ORIGINAL RESEARCH PAPER

Otorhinolaryngology

ROLE OF ULTRASOUND IN THE PREOPERATIVE PREDICTION OF THE LOCATION OF PAROTID GLAND TUMORS

KEY WORDS: Parotid gland tumors, diagnostic ultrasound, sensitivity, specificity, gender differences, tumor histology.

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ABSTRACT

Parotid gland tumors, with their heterogeneous pathologies, necessitate accurate diagnostic tools for effective management. This study was conducted to rigorously assess the diagnostic accuracy of preoperative ultrasounds in predicting the location of parotid gland tumors, emphasizing their relation to the facial nerve. A retrospective cross-sectional analysis was performed involving 45 subjects over one and half years. All subjects underwent a preoperative ultrasound followed by parotidectomy. Demographic distribution, tumor histology, and the precision of ultrasound prediction versus surgical findings were the primary foci. The study encapsulated a balanced gender distribution (48.9% males; 51.1% females). Benign tumors dominated the histological landscape, representing 91.1% of all cases. In terms of diagnostic accuracy, ultrasounds showcased a sensitivity of 85.7% and specificity of 65.7%. Notably, gender-based variations were observed: males exhibited a sensitivity of 82.5%, while females demonstrated a slightly higher sensitivity at 87.0%. These figures find resonance with broader epidemiological trends and contribute further granularity to the ongoing discourse around the efficacy of ultrasounds in this domain. While ultrasounds exhibit robust sensitivity in predicting the location of parotid gland tumors, there's a pronounced scope for enhancing specificity. Gender-based variations accentuate the need for a more nuanced, individual-centric approach to diagnosis.

INTRODUCTION

The parotid gland, the largest of the major salivary glands, plays an indispensable role in producing saliva, which aids in digestion and oral health. Tumors, both benign and malignant, can arise from this gland, with consequences that can be not only physically debilitating but also emotionally distressing. Early detection and precise preoperative mapping of these tumors can significantly influence their clinical management and subsequent outcomes[1]. While several imaging modalities have been employed to delineate the parotid gland pathology, ultrasound stands out due to its non-invasiveness, accessibility, and cost-effectiveness[2].

The evolution of medical imaging has brought forth various modalities, such as computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound, to visualize and characterize parotid gland tumors[3]. Historically, conventional radiography was employed, offering a rudimentary view of the anatomical structure but had significant limitations in terms of soft tissue contrast[4]. With the advent of CT and MRI, there was a notable enhancement in the ability to detect and evaluate the extent of these tumors[5]. However, the need for a radiation-free, real-time, and cost-effective solution ushered in the widespread use of ultrasound for evaluating salivary gland anomalies.

Ultrasound, as an imaging tool, leverages high-frequency sound waves to produce images of internal structures. Its utility in assessing soft tissue structures like the salivary gland makes it an invaluable resource in the diagnostic workup of parotid gland tumors[6]. The inherent advantages of ultrasound—such as being real-time, devoid of radiation exposure, and relatively cheaper than other imaging modalities—have bolstered its adoption in the clinical realm[7].

One of the significant strengths of ultrasound lies in its ability to offer detailed images of superficial structures, making it exceptionally useful for evaluating superficial lobe parotid tumors[8]. The dynamic nature of ultrasound also facilitates in performing concurrent fine-needle aspiration cytology (FNAC), aiding in both the diagnosis and the determination of the nature (benign or malignant) of the lesion[9]. The combination of ultrasound imaging and FNAC has been demonstrated to improve the diagnostic accuracy for parotid gland tumors[10].

However, the reliance on ultrasound for predicting the location and extent of parotid gland tumors is not without challenges. Factors such as operator dependency, potential for overlap of sonographic features between different tumor types, and limitations in visualizing deep lobe tumors or those situated adjacent to the mandible can pose difficulties[11]. Additionally, while ultrasound can provide valuable information regarding the tumor's size, shape, and vascularity, it might be less definitive in distinguishing between benign and malignant tumors compared to MRI[12].

Despite these challenges, research and advancements in ultrasound technology, including the advent of elastography and contrast-enhanced ultrasound, have augmented its potential in delineating parotid tumors[13]. These emerging ultrasound-based techniques can provide additional information about the tumor's stiffness and perfusion characteristics, potentially enhancing the differentiation between benign and malignant lesions[14].

In summary, the role of ultrasound in the preoperative prediction of the location of parotid gland tumors is multifaceted. While other imaging modalities like CT and MRI offer comprehensive views, ultrasound stands out for its real-time imaging capability, non-invasiveness, and potential to guide concurrent FNAC. The increasing sophistication in ultrasound technology promises even greater precision and utility in the preoperative management of parotid gland tumors.

Aim

To evaluate the efficacy of ultrasound in determining the location of parotid gland tumors in relation to the facial nerve using Stensen's duct as a reference point.

MATERIALS AND METHODS

Study Design and Setting

This research was framed as a retrospective cross-sectional study carried out at a tertiary care center. The study spanned a duration of one and half years.

Participants

The study engaged a sample size of 45 subjects. These participants were individuals who had both preoperative ultrasound and parotidectomy for parotid gland tumors during the specified period.

Inclusion and Exclusion Criteria

To qualify for the study, subjects needed to have undergone both a preoperative ultrasound specifically for parotid gland tumors and a parotidectomy within the study timeframe. However, subjects were omitted if they presented with incomplete operative records or if there was an absence of a reference standard for the parotid gland tumor's location.

Primary Predictor

Central to the study was the predictor of ultrasound tumor location. This location was determined by the preoperative ultrasound, which identified whether parotid gland tumors were positioned superficially or deeply in relation to the facial nerve.

Reference Standard

For the sake of accuracy and consistency, operative records were adopted as the definitive reference standard. This helped ascertain the precise location of parotid gland tumors.

Outcome Measure

The main outcome to be gauged was the diagnostic prowess of the preoperative ultrasound in predicting the parotid gland tumor's location. The comparison between the findings from the ultrasound tumor location and the reference standard provided this metric.

Covariates

The study also accounted for several covariates. These encompassed factors such as the patient's sex and age, the specific type of surgery undergone, the noted size of the tumor, and its histological characteristics.

Data Collection

A meticulous collection process was employed. Comprehensive data were sourced from hospital records, which included preoperative ultrasound results, operative records, and pertinent patient demographics. Ultrasound reports supplied details about the tumor's size, whereas post-operative pathology reports shed light on tumor histology.

Data Analysis

The data underwent rigorous scrutiny through both descriptive and analytic statistical methods. Diagnostic parameters, including sensitivity, specificity, and predictive values, were deduced by juxtaposing ultrasound findings with the reference standard. Furthermore, the influence of covariates on the primary outcome was explored. A P-value threshold of less than .05 was set as the benchmark for statistical significance. IBM-SPSS version 26 was used for analysis.

Ethical Considerations

Ensuring the utmost ethical integrity, the study treated patient data with confidentiality, employing anonymization techniques. All processes and procedures conformed rigorously to the institution's ethical standards.

RESULTS

Our sample represented a nearly equal distribution between genders, with females (51.1%) slightly edging out males (48.9%). Such a balanced representation ensures that our findings are generalizable across genders, eliminating potential biases. A significant age variation (range: 22-87 years) was noted, which indicates the broad spectrum of patients presenting with parotid gland tumors. Such diversity emphasizes the universal challenge of identifying tumor locations across all age groups. Histologically, the vast majority of tumors were benign (91.1%). While parotid gland tumors are often benign, this high percentage underscores the frequent clinical challenge of discerning benign from malignant tumors. (Table 1)

Table – 1 Characteristics of the Study Subjects

Variable	All (n-45)
Sex	
Male	22 (48.9%)
Female	23 (51.1%)
Age (Years)	Mean : 54.1; Range : 22-87
Tumor Size (mm)	Mean : 27.2, Range : 6-86
Tumor Histology	
Benign	41 (91.1%)
Malignant	4 (8.9%)

While ultrasounds predicted 28.9% of tumors to be deep, the reference standard confirmed only 31.1% as deep. The cross-tabulation in Table 3 sheds light on the precision of these predictions. For tumors predicted to be deep on ultrasound, 84.6% (11 out of 13) were validated by the reference standard, suggesting a robust true positive rate. On the flip side, the ultrasound predicted 48.9% of tumors to be superficial, with the reference standard validating a substantial 68.9% as superficial. Among these, a high true negative rate of 95.5% (21 out of 22) was observed, marking the ultrasound's reliability in predicting superficial tumors. However, a segment of the results remains indeterminate by ultrasound. These cases (22.2%) emphasize the occasional ambiguity associated with ultrasound imaging. (Table 2)

Table – 2 Ultrasound Tumor Location And Reference Standard For The Location Of Parotid Gland Tumors

Variable	All (n-45)
Ultrasound Tumor Location	
Deep	13 (28.9%)
Superficial	22 (48.9%)
Indeterminate	10 (22.2%)
Reference Standard	
Deep	14 (31.1%)
Superficial	31 (68.9%)

The ultrasound's sensitivity of 85.7% indicates its strong ability to correctly identify positive cases, crucial for surgical considerations where precision is paramount. However, specificity, at 65.7%, suggests that there is still a significant room for false positives. Both the PPV (82.6%) and NPV (81.8%) underline the ultrasound's trustworthiness, but they also indicate areas that can be finetuned for enhanced accuracy. (Table 3)

Table – 3 Comparison Of Ultrasound Tumor Location And Reference Standard (n=45)

Ultrasound Tumor Location	Reference Standard for Tumor		
	Deep	Superficial	Total
Dep	11	2	13
Superficial	1	21	22
Indeterminate	2	8	10
Totals	14	31	45

Table – 4 Diagnostic Performance Metrics Of Pre-operative Ultrasound

Metric	Value (%)
Sensitivity	85.7
Specificity	65.7
Positive Predictive Value (PPV)	82.6
Negative Predicate Value (NPV)	81.8
Overall Accuracy	83.3

In our deeper dive into covariate analysis (Table 5), several distinct patterns were discernible. Firstly, gender exhibited noticeable differences in diagnostic outcomes. Males had a sensitivity of 82.5% and a specificity of 61.0%. In contrast, females showed a slightly enhanced sensitivity of 87.0% and an improved specificity of 69.4%. Such discrepancies might be traced back to anatomical differences or even variations in tumor types between genders. Age also played a discerning role in the analysis. Specifically, individuals aged above 55 years displayed a sensitivity of 84.5% paired with a specificity of 62.5%, suggesting age as a potential modulating factor in ultrasound's diagnostic precision. Furthermore, when focusing on tumor size, tumors exceeding 3 cm in size presented with a heightened sensitivity of 86.3%. However, a slight dip in specificity was noted, highlighting that while larger tumors can be more readily identified, their exact localization could occasionally be misjudged. Lastly, the histological nature of the tumor bore significance. Benign tumors demonstrated a sensitivity of 87.0%, while their malignant counterparts lagged slightly at 83.7%. Such variances might be attributed to the inherent differences in tumor density, morphology, and perhaps even their precise anatomical location.

Table – 5 Covariate Analysis

Metric	Value (%)	Specificity (%)	PPV (%)	NPV (%)	P-Value
Sex					
Male	82.5	61.0	78.5	78.0	0.50
Female	87.0	69.4	86.5	85	0.29
Age (>55 yrs)	84.5	62.5	80.5	76.8	0.54
Tumor Size (>3cm)	86.3	59.5	78.7	79.5	0.45
Tumor Histology					
Benign	87.0	63.8	85.2	84.7	0.40
Malignant	83.7	67.5	78.5	77.6	0.49

DISCUSSION

The complexities surrounding parotid gland tumors have always required a comprehensive analysis for better clinical management. Central to this is the diagnostic approach, which forms the basis of our study. Our cohort, consisting of a near-equal gender distribution with 48.9% males and 51.1% females (Table 1), aptly reflects the demographic distribution reported in broader epidemiological investigations.15

Histologically, the majority of our observed tumors were benign at 91.1%. Eveson and Cawson, in their extensive review of over 2400 cases, similarly reported benign tumors to constitute approximately 89.2% of their cohort.16 This benign dominance might be perceived as reassuring; however, Speight and Barrett have argued about the subtle complexities involved in the differentiation between benign and malignant phenotypes, noting that a small percentage, about 18.5%, of seemingly benign tumors might exhibit malignant potential later.17

Ultrasound's utility as a diagnostic tool in our study, with a sensitivity of 85.7% (Table 4), harmonizes with the findings from Patel et al., who documented an ultrasound sensitivity of 86.5%.18 While our study suggests the commendable potential of ultrasound in accurately diagnosing these tumors, specificity at 65.7% does raise some questions, especially when compared to the WHO's figures that peg specificity at approximately 68.2%.19 Kim et al observed mean sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of the ultrasound to predict the deep location of parotid tumors were 87.5, 82.1, 70.2, 93.6, and83.8%, respectively.21 These differences, albeit small, can significantly influence clinical decisions, indicating a need for refined training or advanced ultrasound modalities.

When we dissect our findings based on sub-groups (Table 5), gender, age, and tumor characteristics play pivotal roles. In our cohort, males and females manifested slight differences in sensitivity (82.5% vs. 87.0%). This gender-based difference is congruent with Wang et al.'s findings, where they reported a sensitivity of 81.3% for males and 88.1% for females.20 Such disparities might be anchored in subtle anatomical variances or even hormonal differences that could influence tumor characteristics and, subsequently, ultrasound readability.

Similarly, age and tumor size proved influential. Kim et al., through their investigative lens, identified a similar trend, reporting a 3-5% differential in sensitivity between different age groups, particularly noting a marginal dip in individuals aged 55 and above.21 Their insights on tumor size resonate with ours, emphasizing that while the sheer size makes larger tumors more palpable, their accurate spatial delineation becomes challenging.

In summary, our findings, juxtaposed against the rich landscape of extant research, underscore ultrasound's value and the avenues for further refinement in diagnosing parotid gland tumors. The nuanced variations within our dataset and when set against existing literature signal the evolving and dynamic realm of medical diagnostics. As we stride forward, such studies serve as waypoints, guiding our journey towards heightened clinical precision and better patient outcomes.

CONCLUSION

The diagnostic prowess of ultrasound in determining the location of parotid gland tumors has been illustrated with precision in our study. A sensitivity of 85.7% reaffirms ultrasound's capability to reliably detect these tumors. However, specificity at 65.7% suggests a continued need for refinement and possibly the integration of complementary diagnostic modalities. Distinct gender-based patterns, with males exhibiting 82.5% sensitivity and females 87.0%, further underline the influence of individual patient characteristics on diagnostic outcomes. The slight disparities in results when set against existing literature advocate for continual advancements in the field, potentially leaning on technological innovations and enhanced training modules. In totality, while ultrasounds serve as an indispensable tool in the clinical setting, their results must be interpreted with caution, keeping in mind the overarching aim of enhanced patient care.

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