchyma or with benign tumors.

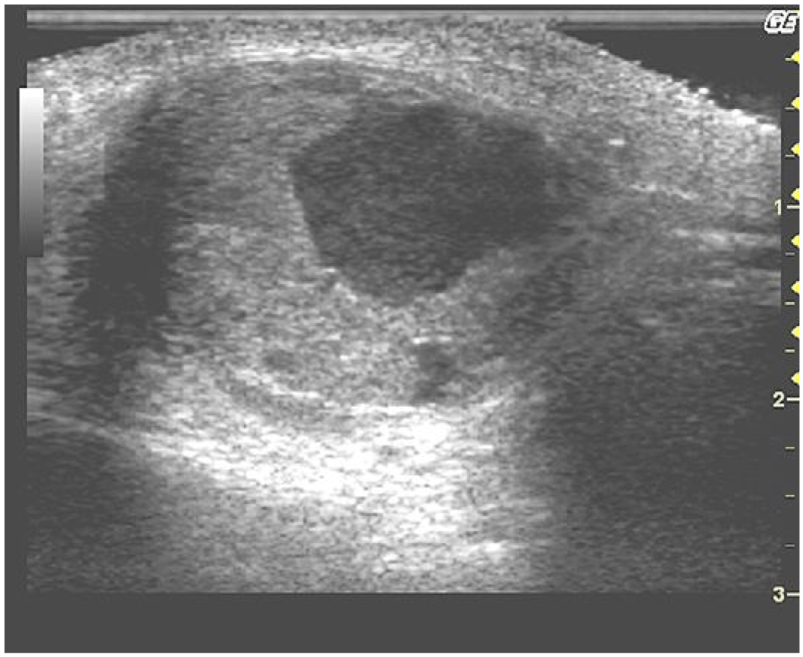


Fig.2.25. Longitudinal sonogram of gland parotid gland.Heterogeneous tumor inside the parenchyma, with a hypoechogenic cyst. Histology was acinic cell carcinoma. (Philips Katz et al.)

2.7.2.3. Nonepithelial Tumors:

Lymph node metastases within the parotid gland: Intraglandular lymph node metastases most often present as multiple, round, well-defined, hypoecheic lesions (Fig. 26). Lymph node metastases of the parotid gland are most commonly caused by malignant melanoma, squamous cell carcinoma, or metastatic carcinoma of the lung or breast. Color Doppler usually shows hyper vascularization.

Lipomas: Lipomas are rare salivary gland tumors On US, these relatively soft, fat-containing tumors typically have an ovoid shape, sharp outlines, and are moderately compressible. Compared with the parotid parenchyma, pure fat-containing lipomas are moderately hypoechoiclesions, Typically, a striated, feathered echogenicity is found (Fig.27).

Hemangiomas and lymphangiomas: In children, hemangiomas are the most frequent tumors of the salivary gland regionsOn US, hemangiomas usually appear as hyperechoic, ill-defined lesions,or as hypoechoic lesions with a typical lobular pattern (Figs.28). Hemangiomasare compressible. Color Doppler shows hyper vascularity of lesion inside the gland indicative of hemangioma.

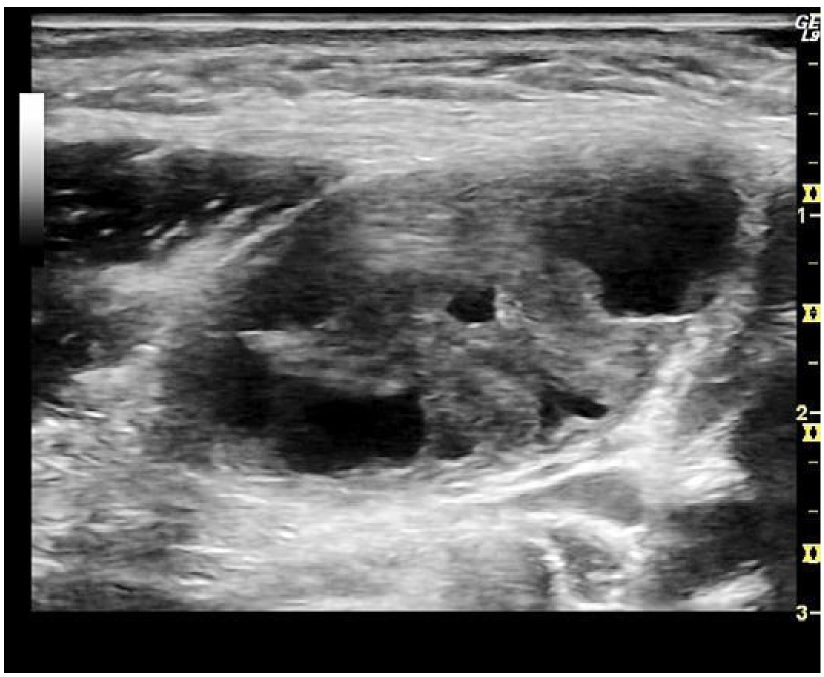


Fig.2.26: Lymph node metastases to the salivary gland. (Philips Katz et al.)

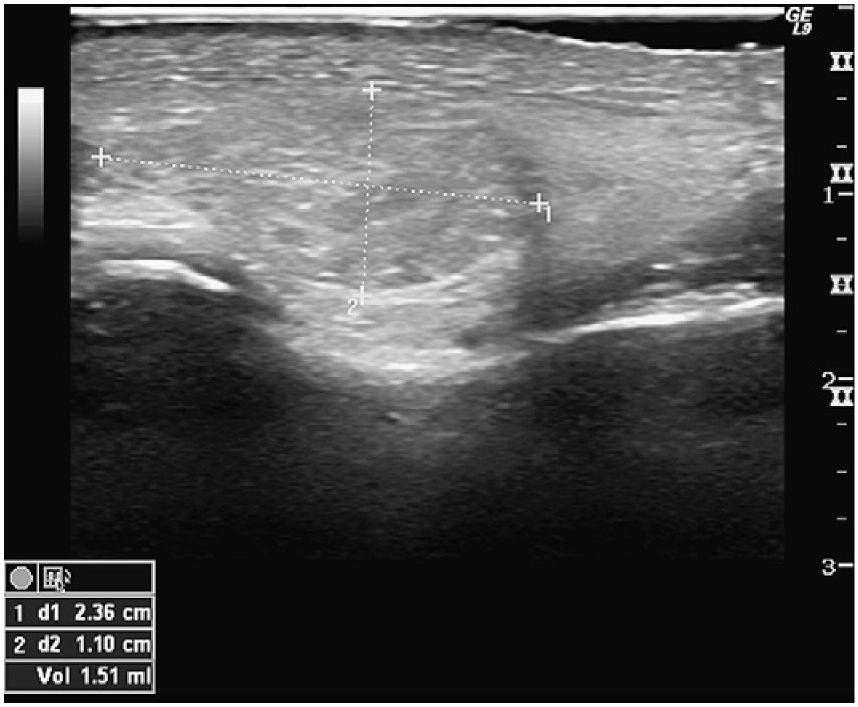


Fig.2.27: Longitudinal sonogram of gland parotid gland. Moderately hypoechogenic lesion with smooth borders. Notice the fine hyperechogenictrabeculation inside the lesion, a typical aspect of lipoma. (Philips Katz et al.)

Fig.2.28: Transverse sonogram of right parotid gland of a 6-month-old baby. Big lobulated hypoechogenic lesion inside the gland indicative of hemangioma. (Philips Katz et al.)

Lymphangioma: on US, they are predominantly cystic lesions with septae of variable thickness (Fig.29). The echogenic components correspond to clusters of atypical lymphatic vessels, which are too small to be seen owing to the spatial resolution of US. On color Doppler, lymphangioma appears avascular or hypo vascularized.

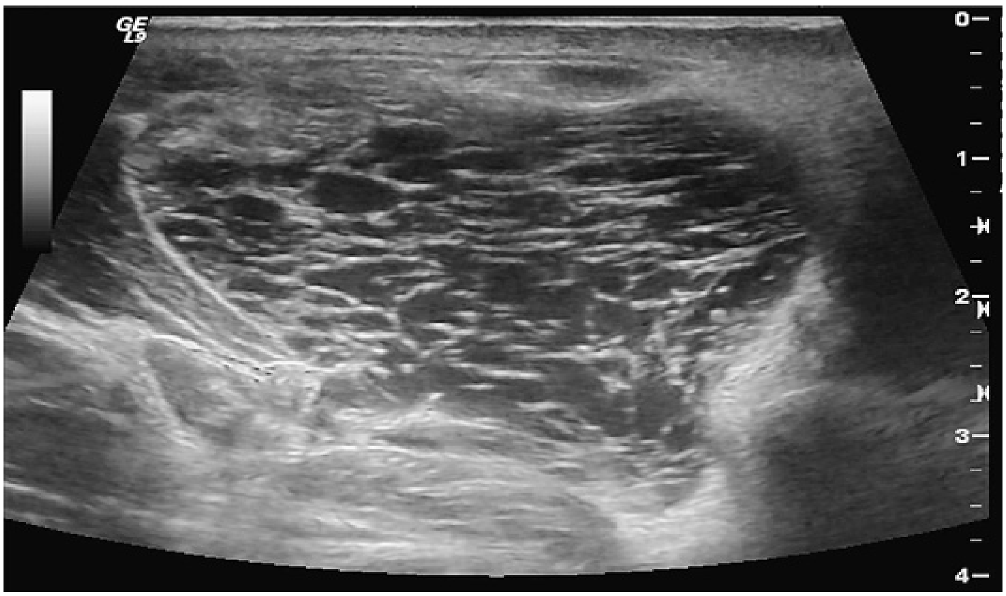


Fig.2.29: Transverse sonogram of right parotid gland. Very big hypoechogenic lesion located at the bottom of the parotid gland with fine hyperechogenic cluster typical of lymphangioma. (Philips Katz et al.)

2.7.2.4. Pseudo-tumors:

Masseter Muscle Hypertrophy: unilateral hypertrophy of the masseter muscle is often misdiagnosed. Hypertrophyof the masseter muscle can be assumed if the masseter measures more than 14mm in its short-axis diameter at rest.

Retention Cysts (Ranulae): These benign lesions generally occur following trauma involving the floor of the mouth. These retention cysts (ranulae) of the sublingual gland can appear hypoechoic. The cyst is always very well delineated in the floor of the mouth (Fig.30).

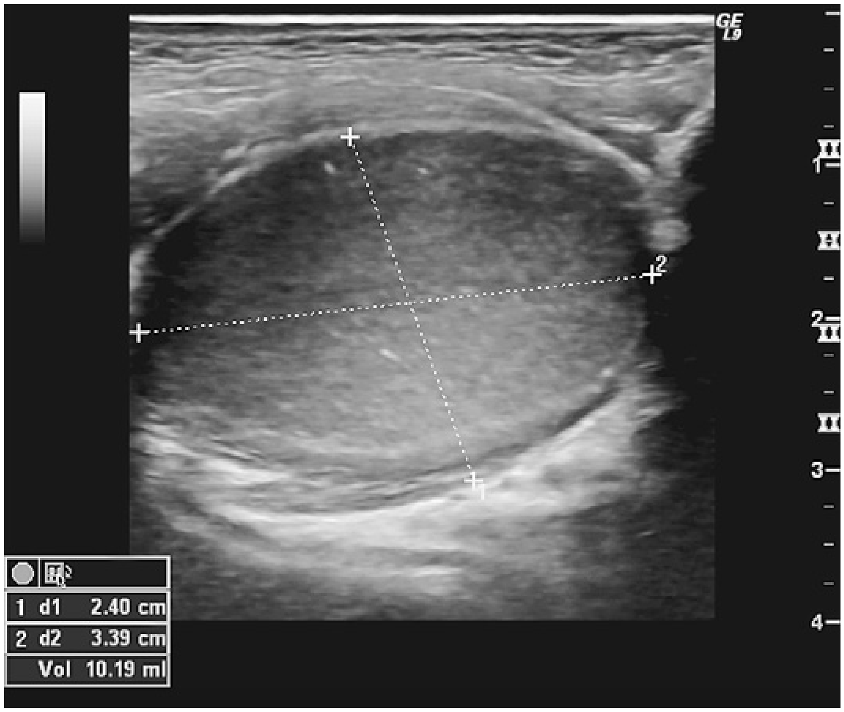


Fig.2.30: Transverse sonogram of right floor of the mouth. Huge hypoechogenic lesion very well delineated and encapsulated located under the Wharton's canal: a ranula. (Philips Katz et al.)

2.8 Ultrasound guided biopsy of the salivary glands:

A safe and accurate investigation particularly for histological diagnosis of tumors, cost effective and accurate procedure with minimal risk of complication.

Chapter Three

3.1 Materials:

3.1.1 Study design:

descriptive cross sectional study.

3.1.2 study area and duration:

The study conducted in the ultrasound department of the college of medical radiological sciences in the Sudan university of sciences and technology, from June to December 2018.

3.1.3 Population:

The study based on two groups of adult Sudanese male :

observed group : 27, snuff users.

control group: 26 , non-users.

3.1.4 Variables:

The variables of this study included:

- The size, echogenicity, echo texture ,blood flow and any pathological changes in the parotid or submandibular glands of both population groups.
- The age and weight of both groups.
- And , the duration of using snuff for the observed group.

3.1.5 Data collection:

The data collected and recorded on a data collection sheet.

3.1.6 Data analysis:

data analyzed by SPSS and Microsoft excel and word programs .

3.1.7 Ethical consideration:

A permission obtained to perform the study in the ultrasound department of the college of medical radiological sciences in SUST.

The privacy of all study populations has been observed.

3.2 Methods:

3.2.1 The machine used:

Apinion ecube7 machine , with12MHz linear transducer.

3.2.2 Ultrasound technique:

The patient was laying in the supine position with the neck extended and the head slightly turned to the opposite side.

Parotid gland has a more complex anatomy that makes measurement of size difficult.

AP and ML diameters of the parotid gland were measured on the same transverse view obtained at the level of the angle of the mandible.

Submandibular gland is more amenable to analyzing size in three dimensions (depth, width, length) by transverse and longitudinal placement of the probe.

AP dimension measured on longitudinal view parallel to the horizontal ramus of the mandible.
ML measured on a perpendicular view obtained at the half point of the AP dimension.
Echogenicity of salivary glands can be compared to either normal thyroid gland(identical) and adjacent muscles(should be more echoic than adjacent muscles). and Normal homogeneity similar to thyroid gland.

Chapter Four

Results

Table(4.1): Descriptive statistics:

	N	Minimum	Maximum	Mean	Std. Deviation
Age	53	20	68	40.32	13.383
Weight	53	52	105	71.68	11.014

Table(4.2): group statistics:

	Case	N	Mean	Std. Deviation	Std. Error Mean	*P value*
Left Submandibular Gland size	Control	26	13.1100	2.959	.58037	0.047
	Users	27	15.1811	4.834	.93034	
Left Submandibular Gland Blood Flow (RI)	Control	26	0.7527	.0322	.00631	0.914
	Users	27	0.7515	.0467	.00904	
Right Submandibular Gland size	Control	26	13.0704	3.441	.67490	0.141
	Users	27	14.9330	5.386	1.03645	
Right Submandibular Gland Blood Flow (RI)	Control	26	0.7527	.0311	.00612	0.760
	Users	27	0.7493	.0454	.00874	
Left Parotid Gland size	Control	26	17.4769	4.077	.79957	0.002
	Users	27	22.8685	10.351	1.99189	
Left Parotid Gland Blood Flow (RI)	Control	26	0.7504	.0341	.00669	0.441
	Users	27	0.7270	.1525	.02936	
Right Parotid Gland size	Control	26	17.3069	4.292	.84164	.017

	Users	27	23.3015	8.248	1.58739	
Right Parotid Gland Blood Flow (RI)	Control	26	0.7542	.031	.00611	0.853

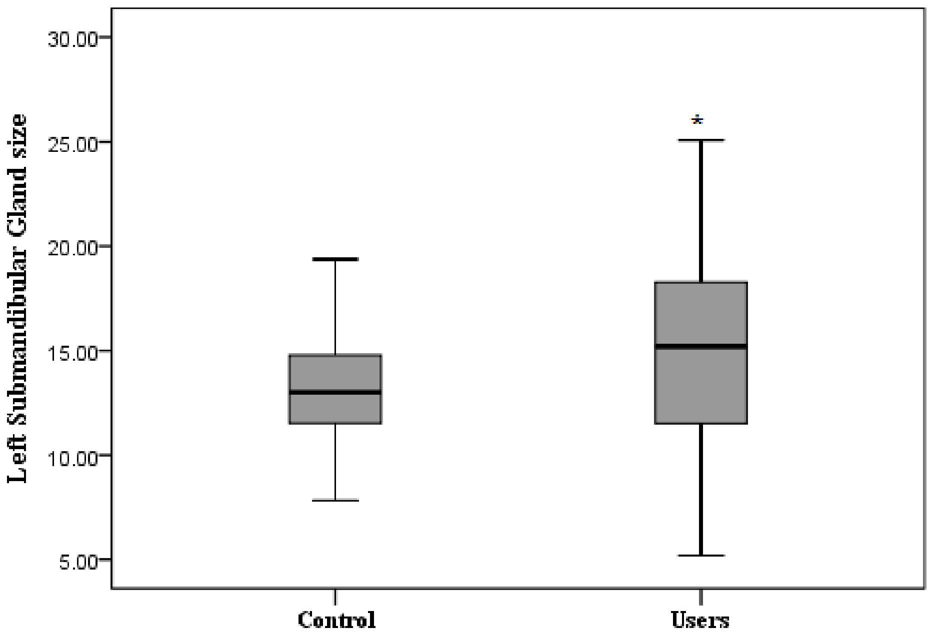
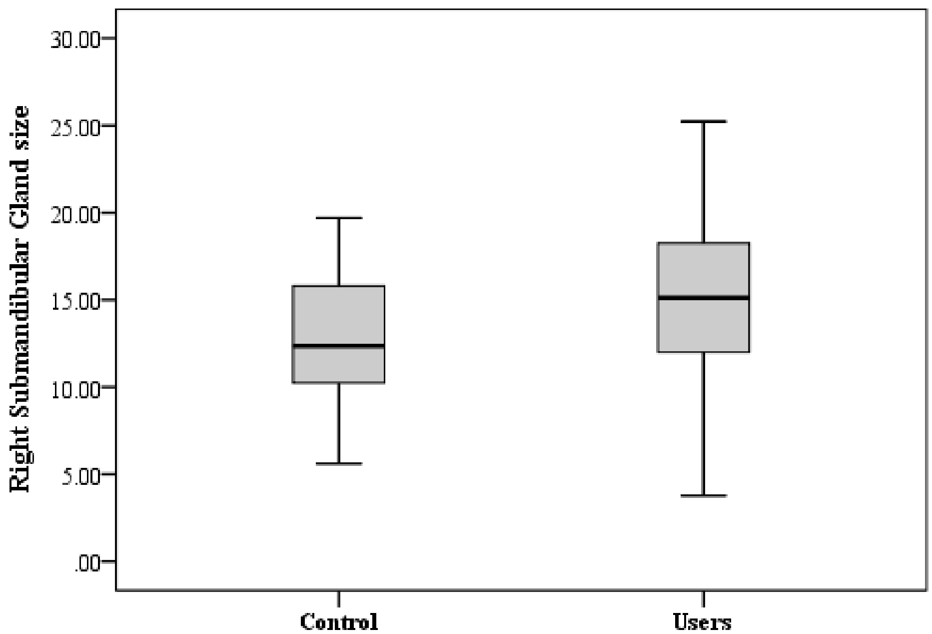
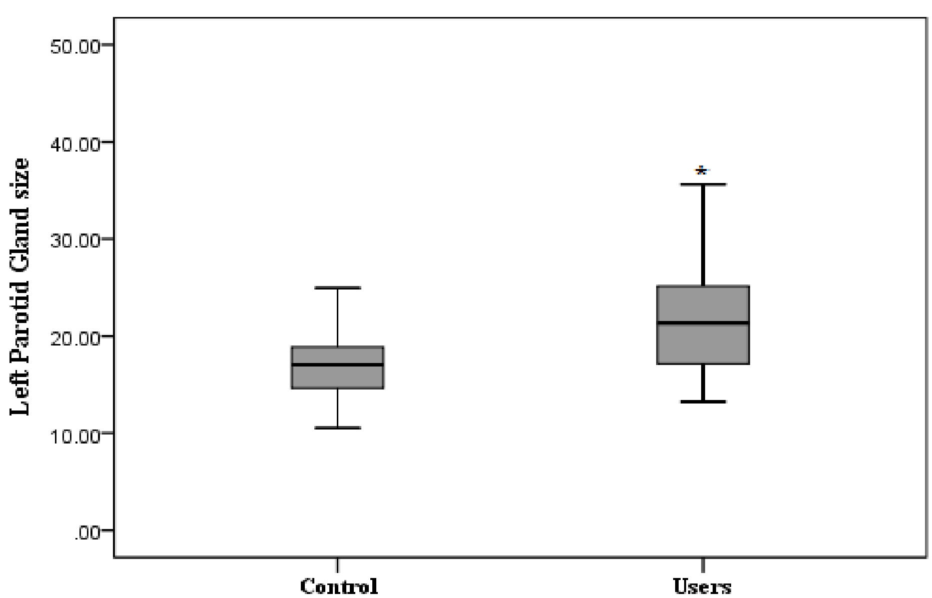


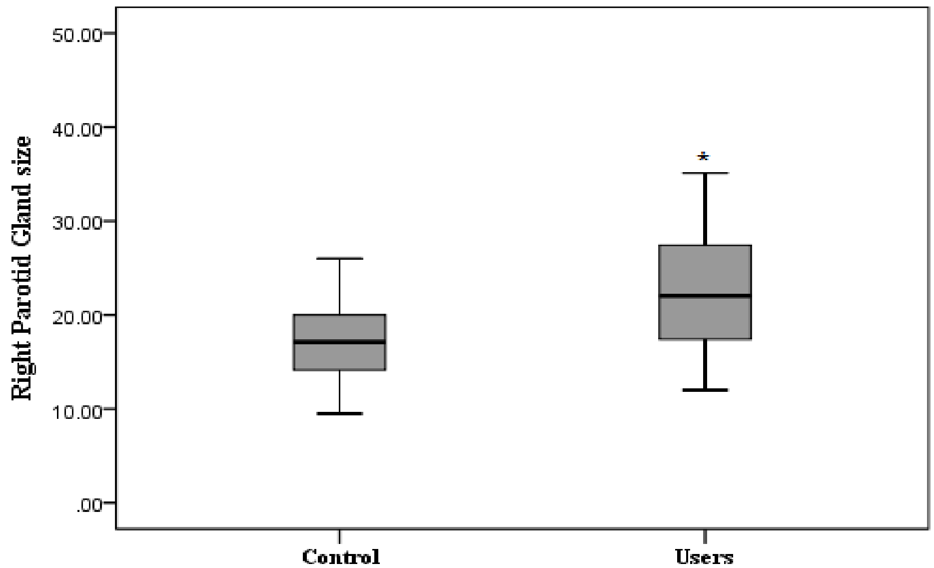
Figure (4.1) : left submandibular gland size.



figure(4.2): right submandibular gland size.



figure(4.3): left parotid gland size.



figure(4.4): right parotid gland size.

Table (4.3):

Left Submandibular Gland echogenicity				
		Case		Total
		Control	Users	
Left Submandibular Gland echogenicity	Hypo	1	0	1
	Normal	25	27	52
Total		26	27	53

Table (4.4):

Right Submandibular Gland Echogenicity				
		Case		Total
		Control	Users	
Right Submandibular Gland Echogenicity	Hypo	1	0	1
	Normal	25	27	52
Total		26	27	53

Table (4.5):

Left Parotid Gland Echogenicity				
		Case		Total
		Control	Users	
Left Parotid Gland Echogenicity	Normal	25	26	51
	Hyper	1	1	2
Total		26	27	53

Table (4.6):

Right Parotid Gland Echogenicity				
		Case		Total
		Control	Users	
Right Parotid Gland Echogenicity	Normal	25	21	46
	Hyper	1	5	6
Total		26	26	52

Chapter five

5.1 Discussion:

The thesis based on the data of healthy people who use snuff but do not complain of any problems in salivary glands. They were randomly selected and examined at the ultrasound clinic of the college of Medical Radiological sciences at SUST, (Study Group).

The results of the study group were compared to the results of control group which consisted of healthy people who do not use snuff and do not complain of health problems in salivary glands.

The difference in the mean of the size of left submandibular glands, right parotid glands and left parotid glands between the study group and control group was significant, the *p value* was 0.047, 0.017 and 0.002 respectively.

Although it's statistical power is limited, this study suggested that use of snuff affects the salivary glands and the salivary glands of snuff-users can be periodically tested using ultrasonography.

Hanaa.H. Bastah(2015), concluded that the nicotine induced atrophy of submandibular salivary ducts. The nicotine is an addictive ingredient of snuff , and the atrophy of salivary duct causes salivary gland hypertrophy, This means that nicotine is a component of snuff that is responsible for increasing the size of salivary glands in the users.

5.2 Conclusion:

Ultrasound is very useful in evaluation of salivary glands,and can be used for periodic screening of users of snuff and other tobacco types. The study concluded that there is no significant association between the use of snuff and any changes in the homogeneity, blood flow or echogenicity of the salivary gland.

The study found that salivary glands of snuff users were significantly larger than those of non-users.

5.3 Recommendation:

A future study in this subject with large population to get more accurate results.

Study on the effects of ingredients of snuff in the salivary glands.

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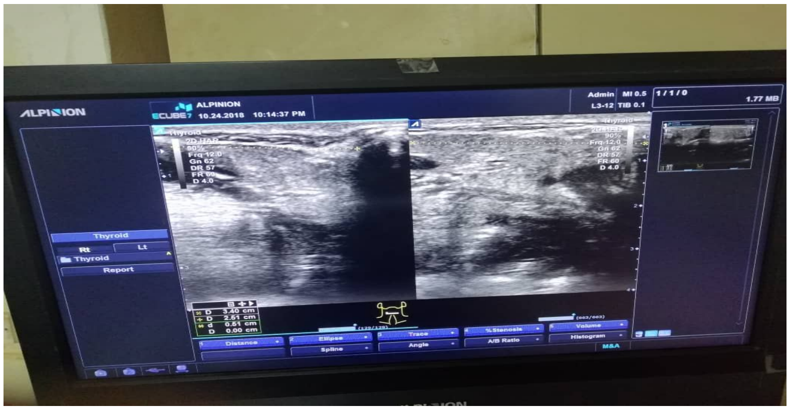
Appendices: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Data sheet

Patient data				Image data								
				normal				abnormal				
No	age	sex	duration	size	texture	echogenicity	vascularity	size	texture	echogenicity	vascularity	Other pathological changes.
1												
2												
3												
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