MEASURING SUB-BANDAGE STATIC AND DYNAMIC COMPRESSION PRESSURES

Suzanne Humen Davey, OTR-CLT/LANA, *Healing Hands of Lymphatics Plus* and HN Mayrovitz, PhD, NSU Ft. Lauderdale FL

INTRODUCTION

Many compression bandages and devices are available for treating limb edema, lymphedema and ulcers. Since the pressures achieved by these play a role in their therapeutic usefulness it is instructive to examine some of these pressure features under different conditions. Of particular interest is the pressure measured between the bandage and the limb variously called interface, surface or sub-bandage pressure. When a compression bandage or device is applied to a limb and the limb is at rest, the pressure is called the resting or static pressure. When the limb is moving and its muscles are contracting, then the pressure change is called the dynamic or working pressure. Each pressure has its own specific role in therapeutic processes [1].

The main purpose of this presentation is to provide initial examples and illustrations of some of the clinically relevant features of various bandages and devices under different conditions. The main goal of this work is educational and is not intended as a comparative study of different features among different products. This would require a much larger undertaking for such comparisons to be scientifically meaningful.

METHODS

Pressure Measurement: Accurate and reliable measurement of interface pressures, especially on a limb, requires a sensor that is sufficiently thin and small so that its presence has an acceptably small effect on the true pressure. In the present case we used a thin (1 mm) square (10 mm^2) capacitive-based sensor that produces an output voltage related to the integrated pressure over the sensor area. Most, if not all, sensors available for measuring interface pressure are nonlinear, so it is necessary to calibrate and correct for such nonlinearity. Our approach is to calibrate the sensor *in situ* using a calibrated vascular cuff – sphygmomanometer combination (Figure 1) and then to use a software-based least-squares optimization procedure to relate measured sensor voltage to actual pressure in mmHg.

Protocol: To obtain information under varying conditions, pressure measurements were obtained using the following sequence. The subject (hereafter called Mary) assumed a supine position on a padded therapy table. The sensor was placed on the posterior calf of her left leg and a stocking was placed over her leg up to the knee. The heel was supported by pillows so that the calf was not in contact with the surface and the sensor was then calibrated *in situ.* A bandage or device was then applied according to manufacturers recommendations by an experienced therapist. Two bandage types (a short stretch and a multilayer bandage system) and two devices (CircAid® Ready-Fit™ and a FarrowWrap™ Classic) were used. These are shown in Figures 2A through 2D with Mary supine. After application, the pressure that was measured (supine-rest pressure). Mary was then assisted to a sitting position with her legs hanging over the edge of the table. The pressure was again measured (seated-hanging pressure). She then was assisted to a flat-footed standing position and pressure measured (standing- rest pressure, Figure 3A. Mary then performed a toe-up maneuver that consisted of contraction of her left calf muscle and dorsiflexion of her left foot. She repeated this 10 times in succession over an interval of 20 seconds. After a brief rest, and while still standing, Mary performed a heel-up maneuver, in which she raised up on her toes 10 times in 20 seconds. She then sat down in an armless chair with feet flat on the floor and pressure was measured (seated-rest pressure, Figure 3B). She then performed a toe-up maneuver sequence, followed by a heel –up sequence as described above. Mary then stood up, and while standing still, another standing rest pressure was obtained. Finally she returned to a supine position and the supine-rest pressure measurement was repeated. The same sequence was used for each bandage or device.

PROCEDURES AND EXAMPLES OF STATIC AND DYNAMIC PRESSURE FEATURES

1. Pressure sensor calibrated in situ

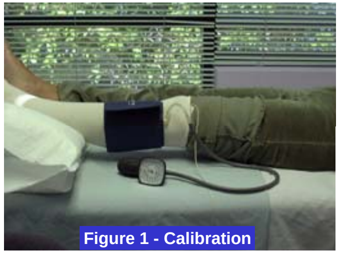
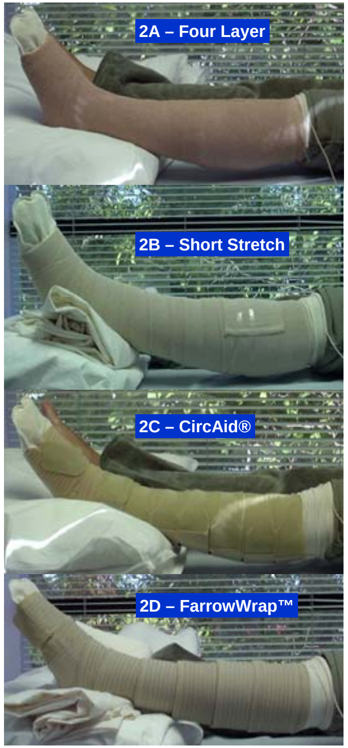


Figure 1 - Calibration

2. After calibration, static pressures determined first in supine position



3. Dynamic pressures

In standing and seated positions, toe-ups and heel-ups are used to simulate exercise-related dynamic changes in interface pressure

Changes in Static Pressure with Position

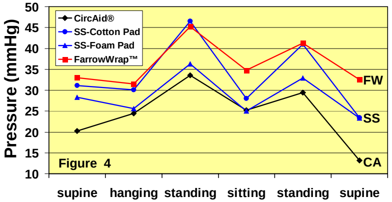


Figure 4 illustrates how static pressure changes with position. Note that standing causes a rise in pressure. Note also the fall in supine-resting pressure after the exercise sequence in some cases. Pressures obtained depend in part on the exact method of application.

Dynamic Pressures via Cuff Compression

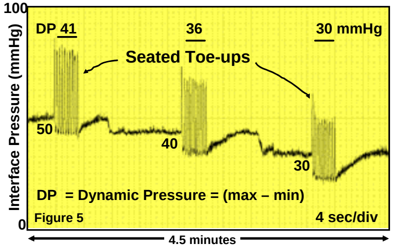


Figure 5 illustrates the impact of static pressure on resultant dynamic pressures. A vascular cuff is put around the calf and inflated. Higher static cuff pressures correspond roughly to less stretchable bandages or devices. Dynamic pressure decreases with decreasing "stiffness".

RESULTS AND DISCUSSION

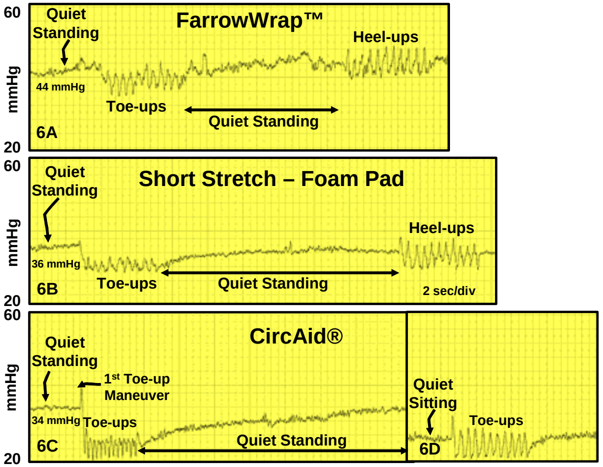


Figure 6 above illustrates several aspects of dynamic pressure. First note that independent of compression method (A, B and C), that after the first toe-up, there is an initial decrease in interface pressure. This is explained by the movement of volume out of the calf area due to foot dorsiflexion and calf muscle contraction. Subsequent dynamic pressures oscillate around this new lower pressure level. When exercise ends, calf volume increases slowly toward its standing-rest level interface pressure returns to its standing-rest pressure level. The pattern for heel-ups is different (A and B) in that during that maneuver the initial decrease in pressure is not evident and the dynamic pressure oscillates around the standing-rest pressure. The toe-up dynamic pressure pattern is also present in the sitting position (D).

CONCLUSION

Compression therapy is one of the most important aspects for treating edema, lymphedema and certain limb ulcers. We know that it works, but there are many details of the mechanisms and processes that are not yet fully understood. This means that it is not always clear as to which bandage or device features are optimum for a given condition or patient. We believe that by more expansive studies along the basic lines outlined in this single case report, some of these clinically relevant informational gaps can at least be partially filled.

[1] Mayrovitz HN and Sims N (2005) Compression Therapy. In: *Wound Healing* Ed. Falabella, AF and Kirsner, RS Chapter 33 pp 409-421 Taylor & Francis, Boca Raton FL

Dr. Mayrovitz may be contacted at:
mayrovitz@limbedema.com