LOCAL TISSUE WATER ASSESSED BY TISSUE DIELECTRIC CONSTANT: ANATOMICAL SITE AND DEPTH DEPENDENCE IN WOMEN PRIOR TO BREAST CANCER RELATED SURGERY

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BACKGROUND and GOALS

Several methods are available to assess overall limb edema including girth and volume measures done either manually or via automation and assessments via electrical impedance methods. However, these methods are not suitable to determine local edema or edema in body parts other than limbs. Quantitative assessment of local edema could provide useful information not previously available to help initially detect, assess and track edema or lymphedema progression in many body parts or anatomical regions.

Recent work showed that local tissue water (LTW), assessed by a tissue dielectric constant (TDC) method, can quantify LTW in arms of patients with breast cancer treatment-related lymphedema (BCRL) to provide a useful discrimination for the presence of lymphedema[1]. It has also been used to evaluate hormone related changes in LTW in arms of pre- and post menopausal women[2].

Since previous uses of this method were mainly on the volar (ventral) forearm, it was our belief that knowledge of anatomical site and tissue depth dependence of TDC values could provide comparative reference data and also help to extend the utility of this method. Thus our goal was to determine and compare TDC values obtained at anatomically paired sites and to investigate tissue depth dependence.

Because one eventual use of this method is to potentially detect developing lymphedema at an early stage, we did measurements on a group of women awaiting surgery for breast cancer at anatomical sites likely to be at risk for developing BCRL. Measurements were also done at corresponding sites in a control healthy group of women.

SUBJECTS

A total of 26 women with ages (mean ± SD) of 56.3±16.4 years (range 27 to 82 years), were evaluated after signing an IRB approved informed consent. Of the 26, 16 were in a patient group who had recently (within one month) been diagnosed with breast cancer and were awaiting breast cancer surgery (age: 65.4±11.6 years) and 10 were healthy controls who had no previous diagnosis of breast cancer (age: 41.9±12.3 years). Patients, as compared to controls, were similar in height (1.64± 0.05 vs. 1.63 ± 0.07 m, NS), weight (76.7 ± 15.4 vs. 73.0 ± 14.4 Kg, NS) , and body mass index (28.7 ± 5.9 vs. 27.5 ± 5.8 Kg/m^2, NS) but was significantly older (p<0.001).

REFERENCES

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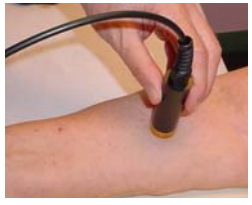
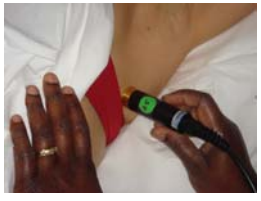
TDC MEASUREMENTS

The device used to measure TDC was the MoistureMeter-D, (Delfin Technologies Ltd, Kuopio Finland, www.delfintech.com). It consists of a cylindrical probe connected to a control unit that displays the TDC value when the probe contacts the skin. The physics and principle of operation has been well described[3-4]. In brief, a 300 MHz signal is generated within the control unit and is transmitted to the tissue via the probe that is in contact with the skin. The portion of the incident electromagnetic wave that is reflected depends on the dielectric constant of the tissue, which itself depends on the amount of free and bound water in the tissue volume through which the wave passes. For reference, pure water has a value of about 78.5. The effective penetration depth depends on probe dimensions, with larger spacing between inner and outer conductors corresponding to greater penetration depths. In this study four different dimension probes were used to characterize depth dependence at the forearm site. These had effective penetration depths of 0.5, 1.5, 2.5 and 5.0 mm. For anatomical site dependence evaluations at forearm, biceps, axilla and thorax, only the 2.5 mm depth probe was used.





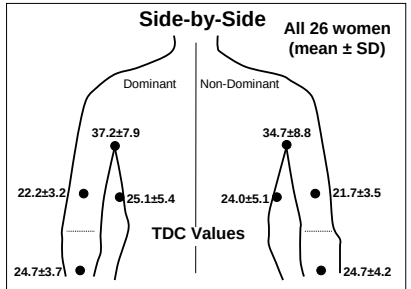
Measurements were done with subjects supine at four paired standardized sites (both sides) as follows: volar forearms, 6 cm distal to the antecubital crease, medial biceps 6 cm proximal to the antecubital crease, axilla and lateral thorax 8 cm below the axilla. Depth measurements at the forearm site were done first. Measurements were obtained in triplicate-pairs alternating between body sides. At each site the three measurements were averaged and used to characterize the site average TDC value. The time required to obtain a single measurement, once the probe was placed in contact with the skin, was about 10 seconds..

ARM VOLUME DETERMINATIONS

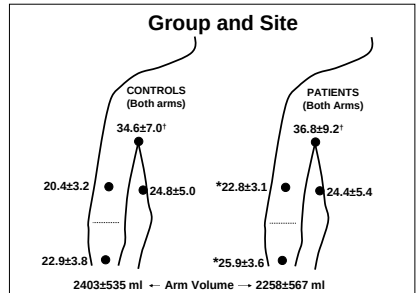
Arm circumferences were measured with a Gulick tape measure At 4 cm intervals starting at the wrist. Arm volumes were calculated using circumference values in a truncated-cone model with calculations done by a validated economical software package (Limb Volumes Professional 4.0, www.limbvolumes.org).

For comparison purposes, arms were designated as either dominant or nondominant depending on the handedness of the subject. For consistency, axilla and thorax sites on the dominant hand side are also designated as dominant sides.

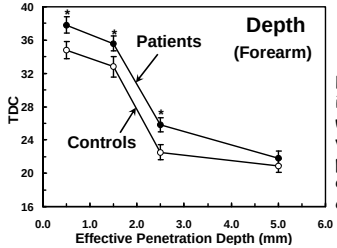
MAIN RESULTS



Side-to-side comparisons. No significant difference in TDC between paired-sides.



Arm TDC values were slightly greater in patients (* p<0.01). Axilla TDC values were greater than at forearm, biceps and thorax († p<0.001). TDC values at biceps were slightly less than at forearm and thorax sites (p<0.001).



Forearm TDC values decreased with effective penetration depth in both groups in a similar pattern. TDC values at each depth were significantly different from all others (p<0.001). Patient values were significantly greater than controls for all effective penetration depths (* p<0.05) except at the deepest penetration depth. Error bars in the adjacent graph are ± 1 SD. Mean values combine the dominant and non-dominant arms within each group.

DISCUSSION AND CONCLUSIONS

The present study is the first to investigate the possibility of using this tissue dielectric constant method to characterize LTW at multiple sites in 'at risk' regions associated with BCRL. Since most breast cancers are unilateral, a goal of this initial study was to determine TDC values at these sites and also compare TDC values between body sides in women already diagnosed with breast cancer and women free of breast cancer. The measurements done would constitute 'baseline' pre-surgery values that would be made if one were planning to track changes in these women following their cancer treatment process.

Despite differences in TDC values among the sites, differences between corresponding body sides were small and not significant. The similarity of dominant-nondominant side TDC values is a feature that would enhance the ability to interpret changes in LTW that occur in an affected body side in BCRL.

Another finding relates to the decrease in TDC values with increasing penetration depth in all subjects. Such dependence is explained by the increasing influence of deeper tissue constituents such as subcutaneous fat and its lower relative water content.

The composite results have several potential clinical implications. Firstly, since TDC measurements can be tailored to reflect changes to different depths, whereas standard used indices of lymphedema such as girth or limb volume reflect conditions of the entire cross-section, it is likely that TDC assessments are more sensitive and flexible for detecting early developing edema or lymphedema.

Another important aspect of the TDC approach to characterizing lymphedema is the fact that assessments can be made in any body area or part since the measurement method is not limited to limbs. Thus it should be possible to assess localized lymphedema and its change in the hand, finger, head, neck, genitalia, and so on. These possibilities need to be validated with further clinical research.

Dr. Mayrovitz invites you to e-mail him at mayrovit@nova.edu with any questions or comments.