

A Method to Estimate Hand Volume Based on Metric Measurements

HN Mayrovitz, N Sims, CJ Hill, T Hernandez, A Greenshner, H Diep, Colleges of Medical Sciences and Allied Health, NSU Davie FL

BACKGROUND-GOALS-APPROACH

Determining upper extremity limb volume and its change during therapy for edema or lymphedema is needed to assess treatment efficacy and outcomes. A near circular cross-section of the arm permits its volume to be accurately estimated with tape-measure-determined circumferences and suitable calculation formulae. However, because of the hand's shape, circumference-determined-volumes may not be accurate. Our aim was to develop and test a metric measurement procedure and algorithm that could usefully estimate hand volumes as an alternative to water displacement. Both hands of thirty volunteers were evaluated. The method tested uses a caliper to measure hand dimensions at standard locations and calculates volume (V_M) by a software algorithm**. V_M was compared to volumes measured by water displacement (V_W) and tape-measure-circumferences (V_T) in 30 subjects (60 hands) using regression analysis and limits of agreement (LOA).

** www.limbvolumes.org

MEASUREMENT OVERVIEW

Measurement and Calculation Procedure

Width and Depth Measurements

Measurements are made using a digital caliper every 3 cm starting at the wrist. (styloid process as reference). Last segment - includes the finger tip may be less than 3 cm

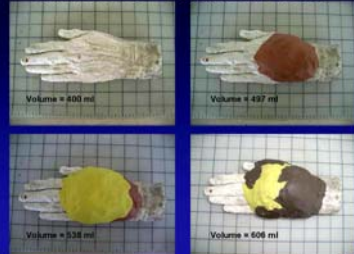
Calculations

Volume of each segment based on a calculation algorithm that treats each segment of length Z as a frustum with an elliptical cross sectional area (S). Total hand volume is then the sum of all segment volumes.

$$\text{Segmental volume} = kZ(S_A + S_B + [S_A S_B]^{1/2})$$

Dr. HN Mayrovitz

Hand Model – Simulated Edema



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HAND MEASUREMENT PROCEDURES



Hand Volume by H₂O Displacement

Subject seated on adjustable chair with back against wall and arm hanging naturally

Hand volumeter is on an adjustable jack that will be raised to just make the wrist zero point under water



Hand Volume by H₂O Displacement

Jack is slowly raised and displaced H₂O is caught by recovery container.

Volume of displaced H₂O is subsequently determined by weighing the H₂O



Hand Volume by H₂O Displacement

Final position of hand in volumeter. Note that water level is just to the zero point on the wrist.

Volume of displaced H₂O is subsequently determined by weighing the H₂O



Hand Volume by H₂O Displacement

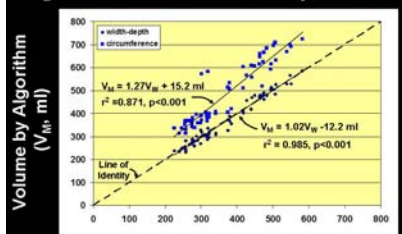
Recovery container weight without H₂O determined prior to collecting H₂O and used as tare weight for measurement of displaced H₂O

Method was tested against actual volume measurements with graduated cylinder

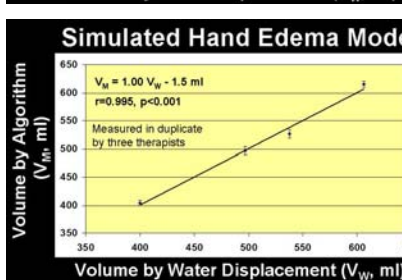


MAIN RESEARCH FINDINGS

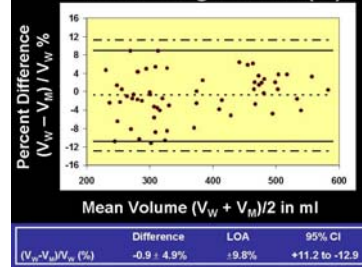
Algorithm vs. Water Displacement



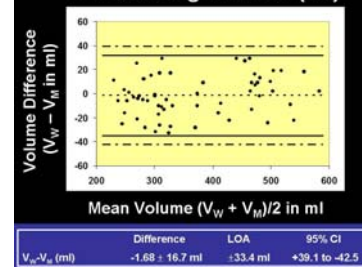
Simulated Hand Edema Model



Limits of Agreement (%)



Limits of Agreement (ml)



RESULTS AND CONCLUSIONS

RESULTS: Volumes determined by water displacement (V_W) and by the new metric method (V_M) were similar being (mean \pm sd) 368 \pm 102 ml vs. 369 \pm 98 ml respectively and were highly correlated $V_M = 0.949V_W + 20.6 \text{ ml}$, $r = 0.987$, $p < 0.001$. The LOA for absolute volume differences and percentages were respectively $\pm 33.3 \text{ ml}$ and $\pm 9.9 \%$. Circumference-determined-volumes ($V_T = 485 \pm 134 \text{ ml}$), significantly overestimated hand volume compared to V_M and V_W ($p < 0.001$).

CONCLUSIONS: Results indicate that this metric method together with the algorithm is useful when hand volumes are needed, but water displacement is either not available or is contraindicated, as when open wounds are present.

Dr. Mayrovitz welcomes your comments and queries. You may contact him at: mayroviti@nova.edu