Effect of Changes in Vascular Volume and Skin Blood Perfusion on Forearm Skin Tissue Dielectric Constant Measured at 300 MHz

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Background

Measurements of local tissue dielectric constant (TDC) via the open-ended coaxial probe method are useful non-invasive measures of local tissue water9-14. The method permits assessment and tracking of changes in skin tissue water in many situations including lymphedema15 and other conditions9-12. The operating principle depends on the direct relationship between TDC values and fluid content within measured tissue to effective depths up to about 5 mm below the epidermal surface. This depth includes dermal tissues as well as vascular structures so there is a question as to affects of blood volume and skin blood flow (SBF) on TDC values obtained. Our objective is to determine the extent to which local blood volume and SBF effect measured TDC values.

Methods

TDC values to a depth of about 1.5 mm and SBF to a similar depth via laser-Doppler flowmetry were measured on the anterior forearms of 20 young adult healthy supine subjects (10 male) under two test conditions. Test 1 was done with the arm horizontal and then passively raised to about 90° for 5 minutes. Test 2 was done with the arm horizontal before and during a 5 minute upper arm cuff compression to a pressure of 50 mmHg. SBF was also measured on the 3rd finger pad during all maneuvers. The forearm target site was 8 cm distal to the antecubital fossa.

Results

Over the wide range of blood volume and SBF shifts associated with the employed maneuvers a 3.0-3.5% change in TDC values was observed. This suggests that for most clinical evaluation and tracking purposes in which such large shifts in blood volume and perfusion are unlikely, the confounding effects of variations in SBF or volume are inconsequential.

Conclusions

From the physiological perspective, the decrease in TDC with arm raising is consistent with a gravity-dependent drainage in vascular volume and the increase in TDC with application of cuff pressure is consistent with reduced drainage from vascular compression.

The finding of an increase in forearm SBF agrees with previous work suggesting that venous leading up to arteriosclerosis. The decrease in SBF at forearm with cuff pressure and at finger with arm raise is consistent with a perfusion pressure reduction accompanying these maneuvers.

References

12. Mayrovitz HN. Local tissue water assessed by measuring forearm skin tissue dielectric constant: dependence on measurement depth, age and body mass index. Skin research and technology. 2010: 16: 16-22.