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Lymphadenopathy: What Defines a Palpable Lymph Node?

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Abstract

Background: The threshold size required to detect lymphadenopathy via palpation has never been formally determined. This study sought to determine the threshold, sensitivity, and error of node palpation and how this changes with experience.

Methods: Lymphadenopathy models were created using poly-vinyl alcohol cryogel to mimic tissue tactility. Node diameter ranged 0.5cm to 4cm. Study subjects were medical students, otolaryngology residents, and otolaryngology consultants. Each subject provided 22 estimates of size. Primary outcomes were the sensitivity, error (true - estimated size), and threshold of palpation.

Results: Thirty subjects completed the study. Sensitivity was 60%, 74%, and 86% for students, residents, and consultants, respectively ($p<0.01$). Error was 0.88cm, 0.61cm, and 0.57cm, respectively ($p<0.05$). Palpation threshold was 1.32cm, 0.83cm, and 0.75cm, respectively ($p<0.05$). All participants detected nodes ≥ 2 cm, while consultants detected nodes ≥ 1 cm.

Conclusions: Experience is associated with decreased palpation threshold and error, and increased sensitivity. Educational interventions should target nodes <2 cm.

Introduction

Palpation remains the primary, simplest, and universal method of evaluating head and neck lymphadenopathy. The sensitivity of palpation to detect of pathological nodes in head and neck cancer ranges from 60% to 82% across different clinical series.¹⁻⁵ This variance in sensitivity may be due to differences in examiner experience; however, the effect of experience on palpation has never been objectively quantified.

In 1990, Watkinson et. al. studied palpation of rabbit tumors and found that sensitivity did not change with clinical experience, suggesting individuals have an inherent and fixed palpation ability that does not improve with practice.⁶ They also found that the diameter required for nodes to be reliability detected (i.e. the threshold size of palpation) was 2 cm.⁶ However, the findings from this study were based on a small sample (n=6) and no study since has reevaluated these findings.

Two studies analyzed the effect of experience on the accuracy of palpation at estimating node size (i.e. error of size estimation). In 2001, Alderson et. al. used models made from hearing mould material and found that error did not change with clinical experience, suggesting that clinicians lack the necessary feedback following clinical encounters to inform improvement.⁷ In contrast, Bartlett et. al. in 2009 used cadaver models with clay nodes and found that palpation error decreased with experience.⁸ Neither of these studies commented on sensitivity or threshold.

The present study sought to determine the effects of examiner experience on the sensitivity, estimation error, and threshold of lymph node palpation in the head and neck. To address these

objectives, standardized validated models of lymphadenopathy were created using poly-vinyl alcohol cryogel (PVA-C), a synthetic tissue-mimicking polymer.

Materials and Methods

Nine palpable low-fidelity models of the human neck were created, each measuring 14 x 8 x 6 cm with one centrally located spherical lymph node embedded 3 cm below the surface (Figure 1). Node diameters were 0.5 cm, 0.75 cm, 1 cm, 1.25 cm, 1.5 cm, 2 cm, 2.5 cm, 3 cm, and 4 cm. Two controls without nodes were also created. A thin layer of nylon mesh was wrapped externally to simulate superficial skin. Models were constructed using poly-vinyl alcohol cryogel (PVA-C), a nontoxic synthetic polymer with tissue-mimicking mechanical properties.^{9,10} Construction methods were based on previously published and validated techniques.¹⁰ In brief, 99% hydrolyzed PVA powder was dissolved in deionized water and the resultant hydrogel was injected into moulds and temperature cycled in an environmental chamber. We followed previously established PVA-C formulations to create the different stiffness between soft tissue and lymph nodes.¹¹

Study participants were medical students, otolaryngology residents, and board-certified otolaryngology consultants recruited from the University of Western Ontario (Table 1). Participation was voluntary and the study was conducted on an individual and confidential basis. No advance preparation was possible. Each participant was asked to palpate all eleven models (including controls) in a pre-determined randomized order. If they detected a node, they provided an estimate of node diameter to the closest tenth of a centimeter. Specific instructions were provided to only palpate the top of each model without lifting it from the underlying surface. A study investigator, was blinded to the node size, was present to ensure instructions were

followed. Once all models were palpated, the participants provided repeat estimates with the models rearranged in a second randomized order. At the end of the study, participants were asked to rate the realism of the models using a 7-point Likert scale, where a rating of 1 represented “Strongly Disagree” and 7 represented “Strong Agree”.

Primary outcome measures were the sensitivity, estimate error, and threshold of palpation. Secondary outcome measures were palpation specificity, retest reliability, and perceived model realism. Sensitivity is defined as the percentage of instances when palpation correctly detected the presence of a node (true positive / true positive + false negatives), while specificity is the percentage of instances when palpation correctly identified the absence of a node (true negative / true negative + false positives). Estimate error is defined as the absolute value of the true node diameter minus the estimated diameter (Error of Estimate = |True – Estimate|). Threshold of palpation is defined as the smallest node diameter reliably palpated by all examiners (i.e. smallest node where sensitivity = 100%). Retest reliability was measured by correlation of the repeated intraobserver estimates for the same node.

Differences in sensitivity and specificity between groups were statistically compared using the Fisher's Exact Test. Differences in palpation error and perceived realism were statistically compared using one-way analysis of variance (ANOVA). Intra-observer reliability between first and second estimates was analyzed using Pearson's *r* correlation. All analyses were conducted using SPSS version 15.0 (SPSS Inc, Chicago, IL).

This project was reviewed and approved by the Clinical Research Impact Committee of the Lawson Health Research Institute Research Ethics board (REB#: 18258E).

Results

Participants

A total of 30 volunteers participated in the study and 660 estimates were collected. Group sizes and demographics are summarized in Table 2.

Sensitivity

The overall sensitivity of palpation by experience level is shown in Figure 2. These data represent both the primary and retest estimates collected for all nine node-containing models. Sensitivity of palpation significantly correlated with examiner experience and was 52% for pre-clinical students, 69% for clinical clerks, 70% for junior residents, 78% for senior residents, and 86% for consultants ($p < 0.01$).

Estimation Error

Overall error of estimation for all tested nodes decreased with examiner experience as shown in Figure 3. The mean error of estimation was 0.97 cm for pre-clinical students, 0.78 cm for clinical clerks, 0.65 cm for junior residents, 0.57 cm for senior residents, and 0.57 cm for consultants ($p < 0.01$).

The decrease in error with experience is also reflected in the range of estimates provided by each group, which decreased with experience (Table 3). For example, for the 2.5 cm node, estimates of pre-clinical students ranged 6.5 cm while consultants ranged 1 cm (Figure 4).

Estimate range is provided only for nodes detected by all participant groups (i.e. 100% sensitivity). When averaged, the collective estimate of node diameter was similar among all groups (Table 3). All groups tended to underestimate the diameter of the node (Table 3).

Threshold of palpation

Regardless of experience, all participants detected nodes 2 cm and larger with 100% sensitivity, with the exception of one pre-clinical medical student who did not palpate the 2.5cm node (Figure 5). For nodes less than 2 cm, sensitivity decreased with diameter, from 68% for the 1.5 cm node to 15% for the 0.5 cm node. Senior residents had 100% sensitivity for the 1.5cm node, while otolaryngology consultants had 100% sensitivity for both the 1.25 cm and 1.5 cm nodes (Table 4).

Retest reliability

Intra-observer reliability was highly correlated between the first and second iterations of model palpation (Figure 6), $r=0.898$ ($p<0.001$).

Specificity of palpation

The overall specificity of palpation for all participants is 97.5% (Figure 7). There were no statistically significant differences in specificity between experience levels.

Perceived model realism

The statement “consistency of the neck mass feels realistic” scored a mean of 4.77 on the 7-point Likert scale for all participants, and the statement “the soft tissue surrounding the neck mass is realistic” scored 4.57 for all participants. There were no statistically significant differences in score between experience levels for neither statement.

Discussion

The ability to detect neck masses during routine physical examination is an essential skill in primary care. Furthermore, nodal staging of head and neck cancer depends on both the location and the longest diameter of pathological lymph nodes. The effectiveness of clinical staging can be improved by maximizing palpation sensitivity and minimizing estimation error to better detect and measure nodes. Variability in examiner skill, in addition to environmental disruptions and the doctor-patient interaction, contributes to clinical error in physical examination.⁷ In this study, we used a standardized model in a controlled setting to eliminate the latter variables to isolate the effects of examiner experience.

Previous studies have suggested that individuals possess an inherent palpation ability that does not improve with experience,⁶ or that clinicians lack necessary feedback following clinical encounters to inform skill improvement.⁷ Our study demonstrated that the sensitivity of palpation significantly increased with examiner experience. This was especially evident when comparing pre-clinical medical students, who were only able to palpate 52% of given nodes, to consultants, who were able to palpate 86% of the nodes (Figure 2). The threshold of palpable nodal size decreased with experience, with those more experienced able to detect smaller nodes not detected by those less experienced. For consultants, the threshold was 1.25 cm, while senior residents had a threshold of 1.5 cm, and all remaining groups had a threshold of 2 cm (Table 4). This

finding is in keeping with conventional knowledge that clinically occult nodes have diameters less than 1.5 cm.¹²

Estimation error of palpation also significantly improved with examiner experience, reflected both in the mean error and estimate range. Pre-clinical medical students gave the widest range of estimates with the highest error, while consultants had the narrowest range and lowest error (Table 3). On average, pre-clinical students were 0.97 cm off from the true diameter, while both consultants and senior residents were equally off by 0.57 cm (Figure 3). Interestingly, while individual error was greater for lower experience groups, their collective estimates approximated the true value equally as well as higher experience groups, demonstrating the *wisdom of the crowds* phenomenon. Similar to Alderson et. al., we also found that all groups tended to underestimate node diameter by about 0.5 cm less than the true value.⁷

The PVA-C formulations used to create our model were based on previously established methods to best simulate the tactile feel of a human neck. The high specificity of 97.5% indicated that the controls lacking nodes were reliably not detected as false positives. Participants judged the node models to be good approximations of what would be encountered in the clinical setting, agreeing with the statements that “the consistency of the neck mass feels realistic” and “the soft tissue surrounding the neck mass is realistic”. Nevertheless, our model was intended to be low-fidelity and does not simulate certain clinical presentations such as deep nodes, nodes against bone, or nodes in previously irradiated necks. In addition, the study may have caused participants to become more vigilant in their exam as compared to actual clinical encounters. Taken together, these biases may have led to overestimation of sensitivity and underestimation of estimation error and threshold. However, this would not have affected the relative differences found between the study groups. Another limitation of our study is the

relatively low sample sizes of participants, all recruited from a single mid-sized academic center. This should be taken into consideration before generalizing the results to other centers.

Maximizing sensitivity and minimizing estimation error can improve the effectiveness of clinical staging. Our results demonstrate that palpation of lymphadenopathy is a skill that progressively improves in these aspects with clinical experience. As such, educational interventions can be designed to augment what is learned with experience, and should target lymph nodes less than 2 cm in diameter. In this study, our model was able to demonstrate differences between five levels of training. With further validation, our model may potentially be used as an outcome measurement to assess future educational interventions, or be itself useful as a low-cost trainer for simulating palpation of pathological lymph nodes.

Conclusion

Detection and measurement of lymphadenopathy through palpation improves with clinical experience. Examiners with more experience had significantly higher sensitivity, lower estimate error, and were able to reliably palpate nodes with smaller diameters. For consultants, the threshold nodal diameter required for detection with 100% sensitivity was 1.25 centimeters.

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Figure Legends

Figure 1: Schematic of lymphadenopathy model

Figure 2: Overall sensitivity by experience

Figure 3: Mean estimation error by experience

Figure 4: Range of estimates by experience for the 2.5cm node

Figure 5: Overall sensitivity by node size

Figure 6: Initial and repeat estimates of all participants

Figure 7: Overall specificity of palpation for all participants