Pump Speed, Needle Size, & Fistula Flow: Means to What End?

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Uremic Toxins

<table>
<thead>
<tr>
<th>Molecules</th>
<th>Molecular weight</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small water soluble compounds</td>
<td>&lt;500 Da</td>
<td>urea, symmetric dimethylarginine, creatinine, guanidines, hippurates, uric acid, citrate, and malate</td>
</tr>
<tr>
<td>Protein-bound solutes</td>
<td>Variable</td>
<td>phosphate, phenol, 3-deoxypentoses, histidine, nicotine, melanins, tyrosine, arginine, and homocysteine</td>
</tr>
<tr>
<td>Middle molecules</td>
<td>&gt;500 Da</td>
<td>α-microglobulin, parathyroid hormone, and advanced glycation end products</td>
</tr>
</tbody>
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Kt/V = \( -\ln\left(\frac{\text{BUN}_{\text{post}}}{\text{BUN}_{\text{pre}}}\right) \)

- Added levels of precision & complexity
  - Equilibrated
  - Single vs. double pool
  - Residual renal function
  - Iso-osmotic urea removal with UF
  - Intradialytic urea generation

CMS Quality Incentive Program (QIP)

"Dose" Kt/V

- Standard: 1.32
- High: 1.71

NKF-KDOQI 2016, 3.1: "We recommend a target single pool Kt/V (spKt/V) of 1.4 per hemodialysis session for patients treated thrice weekly, with a minimum delivered spKt/V of 1.2"
Variable #1: Denominator
\( V_{d_{\text{urea}}} \): Volume of distribution of urea

- Total body water: \( \approx 0.6 \times \text{weight} \)
- Watson
  - Men: \( V = 2.447 + 0.3362 \times \text{weight (kg)} + 0.1074 \times \text{height (cm)} - 0.09516 \times \text{age} \)
  - Women: \( V = -2.097 + 0.2466 \times \text{weight (kg)} + 0.1069 \times \text{height (cm)} \)
- \( \text{https://qxmd.com/calculate/calculator_344/total-body-water-watson-formula} \)

Variable #2: Time

- 4-hour standard?
- Patient acceptance
- Patient autonomy
- Customary practice
- Resource limitations
- Cost

Variable #3: \( K_{d_{\text{urea}}} \)

\( K \) depends on \( Q_b, Q_d, \) and \( K_{oA} \):
Clearance: Role of the AV Access

- AV access flow rate ($Q_a$) 150% desired dialysis pump speed ($Q_b$)

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<th>AV Access Flow Rate ($Q_a$)</th>
<th>Desired Dialysis Pump Speed ($Q_b$)</th>
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<tr>
<td>150% $Q_b$</td>
<td>$Q_b = 300$ ml/min, $K=270$ ml/min</td>
</tr>
<tr>
<td></td>
<td>$Q_b = 500$ ml/min, $K=410$ ml/min</td>
</tr>
</tbody>
</table>

Limiting factors: Pump-speed

- Negative Arterial Pressure
- Overstated concern
- Low risk at pressures allowed by current machine technology
- Rarely clinically significant

Dialysis pump-speed vs. needle size

- **Match Needle Gauge to Blood Flow Rate (BFR)**
  - **Needle Gauge** | **Maximum BFR** |
  - 17-gauge         | < 300 ml/min    |
  - 16-gauge         | 300-350 ml/min  |
  - 15-gauge         | 350-450 ml/min  |
  - 14-gauge         | > 450 ml/min    |

- 2 mm Radial artery
  - Access flow: 450 ml/min
  - Needle size: 17 gauge

- Large brachial artery: 5-6 mm
  - Access flow: >2000 ml/min
  - Needle size: up to 14 gauge
One-size does not fit all:
Scaling the dialysis circuit to patient