ORIGINAL ARTICLE

Scintigraphy in prediction of the submandibular salivary gland function after chorda tympani damage

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Abstract

Background and Purpose: The nerve supply to the submandibular glands is via the facial nerve, specially the chorda tympani transmitting afferent sensory and efferent secretory impulses. The aim of this study is to assess the result of chorda tympani damage during middle ear surgery on submandibular gland function using dynamic scintigraphy by comparing between a denervated submandibular gland with the contra-lateral normal side in patients with unilateral chorda tympani damage. **Patients and Methods:** 19 patients (11 women and 8men) mean age of (49.6±9.8) years with proven chorda tympani damage during their previous middle ear surgery were included in the study. The time of chorda tympani damage ranged from (6 to 79) months mean of (50.9 ± 23.9) months. Our patients were grouped into two groups according to time of postoperative follow-up. Group I consisted of 10 patients with their follow-up period of 6 months or more. Group II consisted of 9 patients their follow-up was 60 months or more. Ultrasonographic measurement of the submandibular gland volume in (ml) was done and the results on both sides were compared to examine for glandular atrophy on the affected side. The perfusion ratio (PR), concentration ratio (CR) and stimulated excretion ratio (SER) were calculated scintigraphically and the results from the salivary gland on both sides were compared. **Results:** For submandibular glands, the mean perfusion ratio (PR), mean concentration ratio (CR) and mean stimulated excretion ratio (SER) were found to be [0.85, 0.90, and 0.91] respectively in group (I) and to be [0.78, 0.87, and 0.89] in group (II). All ratios resulted from decreased radioactivity accumulation on the affected side. Using B-mode ultrasonography, the glands on the contralateral, non operated side were found to be significantly ($P< 0.05$) greater than the ipsilateral, denervated glands as regard the volume in group (II), While, no significant increase in volume of the non-denervated gland were encountered in group (I). **Conclusion:** Chorda tympani damage negatively affects the function of the ipsilateral submandibular gland despite the absence of atrophy. Dynamic submandibular gland scintigraphy is a practical and valuable method of disclosing the decreased capacity of perfusion, concentration and secretion in unilateral neurological denervation. Using B-mode ultrasonography , the late (>60 months) results of chorda tympani damage on submandibular gland were significant for increase in the volume of the contralateral, non denervated gland . An atrophing effect was not ascertained in the submandibular glands denervated parasympathetically due to section of the chorda tympani. Elderly and patient scheduled for radiotherapy for Head and Neck cancer, whom chorda tympani was previously damaged must be dealt with, cautiously.

Key words: submandibular gland, Chorda tympani damage, dynamic scintigraphy

Introduction

The paired submandibular glands (or sub-maxillary glands) are located beneath the floor of the mouth. Lying superior to the , each submandibular gland is divided into superficial and deep lobes, which are separated by the[1]. The secretors cells of the submandibular gland have distinct functions. In particular, the serous cells produce salivary , which aids in the breakdown of in the mouth. Mucous cells secrete which aids in the lubrication of the food as it travels through the . The mucous cells are the most active and therefore the major product of the submandibular glands is saliva. The submandibular gland's highly active acini account for approximately 70% of salivary volume.

Their secretions, like the secretions of other salivary glands, are regulated directly by the and indirectly by the . Parasympathetic innervations to the submandibular glands is provided by the via the , a branch of the that synapses in the . Increased parasympathetic activity promotes the secretion of saliva. The sympathetic nervous system regulates submandibular secretions through of the arteries that supply it[1]. The chorda tympani is vulnerable during pathological conditions of the middle ear and is in danger of being sectioned during otological surgery[2,3]. Submandibular gland scintigraphy has been used in peripheral facial nerve paralysis to predict prognosis and has been found as a reliable indicator in the early symptomatic period[4]. Thus, it is worth investigating the scintigraphic changes in submandibular gland after chorda tympani damage.

Dynamic scintigraphy relies upon the acquisition of images throughout the period of the scan reflecting perfusion, concentration, activation and secretion of submandibular gland. The uptake and secretion of Tc 99-m by the submandibular gland correlates with salivary flow rates[5]. Atrophy in the parasympathetic denervated glands was not ascertained due to the section of the chorda tympani[6, 7]. Our aim was to compare the scintigraphic results of denervated submandibular gland with the contra-lateral normal side in the patient with unilateral chorda tympani damage.

Patients and Methods:

Our study was done on 19 patients with proven chorda tympani damage during their previous middle ear surgery in Otorhinolaryngology department, and radiological assessment was done at Radiology Department in Ain Shams University Hospitals from January 2007 to December 2009. The study was approved by the local ethical committee. Patients were included in the study, only if they had a healthy contra-lateral ear. These patients were clinically and biochemically euthyroid and had no recent history of any disease of either the salivary gland or the thyroid. None of them had complained of mouth dryness nor was taking any prescribed medication that interfered with salivation. They had neither rapid Tc-99 m pertechnetate nor concentration of the tracer in the thyroid gland. None of the women were pregnant. The study group consisted of (19) patients; (11 females and 8 males), their age ranged from 37 to 70 years, mean (49.6±9.8). At the affected side the chorda tympani was damaged as a result of middle-ear surgery. The pathology of the 19 patients was extensive middle-ear and mastoid cholesteatoma. The follow-up period ranged from (6 to 79) months after surgery mean (50.9 ± 23.9) months.

We divided our patients into two groups: Group I: those 6 months or more post surgery. It consisted of 10 patients (6 females and 4 males) their age ranged from 37 to 53 years, mean (43.4±5.3). Group II: those 60 months or more postoperative. It consisted of 9 patients (5 female and 4 male). Their age was ranged 47 and 70 years, mean (57.4 ±7.7). All the patients, on their examination day, had singed an informed consent for submandibular B-mode ultrasonography and dynamic Tc-99m pertechnetate salivary glands scintigraphy.

Submandibular gland ultrasonography:

The submandibular glands were scanned at an angle that enabled maximum possible visualization of the glandular tissue using General Electric US machine (GE logic 900). A small-parts US transducer (12-MHz broadband probe) was used. The duration of the examination was 15 minutes. The submandibular glands were examined in the axial, longitudinal, and oblique planes. The evaluated US features were the texture, size and volume of the affected gland.

The software of the US device used included a feature to calculate the volume in milliliters (mL) based on the measured dimensions [the anterior-posterior, the longitudinal (length), and the lateral –medial width in millimeters].

Scintigraphy:

Dynamic Tc-99m pertechnetate salivary gland scintigarphy was carried out after at least three hours of fasting. Patients were laid in the supine position and the head was fixed slightly in an extended position during the imaging. 370 MBq Tc-99m pertechnetate was injected intravenously to study the kinetics of the function of the submandibular glands. Scanning was performed using Sopha gamma camera equipped with a low energy, high resolution, parallel-hole collimator, with energy centered on 140 keV and with a 20 per cent window.

The images were digitally recorded in a 64 x 64 matrix frame with X2.19 zoom. Salivary gland images were acquired sequentially one frame every 60 seconds for 40 minutes. Salivary secretion was stimulated with 4 ml of pure lemon juice 25 minutes after injection. Region of interest (ROIs) were selected manually in the submandibular glands. The background ROIs were set on the orbital region. The mean count per pixel for each salivary gland with background correction was calculated for every frame. Then, the time activity curves of the salivary glands were generated. As Tc-99 m pertechnetate scintigraphy patterns are variable even in normal population, each patient's normal side served as a control; accordingly the ratio of perfusion (PR), the ratio of the concentration (CR) and the ratio of stimulated excretion (SER) of the affected side to normal side were evaluated as functional parameters for further data analysis.

The perfusion ratio (PR) was found comparing the first images. The numbers were directly related to the perfusion of the glands. The formula was the mean count with background correction in the affected gland/ mean count with background correction in the normal gland. *The concentration ratio (CR)* reflected the mean count at the 10^{th} minute in the affected salivary gland/mean count 10^{th} minute in the normal salivary gland. *The stimulated excretion ratio (SER)* was seen after lemon juice stimulation. It was calculated by a comparison of the results of the salivary glands on opposite sides. The formula was [(mean counts at the 25^{th} minute in the ROIs) – (mean counts at the 35^{th} minute in the ROIs)] / (mean counts at the 25^{th} minute in the ROIs).

RESULTS:

In the submandibular glands, all the ratios were less on the affected side. Quantitative glandular scintigraphic parameters found between the affected side and unaffected sides are shown in Table 1.

	N. of patients		Mean Perfusion ratio (PR)		Mean Concentration ratio (CR)	Mean Stimulated excretion ratio (SER)
Group I	10	2.64/3.09	0.85	150/167	0. 90	0.91
Group II	9	3.36/4.27	0.78	140/160	0.87	0.89

Table 1: Quantitative glandular scintigraphic parameters found between the affected and the unaffected side.

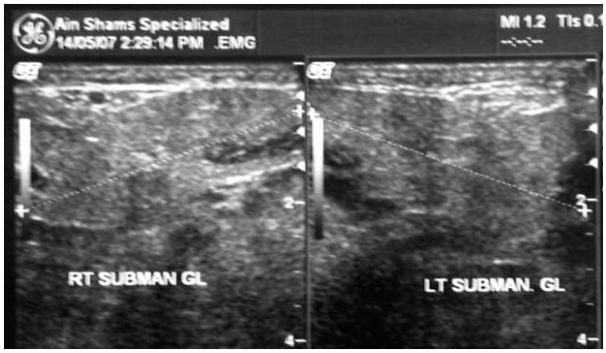

Figure 1: B-mode ultrasonography of both submandibular glands of 53 years old male patient with chorda tympani damage on right side 67 months after surgery, the US evaluation shows increase in size of left (normal) submnadibular gland [8ml] when compared to the right (denervated) one[5.5ml].

Mean count in the affected gland at first minute after background correction was (2.64) and (3.36) in Group I and II respectively compared to (3.09) and (4.27) in normal gland. Thus, the PR was (2.64/3.096) and (3.36/4.27) equal to (0.85) and (0.78) respectively. Mean count in the affected gland at the 10th minute was (150) and (140) compared to (167) and (160) in normal gland. Thus, the CR calculated by dividing (150/ 167) and (140/ 160). Using B-mode ultrasonography there was significant ($P<0.05$) increase in the volume of non denervated (normal) submandibular gland of the 9 patients included in Group II when compared with the denervated submandibular gland of the same patients .On the other hand, there was no significant changes could be detected between both glands in Group I .

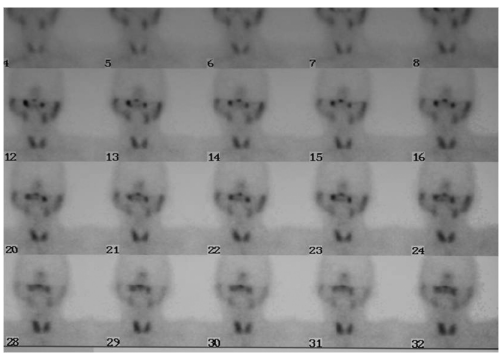

Figure 2: Dynamic salivary gland scintigraphy images of a 60 years old male patient with chorda tympani damage on right side 17 months after surgery. Frame number 5 represents the 10th minute of concentration of salivary glands. The 13th frame (26th minute) is the image taken just after stimulation with lemon juice. The 21th frame is after the measurement of SER. In these frames, right submandibular hypofunction is obvious compared to the left one.

DISCUSSION:

The integrity of the parasympathetic division of the facial nerve is crucial for submandibular gland function. In any condition affecting the chorda tympani, salivary flow from the cannulated submandibular gland can be measured, but it requires a special armamentarium and training. The test is also uncomfortable for patients. The salivary flow test is sometimes inaccurate. Because of edema of the ducts, repeat tests cannot be performed immediately[4]. In contrast, dynamic submandibular gland scintigraphy is easy to perform with minimal discomfort for the patient. It is accepted as a minimally invasive method, since the whole dose of radioactivity for the four major salivary glands approximates the dose of three consecutive skull radiograms[5]. Despite almost 40 years of investigation of normal quantitative results of scintigraphic patterns, the high degree of variability of indices impairs the capability of submandibular gland scintigraphy in the establishment of the normal reference limits[6].

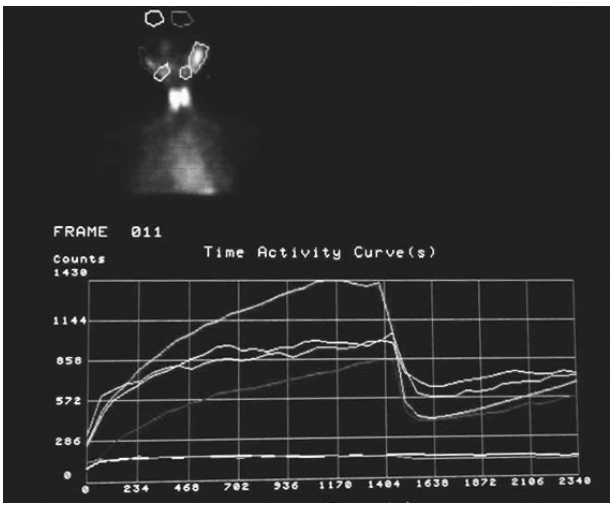

Figure 3: Time activity curves in a 42 years old female patient 6 months after surgery on the left ear. The denervated left submandibular gland is represented by the blue curve which shows lower activity compared to the contralateral (right) submandibular gland which is represented by yellow curve.

The benefit of using submandibular gland scintigraphy in unilateral disease is to obtain a comparison with the normal side between anatomical, physiological and pathological information[7]. While the affected side showed normal volume; contra-lateral, non-denervated submandibular glands were found to be hypertrophied. This hypertrophying effect had been seen as a late sequel of the chorda tympani damage[8]. Increase in the size of the non- denervated gland was seen only in group II (Figure1) of patients while patients in group I did not show any increase in size of the non-denervated submandibular gland. Comparable results were found by Miman et al[8]. The scintigraphic parameters that we used in our study were the same parameters used by Aung et al, to demonstrate the function of the submandibular gland[9].

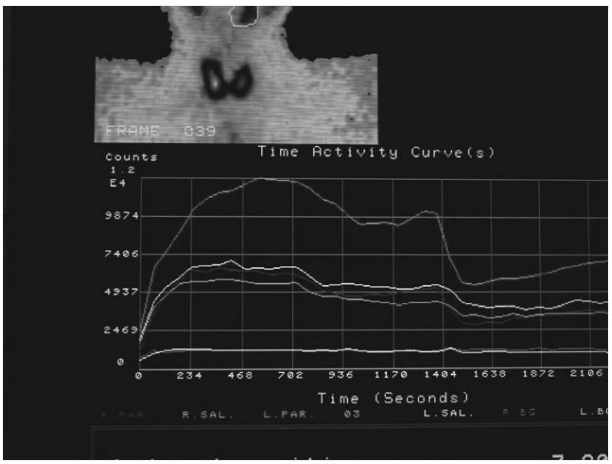

Figure 4: Time activity curves in 70 years old male patient 60 months after surgeryon the right ear. The denervated right submandibular gland is represented by the yellow curve which shows the lowest activity compared to the contralateral healthy submandibular gland which is represented by white curve.

The ability of the gland to take up radioactivity reveals a normal functioning parenchyma. The mean PR for our study was (0.85) and (0.78) for group (I) and (II) respectively, indicating that the parenchyma function of the denervated submandibular glands was affected. The maximal count of the gland shows its concentrating ability. The concentration ratio (CR) was (0. 90) and (0.87) for group (I) and (II) respectively, was also found to be decreased in our study. Finally, if a gland fails to respond to stimulation, this indicates a gross neurological impairment as in our study (SER) was (0.91) and (0.89) for group (I) and (II) respectively (Figures 2, 3, 4).

To predict the bad prognosis of facial paralysis, Taki et al. have used less than 0.8 criteria for CR and SER showing an unrecoverable neurological condition[4]. Despite the absence of explanation of choosing this criterion in their study, our results have fallen in that limit in the group (II) only while; the CR and SER were higher than 0.8 in group (I). This suggests that the submandibular gland dysfunction is proportional to the time of postoperative follow-up.

Taki et al, study also had demonstrated the comparable value of submandibular gland scintigraphy with electro-neurography in the prognosis of peripheral facial paralysis in the early period[4]. They have found that SER was more reliable, featuring an excellent positive predictive value. If both CR and SER were less than 0.8 within 14 days after the onset of the paralysis, none of the patients showed complete recovery suggesting that these criteria were reliable.

Yagmur et al, results support the conclusion of Taki et al, showing all these parameters to be less 0.8 on submandibular glands[4,7]. In agreement to the conclusion of Yagmur et al, that the accuracy and reliability of the results obtained on submandibular glands in chorda tympani damage was confirmed especially the significant submandibular gland functional loss on the affected side[7].

The most valuable role of salivary gland scintigraphy is in comparing a diseased side to the contra-lateral normal functioning side[12]. But the application of salivary scintigraphy to normal subjects discloses a high degree of inter-individual variability in the frequency and magnitude of salivary secretion[6]. Because of the compensation for the decreased function of the denervated submandibular gland by the contra- lateral partner, the side effects of chorda tympani damage are commonly underestimated. But the important functions of saliva should not be ignored.

Malpani et al, discussed newly investigated functions of the saliva[10,13]. Beside the well known function of maintenance of oral hygiene, bolus formation and secretion of digestive enzymes, a recent report showed evidence of an esophago-protective, neuro-endocrine, and neuro-immunomodulator role of the saliva. The compensated volume of contra-lateral gland saliva may be sufficient to maintain the digestive function, but it is not yet known whether this volume is sufficient for these newly suggested roles of the saliva.

Submandibular salivary glands, like many other organs, undergo changes with age. The gland parenchyma is atrophic in aged individuals and shows morphological alterations, changes in the acinar cell organelles and a reduction in the proportional volume of acini[14-17]. Total saliva shows a decrease, and the level of secretor granules in submandibular salivary glands also decreases with age[18,19]. Age-related decreases in flow rates of saliva have been observed by Percival et al,[20]. In addition, decreased saliva production is common among elderly people[21].

So we can argue that patient's who had a unilateral damage to the chorda tympani during ear surgery especially when young, face an incremental decrease in salivary gland function with age. This may be detrimental to their health especially for example if they will have any sort of radiation therapy to the head and neck later in life with the increasing incidence of upper aero-digestive tract cancers and the increased use of radiotherapy[10,13,22,23]. Thus it should be worthwhile to know if the patient who is going to receive radiotherapy to the head and neck had undergone previous ear surgery in which case they will be more prone to xerostomia, diminished salivary secretion and all its deleterious effects. Those patients can be scheduled to a major strategy in order to prevent complications of radiotherapy.

Newer techniques including three-dimensional planning and intensity-modulated radiation, where the dosage can be varied across the treatment volume, aim to spare the normal tissues including the salivary glands. In very specific cases, such as head and neck cancers with N0 neck nodes involved where only one side of the neck is being irradiated, a submandibular gland can be surgically transferred to a shielded area in the submental space to protect it from the radiation[24].

In conclusion, chorda tympani damage negatively affects the function of the ipsilateral submandibular gland despite the absence of atrophy. Elderly and patient scheduled for radiotherapy for Head and Neck cancer, whom chorda tympani was previously damaged must be dealt with, cautiously. Dynamic salivary gland scintigraphy is a practical and valuable method of disclosing the decreased capacity of perfusion, concentration and secretor function in unilateral neurological deprivation. Using B-mode ultrasonography the late (>60months) results of chorda tympani damage on submandibular gland were significant for increase in the volume of the contra-lateral, non denerveted gland. An atrophying effect was not ascertained in the submandibular glands denervated para-sympathetically due to section of the chorda tympani.

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