Optimal Use of Vascular Access:
What to Know? What to Do?

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Disclosure

Speaker name: Prof. Bernard Canaud

- I have the following potential conflicts of interest to report:
  - Consulting
  - Employment in industry (FMC)
  - Shareholder in a healthcare company
  - Owner of a healthcare company
  - Other(s)
  - I do not have any potential conflict of interest
Outlook of presentation

Vascular Access for Hemodialysis
From a Nursing Perspective

What to Know?

What to Do?

Optimize VA Performances
What to know?

• Vascular access characteristics
• Extracorporeal blood flow
  – Treatment time
  – Blood volume processed
• Recirculation
  – Catheter versus AVF or AVG
• Vascular access blood flow
• Pressure regime
  – Resistance
• Closure time
What to know?

- Vascular access characteristics
  - Extracorporeal blood flow
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Characteristics of Good Vascular Access for Dialysis

• Easy and friendly to use
• Deliver adequate blood flow
  - Treatment time - Dialysis modality
• Sustain performances
  - Blood flow - Recirculation - Pressure
• Ensure treatment adequacy
  - Kt/V - Convective volume
• Reduce morbidity
  - Low cost of maintenance
Vascular Access Is A Daily Concern For CKD Patients

Temporary/Short-Term
- Acute Catheter Untunneled CVC

Permanent/Long-Term
- Chronic Catheter Tunneled CVC
- AV Fistula Autologous
- AV Graft PTFE/Biologic

CVC, Central Venous Catheter
# Main Characteristics of Chronic Vascular Accesses

<table>
<thead>
<tr>
<th>AV Fistula</th>
<th>AV Graft</th>
<th>Tunneled CVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustained blood flow &amp; performances</td>
<td>Limited blood flow &amp; performances</td>
<td>Limited blood flow &amp; performances</td>
</tr>
<tr>
<td>Lowest rate of thrombosis and/or stenosis</td>
<td>Higher rate of thrombosis and/or stenosis</td>
<td>- Intrinsic limitation</td>
</tr>
<tr>
<td>Lowest rate of infection</td>
<td>Higher rate of infection</td>
<td>- Venous access (low pressure)</td>
</tr>
<tr>
<td>Fewest interventions requirement</td>
<td>Higher interventions requirement</td>
<td>Higher recirculation</td>
</tr>
<tr>
<td>Longer access survival rates</td>
<td>Short access survival rates</td>
<td>Higher rate of dysfunction</td>
</tr>
<tr>
<td>Lowest costs of maintenance</td>
<td>Higher costs of maintenance</td>
<td>Higher interventions requirement</td>
</tr>
<tr>
<td></td>
<td>Frequent graft revision &amp; replacement</td>
<td>Higher costs of maintenance &amp; use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Higher rate of infection</td>
</tr>
</tbody>
</table>

**Tunneled CVC**

- Limited blood flow & performances
  - Intrinsic limitation
  - Venous access (low pressure)
- Higher recirculation
- Higher rate of dysfunction
- Higher interventions requirement
- Higher costs of maintenance & use
- Higher rate of infection
Vascular Access Pathway of CKD Patient

Unprepared Incident Patient

Arterio-Venous Fistula

Central Venous Catheter

Arterio-Venous Graft

Prepared Incident Patient

Arterio-Venous Fistula

Central Venous Catheter

Arterio-Venous Fistula
Why they differ in performances?

**Arterio-Venous Access**
- **Arterialized vein or graft**
  - High arterial pressure regime
  - High blood flow
  -Insensitive to hypovolemia
  - Low venous pressure return
  - Low or absence of access recirculation
  - Cardiopulmonary recirculation

**Veno-Venous Access**
- **Central venous catheter**
  - Low central venous pressure regime
  - Low blood flow
  - Sensitive to hypovolemia
  - High venous pressure return
  - Significant access recirculation
  - No cardiopulmonary recirculation
Perfect RadioCephalic AV Fistula
Perfect AV Prosthetic Graft with PTFE
BrachioCephalic Loop
Permcath, Quinton
Right Tip Position of Internal Jugular CVC

SVC-Right Atrium Junction
What to know?

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Effective Blood Flow and Pressure Regime
Effective Treatment Time and Blood Volume Treated

BVT = QB x tHD (liter)

BVT = 380 x 151 = 57.38 l

BVT = 380 x 240 = 91.20 l
What to know?

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Recirculation Phenomenon
Arterio-Venous Access

CardioPulmonary Recirculation

Blood Flow

Dialysate Flow

Uremic Toxins

ICC

ECC
Access Recirculation Phenomenon

Fraction of venous blood cleared back flowing through the vascular access into the arterial needle (%)
No CardioPulmonary Recirculation
Recirculation Phenomenon in Catheter

Purely Recirculation of VA

Recirculation phenomenon has a ‘diluting’ effect on uremic blood concentration that reduces their clearance.

Fraction of cleaned blood reaspirate and mixed to uremic blood
Access Recirculation Measurement Using US Dilution Technique

Krivitski Method
Access Flow Recirculation Measurement Using US Dilution Technique

A blue venous (upper) dilution curve followed by a red (lower) arterial curve. The ratio of the areas under the curves indicates 28% recirculation.
Access Recirculation Increases when EC Blood Flow is Too High Compared to VA Blood Flow

EC Blood Flow > VA Flow
Vascular Stenosis (vein side) Increases Access Recirculation
Vascular Stenosis (arterial) May Not Increase Access Recirculation

When 0% recirculation occurs although access flow is less than delivered blood flow, a mid-graft stenosis limits access flow. Pump flow (Qb) bypasses the stenosis.

Reversing lines creates an artificial recirculation loop with a mixing site at the arterial side of the access, and permits access flow measurement.
Recirculation Measured by HD Machine Using Blood Temperature Sensor (BTM)
Blood Flow and Recirculation
What to know?

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Krivitski Method
Access Flow Measurement

![Graph showing venous and arterial curves with an access flow of 680 mL/min.](12c31e7d247.wdq)

Access Flow

680 mL/min
Consequences of High Vascular Access Flow

- High Output Cardiac Failure
- Distal Ischemia
- Accelerated Atherosclerosis
Cardiac Output Measurement is Also Possible in the Absence of Recirculation

Cardiac Output

\[ 5.4 \, \text{L/min} \]

\[ \text{CI} = 3.1 \, \text{L/min/m}^2 \]

\[ \text{CBV} = 0.8 \, \text{L} \]
Access Flow by Type of Vascular Access

Autologous AV Fistula

RadioCephalic AVF

BrachioCephalic AVF

Distal

Proximal

Measured Access Flow (mL/min)

0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200

Transposed BrachioCephalic
Threshold Access Flow Values for Native AV Fistula

- **Upper Access Flow Threshold**
- **Flow Trending Threshold**
- **Critical Flow Level**

- **Measured Access Flow (mL/min)**
  - 0 to 200: Probably significant stenosis
  - 200 to 600: Potential stenosis
  - 600 to 800: Adequate flow
  - 800 to 2200: Potential cardiac overload

1 ERA-EDTA recommended threshold
Access Flow by Type of Vascular Access

PTFE AV Graft

Loop RadioCephalic AVG
Loop BrachioCephalic AVG
Loop Thigh AVG

Measured Access Flow (mL/min)
Threshold Access Flow Values for PTFE AV Grafts

- **Upper Access Flow Threshold**
  - Probably significant stenosis

- **Flow Trending Threshold**
  - Potential stenosis

- **Critical Flow Level**
  - Adequate flow
  - Potential cardiac overload

**Measured Access Flow (mL/min)**

- 0 to 200
- 200 to 600
- 600 to 800
- 800 to 1000
- 1000 to 1200
- 1200 to 1400
- 1400 to 1600
- 1600 to 1800
- 1800 to 2000
- 2000 to 2200
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Blood Flow and Pressure Regime
Effective blood flux $Q_B$, ml/min (Transonics®)

Prescribed blood flow, $Q_B$, ml/min

AVF

DualCath

10 patients
What to know?

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Prolonged Closure Time
Probable Stenosis on Venous Side

Clinical Meaning

> 5 minutes
Can stenosis

> 10 minutes
Probable stenosis
Enormous Humero-Cephalic AV Fistula

Probable subclavian vein stenosis (subclavian impingement) and high-flow AVF
Enormous Radio-Cephalic AV Fistula

Probable basilic vein stenosis and high-flow AVF
What to Do?

• Clinical assessment of vascular access
• Monitor performances
  – Vascular access
  – Dialysis efficacy
• Optimize extracorporeal blood flow
  – Vascular access type
  – Make right choice of needles
  – Improve cannulation technique
• Alert Nephrologist in case of dysfunction or problem
• Refer to specialist in case of persisting problem
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Clinical Assessment of Vascular Access

Look

Feel

Listen
Non Mature RadioCephalic AV Fistula
What to Do?

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Guideline 4.1. Nurses and medical staff should be involved in vein preservation and monitoring of the vascular access. Every patient with chronic kidney disease should have a declared plan for preserving the vascular access and potential access sites (Evidence level IV).

Guideline 4.2. Any staff involved in handling vascular access or cannulating veins in renal patients should be adequately trained and be in a continuous training scheme for access management (Evidence level IV).

Guideline 4.3. An autogenous fistula should be cannulated when adequate maturation has occurred (Evidence level III).

Guideline 4.4. The rope ladder technique should be used for cannulation of grafts (Evidence level III).
Guideline 5.1. Prior to any cannulation, autogenous arteriovenous fistulae and grafts should be assessed by physical examination (Evidence level IV).

Guideline 5.2. Objective monitoring of access function should be performed at a regular base by measuring access flow (Evidence level II).
### Quantifying Performances of Access

<table>
<thead>
<tr>
<th>Vascular Access Flow</th>
<th>Access Recirculation</th>
<th>Pressure Regime</th>
</tr>
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</table>
| • Ultrasound dilution technique  
  - During HD sessions  
  - Transonic HD monitor  
  - CRIT-Line monitor  
| • Ultrasound dilution technique  
  - During HD sessions  
  - Transonic HD monitor  
  - CRIT-Line monitor  
| • Static pressure measurement  
  - Arterial side  
  - Venous side  
| • Duplex ultrasound technique  
  - During inter HD phases  
  - Portable duplex US device  
| • Temperature dilution technique  
  - During HD sessions  
  - Blood temperature monitor  
| • Temperature dilution technique  
  - During HD sessions  
  - Blood temperature monitor  
| • Dynamic pressure measurement  
  - Arterial side  
  - Venous side  
| • Ionic dialysance technique  
  - During HD sessions  
  - Ionic dialysance monitor  
| • Ionic dialysance technique  
  - During HD sessions  
  - Ionic dialysance monitor  
| • Glucose dilution technique  
  • Dye dilution technique ...  
| • Glucose dilution technique  
  • Dye dilution technique ...  
| • Dye dilution technique  
  • Dye dilution technique ...  

- **Static pressure measurement**
- Arterial side
- Venous side
- During HD session

- **Dynamic pressure measurement**
- Arterial side
- Venous side
- During HD session
Dialysis Efficacy Monitoring, $K_t/V$

Urea/Ionic Dialysance

\[
\frac{K_t}{V} = -\ln\left(\frac{R-0.008 \cdot t}{4-3.5 \cdot R}\right) \frac{\Delta BW}{BW}
\]
Effect of Reversing Catheter Lines on Recirculation

Prospective Study
14 pats CKD5-HD
DualCath Jug 9, SClav 5

Level C et al, Blood Purif. 2002; 20:182-188
Maximum Blood Flow and Pressure Regime
What to Do?

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Guidance for Vascular Access Site Needling

Onsite needling guidance by US

VA mapping
Choice of Needles for AVF Cannulation

Back-eye opening allows blood intake from both sides of the needle; can be used as arterial or venous needle.

Arterial needle

Venous needle

Non-back-eye needle—for venous use only
The “Art of Needling”

AV Fistula

Blocking the vein

AV PTFE Graft

Pinching the PTFE
## Match Needle Gauge to Blood Flow Rate (Qb)

<table>
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<tr>
<th>Needle Gauge</th>
<th>Maximum Qb</th>
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<tbody>
<tr>
<td>17-gauge</td>
<td>&lt; 300 mL/min</td>
</tr>
<tr>
<td>16-gauge</td>
<td>300-350 mL/min</td>
</tr>
<tr>
<td>15-gauge</td>
<td>350-450 mL/min</td>
</tr>
<tr>
<td>14-gauge</td>
<td>&gt; 450 mL/min</td>
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VA Surveillance and Decisional Algorithm of Intervention
Pat. Bour. MJ, AV Fistula, Reduction Kt/V

- spKt/V values from 1.00 to 2.50
- DualCath period
- AVF period
- Vascular Exploration indicated
Ultrasound and Doppler imaging

Proximal stenosis on the AV fistula
Phlebography and angioplasty

Proximal stenosis

After angioplasty
Take Home Message

Vascular access is a key component in renal replacement therapy outcomes

- Protect ‘lifeline’ of chronic kidney patient
- Privilege arterio-venous access
- Monitor vascular access performances
- Optimize extracorporeal blood flow
- Improve needling technique
- Implement quality assurance process
To learn more, read the Vascular Access EDTNA...