

Abstract

Skin Tissue Dielectric Constant Measurements as a Non-Invasive Method to Detect Early Lymphedema in Women Treated for Breast Cancer

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Background: Women with breast cancer who undergo breast cancer surgery are at increased risk of developing treatment-related lymphedema. Frequently lymphedema is not recognized until obvious swelling and functional limitations are present. There is a need for continued development and validation of quantitative methods and criteria that can reliably detect early or sub-clinical lymphedema.

Objective: To determine the potential use of tissue dielectric constant (TDC) measurements as a means to detect lymphedema in women who have been treated for breast cancer. It is hypothesized that TDC values, as indices of local skin tissue water, would reveal early lymphedema prior to recognition of symptoms and physical signs by the patient.

Methods: For 46 women who were surgically-treated for unilateral breast cancer, at-risk and control arm volumes (VA and VC) were determined from girth measurements taken at 4cm intervals from wrist to axilla. Percentage edema volume (%EVOL) was determined as $100(VA-VC)/VC$. Patient ages (mean \pm SD) were 63.3 ± 11.3 years. Surgical procedures had occurred 32.6 ± 23.0 months prior to TDC evaluation. As a group the number of axillary nodes removed ranged from 1 to 27 with a mean of 7.4 ± 8.6 . In addition to surgery, 34 (73.9%) also received post-surgical radiation therapy. TDC was measured at 300 MHz bilaterally on the hand dorsum, anterior forearm, biceps, anterior shoulder and lateral thorax to a depth of 2.5mm.

The ratio of TDC values of the at-risk to control arm were determined for each measurement site and compared to patient subsets grouped according to their %EVOL and nodes removed.

Results: At the time of evaluation 34.9% of patients had %EVOL greater than 5% and 15.2% had %EVOL greater than 10%. These levels are threshold-limits often used to define lymphedema presence. Bicep TDC ratios for patients with %EVOL below and above these thresholds were 0.993 ± 0.082 vs. 1.210 ± 0.376 , $p=0.006$ (Mann-Whitney) for the 5% threshold and 1.009 ± 0.099 vs. 1.396 ± 0.508 , $p=0.027$ for the 10% threshold. At no other site were TDC values significantly different between low and high %EVOL patient subsets. Both bicep and forearm TDC ratios positively correlated with the number of axillary nodes removed. For patients with %EVOL >5%, Pearson correlation coefficient r-values of forearm and bicep ratios vs. number of nodes removed were respectively 0.764 ($p<0.001$) and 0.692 ($p<0.01$). Arm volume ratios showed no significant relationship to either nodes removed or time from surgery. The most frequently reported symptoms were arm numbness, tingling, or ache each reported by 43.8% of patients with %EVOL >5%. Patients with %EVOL >10% reported more symptoms.

Conclusions: These findings show that the biceps TDC ratio may be the parameter most indicative of a useful measure for early detection of lymphedema, although both bicep and forearm ratios increase with increasing number of nodes removed.