The StenTec Gauge for Measuring Static Intra-access Pressure Ratio (Pia Ratio) of Fistulas and Grafts

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All Surveillance Techniques Attempt to Measure the Hydraulic Resistance of the Access

**Venous Access Pressure Ratio (VAPR) =**

\[
\frac{\text{Venous Access Pressure}}{\text{MAP}} = \frac{\text{Arterial Pressure} - \text{Venous Access Pressure}}{\text{Access Flow}}
\]

Monitoring and Surveillance Methods

Physical Examination:
- Time intensive, requiring monthly exam by same physician
- Non-quantitative
- Requires experience and training

Static Pressures normalized to arterial pressure (Pia Ratio)
- By dialysis machine pressure gauges, complicated and inaccurate
- By independent pressure gauge requires filter, access to fistula needle tubing
- Trend analysis not needed

Dynamic Pressures normalized to arterial pressure
- Easily obtained
- Mostly determined by blood flow rate, hematocrit, needle size, etc
- With system data collection static pressure can be predicted (VascAlert)
- Trend analysis needed

Access Flow Measurement (not normalized to arterial pressure)
- Does not predict dysfunction or thrombosis risk in grafts
- Time intensive and expensive
- Trend analysis needed

The KDOQI Guidelines of 2005 for Surveillance of grafts and fistulas chose intra-access flow as the best measure, but in regards to access flow they stated the following:

Access flow measured by ultrasound dilution, conductance dilution, thermal dilution, Doppler or other technique should be performed monthly. The assessment of flow should be performed during the first 1.5 hours of the treatment to eliminate error caused by decreases in cardiac output related to ultrafiltration. The mean value of 3 separate determinations performed at a single treatment should be considered the access flow.

Access Flow less than 600 mL/min, the patient should be referred for fistulogram.
Access Flow less than 1,000 mL/min that has decreased by more than 25% over 4 months should be referred for fistulogram.

All of this is a pretty complicated algorithm...

KDOQI Guidelines also stated:

“Prospective Surveillance using dynamic or static venous dialysis pressures detects outflow stenoses” but stated that between the two, static pressure readings PIA (normalized to systemic pressure) are much preferable to dynamic pressure readings.
KDOQI Guidelines for Normalized $P_{ia}$

<table>
<thead>
<tr>
<th>Degree of Stenosis</th>
<th>Access Pressure Ratio</th>
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</thead>
<tbody>
<tr>
<td>Arterial Segment</td>
<td>Venous Segment</td>
</tr>
<tr>
<td>-25% of diameter</td>
<td>0.80 ± 0.05</td>
</tr>
<tr>
<td>-50% of diameter</td>
<td>0.50 ± 0.05</td>
</tr>
<tr>
<td>&gt;50% of diameter</td>
<td>0.20 ± 0.05</td>
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</tbody>
</table>

Original Papers by Besarab Showed that Systolic $P_{ia}$ Ratio was Even Better than Mean Pressure for Predicting Stenosis


Pressure vs. Volume of Blood in the Fistula Needle Tubing

$PV = nRT$

$P_1 = ATM$

$V_1$

$P_2/ATM + P_{ia}$ Systolic

$V_2 = V_1*P_1/P_2$

To use the StenTec Gauge, do the following:

1. Place fistula needle "dry" and capped into the fistula or graft and tape in place as usual.
2. Note the systemic systolic blood pressure (SBP) of the patient.
3. Lay the clear plastic Gauge over the fistula needle and tubing, with the left end of the clear tubing at the "0" point of the graph, and the fistula needle tubing under the line that most closely indicates the BPS of the patient.
4. Note the highest point of progress of the air-fluid interface into the tubing and compare it to the slanted lines to determine the $P_{ia}$ Ratio.
5. Repeat for the other fistula needle.
6. The red lines for $P_{ia}$ values of 0.5 or more indicate a high probability of outflow stenosis of a fistula. $P_{ia}$ values of 0.75 or more indicate a high probability of outflow stenosis of a graft (as described by the KDOQI Guidelines).
7. Maintain a record of $P_{ia}$ for arterial and venous needles over time for each patient, or mark the gauge with each measurement. Continuously increasing $P_{ia}$ values indicate a need for intervention.
Accuracy of measurement of pressure is within 5% by static tests.

In mock circulation, fistula tubing pressure reflects intra-access circulation exactly.

Pressure Reading by StenTec Closely Follows that Measured by the Compass Miniature Pressure Gauge.
Availability of StenTec™

- Publication in Seminars in Dialysis this year
- Gauges can be copied from electronic version
- Reprints of Gauges for 0-1000’ elevation are available at modest price from HemoCleanse

Conclusions

- StenTec™ accurately measures the static access pressure at systole
- Graphic features immediately calculate the Pia ratio.
- Early clinical experience demonstrates that fistula stenosis is accompanied by rapidly rising Pia ratio measured by StenTec, and that a continued low Pia ratio indicates lack of stenosis.
- A larger clinical trial will determine whether StenTec monitoring has greater sensitivity and specificity than fistula flow measurements and clinical exam
- A much larger clinical trial would be needed to demonstrate whether any type of access monitoring results in longer fistula and graft function