# Measurement of Edema Using Volumetric Plethysmography

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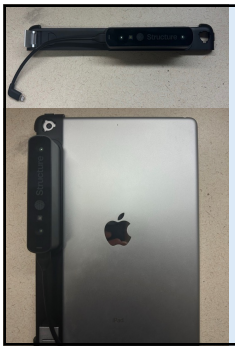
## Disclosures

- Nothing to disclose.

## Quantifying Edema

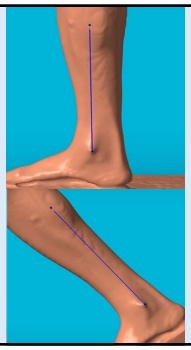
- Assessment of edema has been empirical and difficult to quantify.
- *VCSS* grades edema according to the time of day it reaches maximum. Many clinicians try to go a step further describing it variously as "pitting", "ankle edema", or "gross" if it involves the entire limb.
- Tape measurements of the limb are widely used but are imprecise at best.
- Water plethysmography is precise but impractical for routine clinical use. Volume surrogates such as electrical impedance may be precise but do not yield edema volume directly.
- Sophisticated 3D measurements with laser are available but expensive.



**iPad Based Edema Meter**

- Inexpensive 3D scanner and software.
- Widely available commercially from several vendors.
- Hardware specific protocol is easily developed for limb volumetry.


- The distance between the scanner and the limb should be three feet or less (we use a Hoola-hoop) to minimize zoom error.



- The target for 3D measurement is a 25 cm long leg volume, starting at the medial malleolus. This is electronically marked by a line between two dots as shown here.
- Limb tilt does not affect the result.

Volume Variance as Measured by Two Different Technicians on the Same Subject Limb.

| Subject | Scan Side | Technician 1 | Technician 2 |
|---|---|---|---|
| 1 | R | 1535 | 1517 |
| | L | 1526 | 1564 |
| 2 | R | 1528 | 1544 |
| | L | 1631 | 1619 |
| 3 | R | 1866 | 1841 |
| | L | 1775 | 1800 |
| 4 | R | 1795 | 1828 |
| | L | 1738 | 1774 |
| 5 | R | 1950 | 1939 |
| | L | 1993 | 1942 |
| 6 | R | 1718 | 1754 |
| | L | 1761 | 1722 |
| 7 | R | 2066 | 2104 |
| | L | 2023 | 2068 |
| 8 | R | 1513 | 1552 |
| | L | 1595 | 1640 |
| 9 | R | 1971 | 1962 |
| | L | 2023 | 1958 |
| 10 | R | 2275 | 2196 |
| | L | 2333 | 2319 |
| Mean Volume Difference ±SD | 2.6%±1.5 | 1.8%±0.9 | |
| Relative Standard Error | 2.6% | 3.0% | 2.8% |

## Conclusions

- An iPad-based 3D scanner can be used for routine limb volumetry in the clinic
- The equipment and software are widely available and inexpensive. The measurement method is simple and quick (15 minutes) amenable for routine clinical use.
- Volumetric data obtained by this method cannot be validated by external comparison by another method because the target limb volume cannot be precisely duplicated between methods.
- However, internal validation has been established by comparison of results between different technicians. It yields low variance and low standard error.

The End