# Portable Device For Breast Volume Measurement

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## ABSTRACT

Our client, Dr. Ramzi Shehadi is a reconstructive surgeon interested in developing a device to pre-operatively measure the volume of a patient's healthy breast in order to more accurately perform the Transverse Rectus Abdominus Myocutaneous (TRAM) Flap procedure on the breast that underwent a mastectomy. The device would improve the rate of success of the procedure and the symmetry of the breasts – especially for surgeons lacking significant experience with the procedure. Our final design uses volume displacement principles and incorporates two containers, a valve, and a sliding scale to measure the breast volume. The device was designed to accurately measure breast sizes up to 600 $cm^3$ for the small version, and 1300 $cm^3$ for the large version. This encompassed a small to medium breast size range. It was demonstrated through testing that the device was able to determine volume precisely and with the desired accuracy.

## INTRODUCTION

- **Problem Statement:** A simple, cheap, portable device is needed in order to pre-operatively determine the volume of a breast
- Mastectomies are the most common treatment for breast cancer[1]
- TRAM flap procedure is performed after mastectomy[2]
- Knowing the volume of the healthy breast pre-surgery would allow surgeons to determine the amount of tissue to take during the procedure

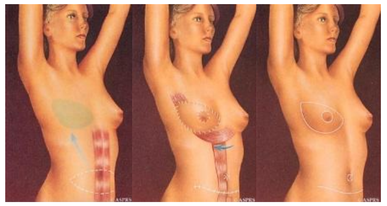

**Figure 1:** TRAM flap procedure illustration with tissue taken from the abdomen and transferred to the breast. [1]

## CURRENT METHODS

- Comparison to prosthetics
- Estimation by using touch and sight
- 3D Imaging devices
- MRI scan
- Cast molds
- Grossman-Roudner device[3]

**Figure 2:** *HandyScan 3D,* a portable laser device able to produce an accurate 3-D image from which a volume could easily be determined[4]

**Figure 3:** Grossman-Roudner device measures volume using cone geometry[3]

## DESIGN SPECIFICATIONS

- Quick determination of breast size
- Accurate within 10% of the actual breast volume
- Simple enough for any one person to use
- Portable in a clinical setting
- No more than 10lbs
- $500 preliminary budget

**Table 1:** Design matrix describing the justification for the final design choice

| Category | Lasers | Water Displacement | 3D Imaging |
|---|---|---|---|
| **Cost (25)** | 10 | 25 | 15 |
| **Accuracy (20)** | 5 | 15 | 10 |
| **Portability (15)** | 7 | 12 | 7 |
| **Ease of Use (15)** | 5 | 12 | 14 |
| **Maintenance (10)** | 9 | 5 | 9 |
| **Speed (5)** | 1 | 4 | 4 |
| **Patient Comfort (5)** | 5 | 3 | 5 |
| **Safety (5)** | 5 | 5 | 5 |
| **Total (100)** | 47 | 81 | 69 |

## FINAL DESIGN

Components:

- External container: Acrylic cylinder, acrylic cap, and aluminum bottom that holds water that flows into primary container
- Primary container: PVC cylinder in which the breast is inserted and water flows into
- Valve: Starts and stops flow between external and primary container
- Membrane: LDPE film attached to the rim of the primary container, forming a water-tight seal between the breast and the primary container
- Membrane seal: Steel hose clamp attaches membrane to primary container
- Scale: ABS component allowed to be adjusted up and down the external container, and calibrated to show the volume of the breast as a function of the water remaining in the external container

Process:

- Breast is inserted into primary container in loose fitting membrane
- Top of scale is positioned at water level of external container
- Valve is opened, water fills primary container around breast
- Remaining water level in external container is measured by the scale, determining breast volume

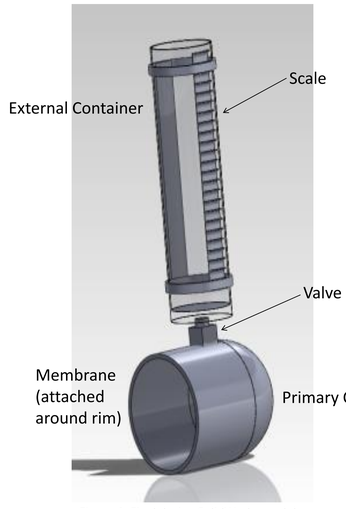


**Figure 4:** Final design SolidWorks model

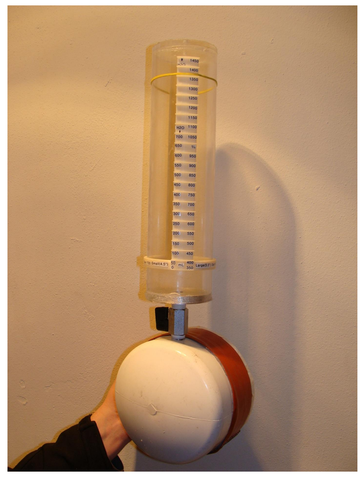

**Figure 5:** Final larger-sized prototype

Cost Analysis:

**Table 2:** Cost Analysis of small version of device

| Part of Design | Specific Material | Cost |
|---|---|---|
| Primary Container | 4½ inch diameter PVC Slip Cap | $7.71 |
| Membrane | Dual-layered LDPE Sheet | $2.40 |
| Membrane Attachment | 4⅛ – 7 inch Steel Hose Clamp | $1.72 |
| Membrane Attachment Cover | 12 x 12 inch, 1/32 inch think, Nitrile | $10.36 |
| Valve | ¼ inch end, Male x Female threaded, Chrome-plated, Brass Ball Valve | $7.90 |
| External Container (Bottom) | 1 inch thick, 3½ inch diameter, High-strength, Aluminum disk | $19.71 |
| External Container (Sides) | 12 inch long, 3 inch inside diameter, ⅛ inch thick wall, Acrylic cylinder | $22.03 |
| External Container (Top) | ¼ inch thick, 3 inch diameter Acrylic disk | $6.64 |
| Scale | ABS (Rapid Prototyped) | $57.04 |
| | | **Total Cost = $135.51** |

## RESULTS

**Table 3:** The mean was found from 5 measurements of each object

| Object Number | Accepted Volume | Mean | Standard Deviation |
|---|---|---|---|
| 1 | 260 mL | 280 mL | 11.18 mL |
| 2 | 150 mL | 180 mL | 20.92 mL |
| 3 | 125 mL | 160 mL | 13.69 mL |

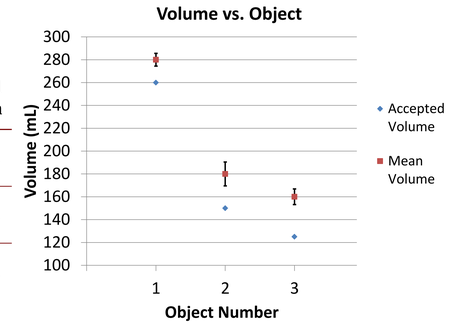


**Figure 6:** Error bars were one standard deviation of data set

## DISCUSSION

- Testing shows repeatability
- Reasonably accurate – gives an approximate volume
- Slightly difficult to use
- Measurement was more accurate for uniform objects
- Device determined volume quickly
- Inversion of device was efficient
- Easy to switch primary container sizes

## FUTURE WORK

- Improve ease of use
- Wider range of sizes
- Test the device on prosthetics and human breasts
- Change external container to a more compact size
- Add transducer that outputs the volume based on measured pressure
- Coverable or sterilizable
- Increase durability of device
- Develop better seals between containers, membrane, and valve
- Increase denominations on scale

## ACKNOWLEDGEMENTS

Dr. Ramzi Shehadi, Dr. Tracy Puccinelli, and Dr. John Puccinelli

## REFERENCES

1. "TRAM Flap." *Reconstructive Breast Surgery*. Web. 15 Nov. 2011. <http://www.breastreconstruction.ca/living_tram.htm>.
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