

## Forearm Bloodflow

### Protocol for measuring forearm bloodflow with the TL400 Totalab or the EC5R Strain Gauge Plethysmograph:

#### Setup

The subject should sit or lie with the arm level and relaxed. Support the arm at the elbow and wrist with foam blocks for comfort and to raise the center part of the forearm to make room for the strain gauge. Place an SC12D (this is a rapid version of the SC12) venous occlusion cuff above the elbow and a TMC7 cuff on the wrist. Measure the largest part of the forearm and select a strain gauge which will stretch about 2 cm when it is applied.

The strain gauge is applied double by bringing the loop back in the direction of the cable and looping around the limb. The end of the loop hooks over the gauge end and fits into the groove behind the black end piece. Use adhesive tape to secure the gauge in two places. One strip of tape should go over the gauge end and the other should secure the cable to the skin a few centimeters from the end. The purpose of the tape is to prevent movement of the wire from disturbing the gauge.

An E20 Rapid Cuff Inflator is necessary to inflate the venous occlusion cuff quickly. Speed of inflation is important in order to have a clear starting point for the inflow curve. Block one half of the blue Y connector on the E20 and connect the other half to the SC12D by inserting the tube from the cuff directly into the aluminum fitting in the Y.

#### Theory

Forearm bloodflow is measured by stopping flow out of the limb at an instant while not changing the rate of arterial inflow. This is done by inflating a venous occlusion cuff above the elbow to a pressure of 50 mm Hg. This pressure is sufficient to shut the veins, but not the arteries. As blood flows into the limb, it causes the limb to swell and the rate of swelling is a measure of the arterial flow rate at that instant. The assumption is made that flow is similar throughout the limb so the volume flow rate is equal throughout the measurement volume. Flow rates are commonly measured in the cc's of flow per 100 cc's of tissue. This type of normalized measurement makes it possible to compare flow rates regardless of the subject's size. Flow to the hand is quite variable so it is usually stopped during the test by inflating a wrist cuff above systolic pressure.

#### Instrument Setup

Preset the venous occlusion **cuff pressure to 50 mm Hg**. Set the **chart speed** of the plethysmograph to **5 mm/sec** (Slow). The **Mode** should be set to **Strain gauge** and the **coupling** to **DC** (vein.). Sensitivity may vary depending on the subject, but a good starting point is **0.2%/cm**. This means that each centimeter of deflection on the chart paper represents 0.2% change of volume of the limb. Adjust the range as necessary to get a slope of approximately 45° for maximum sensitivity.

#### Technique

Inflate the wrist cuff to about 15 mmHg above the subject's systolic pressure prior to making a measurement. Run the chart recorder on **Slow** and press the **Balance** switch. Adjust the baseline position after balancing to be near the bottom of the chart (2 mm up is ideal.) Press the **Mode** button on the E20 to inflate the venous occlusion cuff. The tracing should rise indicating the volume increase due to arterial flow into the limb. The cuff may be deflated again after about 5 seconds and the tracing will return to the baseline. Repeated measurements can be made quite rapidly by repeatedly inflating the cuff. Each inflation yields another flow measurement.

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D. E. Hokanson, Inc.  
12840 NE 21<sup>st</sup> Pl.  
Bellevue, WA 98005 USA  
(425)882-1689  
(800)999-8251  
Fax (425)881-1636

Hokanson instruments  
are manufactured in  
Bellevue, Washington, USA

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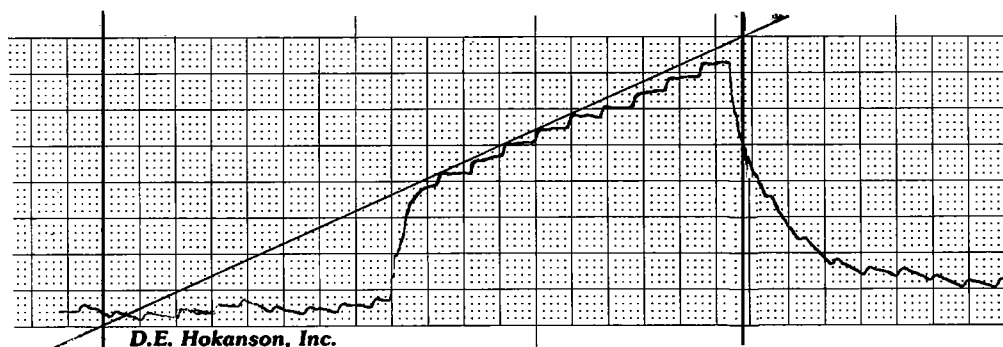
## Calculation

Flow is measured by determining the initial slope of the volume curve after any cuff artifact which might exist. The cuff artifact is a rapid rise of the curve immediately after inflation of the venous occlusion cuff due to blood being pushed back down the arm. Place a straight edge tangent to the first pulses after the cuff artifact and draw a line completely across the chart. Drawing the line requires some judgment, but with practice consistent results are possible.

To determine the slope of the line, figure the change in volume per unit time. Find the time required for the line to cross the chart by drawing a line straight up from the point where the line crosses the bottom of the chart; then measure the time horizontally to where the line crosses the top of the chart. On **Slow** speed the chart moves 5 mm/sec. The volume change from the bottom to the top of the chart is 4 times the **Range** setting for the EC5R or TL400 since the chart is 4 centimeters wide and the **Range** is listed as a sensitivity of X%/cm. Divide 60 seconds by the time required for the line to cross the chart to find out how many times the line would have crossed the chart in a minute and multiply this number by the volume change across the chart. The result is in % volume change per minute. This is the equivalent of cc's of flow per 100 cc's of tissue per minute since 1 cc/100 cc's is 0.1%. Resting values are usually around 3%/min.

## Example 1

The following chart was recorded from a TL400 Totalab strain gauge plethysmograph. The **Range** was set to 0.2% and the chart speed was 5 mm/sec. The tangent line is drawn and the time for this line to cross the chart is 17.8 seconds ( 89 mm / 5 mm / sec ). The volume change across the chart is  $0.2 \times 4$  or 0.8%. The flow rate is therefore  $60/17.8 \times 0.8\% = 2.70\%/min$ .



## Example 2

This recording was made with the same setup as Example 1, but with another subject. Note that the pulse is less pronounced and the initial cuff artifact is slightly smaller. Respiratory variation of the baseline is more noticeable in this subject. In this example the time to cross the chart is 12.8 seconds. The flow rate is  $60/12.8 \times 0.8\% = 3.75\%/min$ .

