Axillary lymph nodes localization with on screen guided handheld ultrasound

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Purpose or Learning Objective:

Axillary lymph node (ALN) metastatic involvement is the most important predictor of survival and recurrence in breast cancer patients. Accurate assessment of ALN metastasis is crucial for staging and treating breast cancer [1]. The surgical approach to axillary staging and management in early-stage breast cancer has evolved from complete axillary dissection to sentinel ALN biopsy, aiming to reduce the significant morbidity associated with full axillary lymph node dissection [1,2].

More recently, conservative ALN management has advanced further, guided by findings from the American College of Surgeons Oncology Group (ACOSOG) Z0011 [1] and the Sentinel Node vs. Observation After Axillary Ultrasound (SOUND) [3] trials. Axillary ultrasound (AUS) is the primary imaging method for evaluating women with newly diagnosed breast cancer [1,4]. Additionally, the National Comprehensive Cancer Network (NCCN) guidelines now recommend axillary assessment with ultrasound as part of the routine workup for invasive breast cancer [1].

However, re-identifying abnormal ALNs during AUS exams, such as after neoadjuvant chemotherapy or at biopsy, can be challenging due to the nodes’ similar appearance, proximity, and mobility [5,6,7].

In this study, we aimed to evaluate the reproducibility of locating normal ALNs during AUS using on-screen guidance with real-time 3D mapping.

Methods or Background:

This prospective study was approved by the Institutional Review Board (IRB) at Dacia Clinic (Oak Park, IL, USA). Bilateral axillary ultrasound was performed on 20 female subjects (2021–2024) using a linear probe (6-18 MHz) following the research protocol. A total of 85 ALNs were evaluated and 42 ALNs were used for the analysis. 43 ALNs were retrospectively excluded due to either incomplete data in 31 ALNs or errors in setting the axillary reference or ALN center in the remaining 12 ALNs.

Axillary scanning was performed by 4 sonographers and 2 radiologists with experience in breast ultrasound, all ultrasound operators were right-handed. 2 of 6 operators scanned the same subject. A 3D mapping device with magnetically tracked position sensors (BVN G-2000, MetriTrack Inc., USA) was integrated with the ultrasound machine. The device provided the automated 3D mapping of the ALN for the first operator, guided the second operator to re-identify the same ALN and measured the movement of the subjects and axillary references during scanning. Each ultrasound operator measured the 3 orthogonal diameters of each sampled lymph node, and the midpoint of the longest diameter, which was matched by both operators was assigned as the ALN 3D center. ALN mapping was conducted relative to the subject's body and reproducible axillary references (e.g. other axillary lymph nodes or axillary vascular structures, see Fig.1). The 3D probe position and orientation were matched between operators to identify and measure the position of ALNs (see Fig. 2).

The ALN 3D center displacement between the first and second ultrasound operator relative to the set axillary reference was used to evaluate the inter-operator positional reproducibility. The effect of displacement of axillary references and body movement during scanning on the position reproducibility of ALNs was analyzed using statistical models (linear and logistic regression) and machine learning models (regression trees).

Results or Findings:

All patients were women with an average age of 48.7 ± 7.6 years. The average largest lymph node diameter measured 11.9 ± 4.0 mm. There were 23 ALNs in the right axilla and 19 in the left axilla.

The average interoperator ALN displacement was 6.09 ± 2.97 mm when axillary reference movement was ≤5 mm, increasing to 12.36 ± 5.77 mm when it exceeded 5 mm. For the right axilla, average interoperator displacement was 8.49 ± 4.25 mm, with 70% of ALNs localized within 10 mm between operators. For the left axilla, displacement averaged 12.03 ± 6.83 mm, with 37% of ALNs localized within 10 mm.

The first operator’s average axillary reference displacement was 2.83 ± 2.61 mm for the right axilla and 5.38 ± 4.98 mm for the left.

A logistic regression model showed a strong predictive power for ALNs displacement based on axillary reference movements during ultrasound scanning, with an AUC of 82% (95% CI: 69%-96%) for ALN displacements <10 mm (see Fig. 3). Both logistic and linear regression models identified axillary reference movement during the first operator’s scan as the strongest predictor of the second operator’s ALN localization accuracy, followed by body rotation in transverse and horizontal planes.

The regression tree (see Fig. 4) shows an interoperator ALN displacement of 4.8 mm when internal axillary reference movement for both operators is limited to 4 mm and horizontal plane body rotation is <1.2 degrees.

Conclusion:

Computer-assisted axillary scanning with on-screen 3D guidance enables re-localization of axillary lymph nodes within 10 mm, facilitating confident and speedy identification. Matching 3D probe orientation between operators aids in comparing ALNs morphology, further supporting consistent re-identification. The precise localization of ALNs within 10 mm between operators can be reliably performed when the axillary reference movement is kept below 5 mm.

The localization of right axillary ALNs was notably more precise than that of the left axilla, likely due to right-handed operators experiencing greater difficulty when scanning the left axilla across the patient’s body.

The results of this study suggest that computer-assisted localization of axillary lymph nodes can be used to improve the management of axilla in patients with abnormal lymph nodes. However, further studies are needed in this patient population.

This study was limited by the relatively small number of patients with normal ALNs and the absence of a control group.

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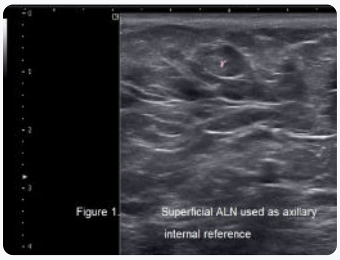

Fig 1: Superficial lymph node used as axillary reference.

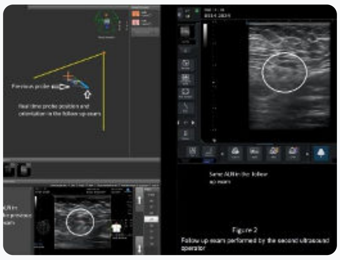

Fig 2: Follow up exam performed by the second operator.

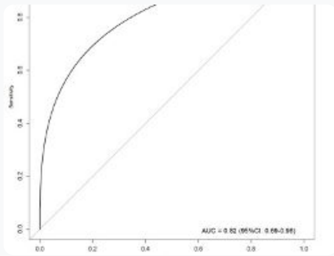

Fig 3: AUC for logistic regression model showing the predictive value of localizing ALNs within 10 mm between different operators.

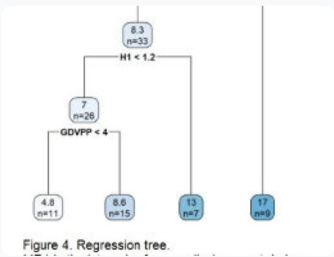

Fig 4: Regression tree showing the ALN displacements relative to the axillary reference and patient movement.