Optimal Use of High Volume HDF
From a Nursing Perspective

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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
Agenda of the presentation

- Why HDF is necessary in RR options?
- What is HDF?
- What is the target in HDF treatment?
  - Convective dose
- What are the factors implicated?
  - Patient-dependent factor
  - Technical-dependent factor
  - Nurse-dependent factor
- Where are the problems?
- How to fix them?
- Take home message
Agenda of the presentation

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- Take home message
Side effects of conventional hemodialysis

Maltolerance of dialysis sessions

Intradialytic Hypotension

Poor Quality of Life

Cardiac Stunning

Stroke

Gut ischemia - Translocation
Limits of conventional hemodialysis

Dialysis-related pathology

Bar chart showing annual crude mortality: Japan, 6.6%; Europe, 15.6%; USA, 21.7%.
Dialysis dose (Kt/V) is recognised as being far below uremic patient needs.

**Diffusive Dose**

**Kt/V or Total Kt**

**Dialysis Adequacy**

**Na & H₂O Removal UF/Dry Weight**
Advancing therapy is a necessity

“WE CANNOT SOLVE OUR PROBLEMS WITH THE SAME THINKING WE USED WHEN WE CREATED THEM”

Albert Einstein
Mimicking native kidney functions

Native Kidney, Nephron

Artificial Kidney, Hemodiafiltration

Convection (C)

Diffusion (D)
Agenda of the presentation

• Why HDF is necessary as RR option?
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• Take home message
Components of solute clearances and dialysis modality

- **Low Flux HD**
- **High Flux HD**
- **HDF**
- **HF**

### Diffusive Permeability (KoA)
- **Diffusion**
- **Q_d & t_{HD}**
- **Convection**
- **Sieving Coefficient (SC)**

<table>
<thead>
<tr>
<th>Solute</th>
<th>Molecular Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>(60)</td>
</tr>
<tr>
<td>Vit B12</td>
<td>(1355)</td>
</tr>
<tr>
<td>Inulin</td>
<td>(5200)</td>
</tr>
<tr>
<td>B2-Microglobulin</td>
<td>(11800)</td>
</tr>
<tr>
<td>Albumin</td>
<td>(66000)</td>
</tr>
</tbody>
</table>
## Treatment Schedule
- HDF postdilution
- FX800
- x 3 ses. per week
- 4 hours
- QB = 400 ml/min
- QD = 500 ml/min
- QSUB = 100 ml/min
- Weight Loss = 2.5 L
- Anticoagulation: Fragmin 5000 IU
- Dialysate electrolytes
- iKt = 200 ml/min

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of blood treated per session</td>
<td>96 L / ses.</td>
</tr>
<tr>
<td>Amount of blood cleared per session of urea</td>
<td>48 L / ses.</td>
</tr>
<tr>
<td>Total Substitution Volume</td>
<td>24 L / ses.</td>
</tr>
<tr>
<td>Total Ultrafiltration Volume</td>
<td>26.5 L / ses.</td>
</tr>
<tr>
<td>Amount of blood cleared per session of β-2M</td>
<td>15.9 L / ses.</td>
</tr>
</tbody>
</table>

### Calculations
- Amount of blood treated per session:
  \[ 400\text{ml/min} \times 240\text{min} = 96\text{L} / \text{ses.} \]
- Amount of blood cleared per session of urea:
  \[ 200\text{ml/min} \times 240\text{min} = 48\text{L} / \text{ses.} \]
- Total Substitution Volume:
  \[ 100\text{ml/min} \times 240\text{min} = 24\text{L} / \text{ses.} \]
- Total Ultrafiltration Volume:
  \[ 24 + 2.5 = 26.5\text{L} / \text{ses.} \]
- Amount of blood cleared per session of β-2M:
  \[ 26.5 \times 0.6 = 15.9\text{L} / \text{ses.} \]
How to define online hemodiafiltration?

- Combine **diffusive & convective** solute transport.

- **Use of a high-flux membrane:**
  - Ultrafiltration coefficient > 20 mL/h/mm Hg/m²
  - Sieving coefficient (SC) β2-microglobulin > 0.6.

- **Achieve an ultrafiltration volume of at least 20% of the total blood volume processed.**
Agenda of the presentation

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  - Convective dose
- What are the factors implicated?
  - Patient-dependent factor
  - Technical-dependent factor
  - Nurse-dependent factor
- Where are the problems?
- How to fix them?
- Take home message
Increasing Convective Dose: The Way of Enhancing Clearance of Middle Molecules

Convective Dose

Total Ultrafiltration Volume

Diffusive Dose

Kt/V or Total Kt

Patient Metabolic Needs

Dialysis Adequacy

Adequate Removal Middle Molecules

Na & H₂O Removal UF/Dry Weight
DOPPS Introduces the “Convective Dose” Concept

European Results from DOPPS

Evidence of OL-HDF survival benefit has been accumulating steadily, now capped by the ESHOL study.

Randomized clinical trials in Europe

- **Dutch Trial**
  - Open label RCT
  - LF-HD vs HDF
  - 358/356
  - Published

- **Turkish Trial**
  - Open label RCT
  - HF-HD vs HDF
  - 220/228
  - Published

- **Catalonian Trial**
  - Open label RCT
  - HF-HD vs HDF
  - 450/456
  - Published

- **French Trial**
  - Open label RCT
  - HF-HD vs HDF
  - > 65yo
  - 200/200
  - Pending

- **CONTRAST Study**
- **Turkish HDF Study**
- **ESHOL Study**
- **French HDF Study**
## Minimum Threshold Convective Volume Required to Improve CKD Patient Survival Benefit

<table>
<thead>
<tr>
<th>Study</th>
<th>Volume Designation</th>
<th>Substitution Volume per session</th>
<th>Ultrafiltered Volume per session</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DOPPS</strong> Canaud et al.</td>
<td>Substitution volume</td>
<td>&gt; 15 L</td>
<td>17.5 L/ses</td>
</tr>
<tr>
<td><strong>RISCAVID</strong> Panichi et al.</td>
<td>Substitution volume</td>
<td>&gt; 23 L</td>
<td>23 L/ses</td>
</tr>
<tr>
<td><strong>CONTRAST</strong> Grooteman et al.</td>
<td>Convection volume</td>
<td>&gt; 21.95 L</td>
<td>21.95 L/ses</td>
</tr>
<tr>
<td><strong>Turkish OL-HDF</strong> Ok et al.</td>
<td>Substitution volume</td>
<td>&gt; 17.4 L</td>
<td>20 L/ses</td>
</tr>
<tr>
<td><strong>ESHOL</strong> Maduell et al.</td>
<td>Convection volume</td>
<td>&gt; 23 L</td>
<td>&gt; 23 L/ses</td>
</tr>
</tbody>
</table>

HDF Prescription
Total Ultrafiltered Volume (High-Volume HDF): Patient, Practice & Technique

- Dynamic Hemodiafilter Performances
- HDF Machine Performances
- Substitution Volume
  - UF Weight Loss/Gain
  - Total Ultrafiltered (Convective) Volume
- Time & Duration of Sessions
- Effective Blood Flow

How to Quantify HDF Performances?

• The EUDIAL group felt that the **key quantifier for HDF** (in addition to standard adequacy measures) should be **total ultrafiltered volume**.

• When some or all of the replacement fluid is infused upstream of ultrafiltration process (pre-, mid-, or mixed-dilution), the ultrafiltration volume must be **adjusted for the degree of dilution**.

• A measure of serum $\beta_2$-microglobulin clearance or plasma level would also be a logical quantifier of the effect of HDF.

European Dialysis Working Group

Modalities of Substitution in HDF

- Pre-dilution
- Mixed-Dilution
- Post-dilution

Q_B in \rightarrow Q_B out

\textit{Pre-dilution} \quad \textit{Mixed-Dilution} \quad \textit{Post-dilution}
Advantages & Disadvantages of Substitution Modalities

<table>
<thead>
<tr>
<th>Post-dilution HDF</th>
<th>Pre-dilution HDF</th>
<th>Mixed-dilution HDF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pro:</strong></td>
<td><strong>Pro:</strong></td>
<td><strong>Pro:</strong></td>
</tr>
<tr>
<td>• High solute clearance &amp; removal</td>
<td>• Hemodilution</td>
<td>• Avoid drawbacks of both post &amp; pre-dilution methods</td>
</tr>
<tr>
<td>- Small, Middle &amp; High MW solutes</td>
<td>- Decrease protocrit &amp; hematocrit</td>
<td></td>
</tr>
<tr>
<td>• Reduce consumption of substitution volume</td>
<td>- Reduce viscosity &amp; oncotic pressure</td>
<td></td>
</tr>
<tr>
<td><strong>Con:</strong></td>
<td><strong>Con:</strong></td>
<td><strong>Con:</strong></td>
</tr>
<tr>
<td>• Hemoconcentration</td>
<td>• Reduce fibers &amp; membrane fouling</td>
<td>• Require specific hardware equipment</td>
</tr>
<tr>
<td>- Increase protocrit &amp; hematocrit</td>
<td>- Facilitate protein-bound solute clearance &amp; removal</td>
<td>- Two infusion pumps</td>
</tr>
<tr>
<td>- Increase viscosity &amp; oncotic pressure</td>
<td>- Preserve hydraulic &amp; solute membrane permeability</td>
<td>- Specific blood tubing set</td>
</tr>
<tr>
<td>- Fibers and membrane fouling</td>
<td>- Reduce membrane stress</td>
<td>- Require specific software &amp; algorithm</td>
</tr>
<tr>
<td>• Reduce hydraulic &amp; solute membrane permeability</td>
<td>• Reduce solute clearance &amp; removal</td>
<td>- Accounting for hematocrit &amp; protocrit changes</td>
</tr>
<tr>
<td>- Increase transmembrane pressure</td>
<td>- Small &gt; Middle &amp; High MW solutes</td>
<td>- Adjusting post/pre infusion ratio keeping transmembrane pressure in target</td>
</tr>
<tr>
<td>- Reduce sieving coefficient</td>
<td>• Increase consumption of substitution volume</td>
<td>- Increase consumption of substitution volume</td>
</tr>
<tr>
<td>- Fibers clotting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Potential alarms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Increase membrane stress</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Potential albumin leakage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Dilution factor applicable to match performances to postdilution HDF

- Pre-dilution
  - Dilution Factor x 2
  - $Q_B$ in

- Mixed-Dilution
  - Dilution Factor x 1.5

- Post-dilution
  - (Ref)
  - $Q_B$ out

$Q_{UF}$
From Dialyzer Clearance to Body Mass Transfer
Effective Solute Mass Removal

\[ K_D \Sigma D+C+A \text{ (ml/min)} \]

\[ K_B \text{ (mmol/min)} \]

\[ K_B.C_s \text{ (mmol/ses/wk)} \]

Solute Dialyzer Clearance

Solute Body Clearance

Solute Mass Transfer

**Solute**
- Characteristics
  - Membrane Permeability
  - Surface Area - Filter Design

**Dialyzer**
- Characteristics
  - Blood Flow
  - Dialysate Flow
  - Ultrafiltration Flow

**Operational Conditions**
- Effective Treatment Time
  - Frequency
  - Time Duration

**Patient Characteristics**
- Pharmacodynamic
- Pharmacokinetic
- Effective flow/time
- Recirculation...
Agenda of the presentation

• Why HDF is necessary as RR option?
• What is HDF?
• What is the target in HDF treatment?
  – Convective dose
• What are the factors implicated?
  – Patient-dependent factor
  – Technical-dependent factor
  – Nurse-dependent factor
• Where are the problems?
• How to fix them?
• Take home message
Achieving High-Volume HDF: Integrated Approaches in Clinical Practice
### Patient Profile

<table>
<thead>
<tr>
<th>Favorable</th>
<th>Unfavorable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young CKD patient</td>
<td>Elderly, Diabetic, Cardiac patients</td>
</tr>
<tr>
<td>Arterio-Venous Fistula or AV-Graft</td>
<td>Central venous catheter</td>
</tr>
<tr>
<td>High vascular access blood flow</td>
<td>Recent AVF or poorly developed AVF</td>
</tr>
<tr>
<td>Large bore needle</td>
<td>Small bore needle or catheter</td>
</tr>
<tr>
<td>Low hematocrit</td>
<td>High hematocrit</td>
</tr>
<tr>
<td>Low protein/albumin</td>
<td>High protein/albumin</td>
</tr>
<tr>
<td>Long treatment time</td>
<td>Short treatment time</td>
</tr>
<tr>
<td>Low ultrafiltration weight loss</td>
<td>High ultrafiltration weight loss</td>
</tr>
</tbody>
</table>

Favorable:

- Young CKD patient
- Arterio-Venous Fistula or AV-Graft
- High vascular access blood flow
- Large bore needle
- Low hematocrit
- Low protein/albumin
- Long treatment time
- Low ultrafiltration weight loss

Unfavorable:

- Elderly, Diabetic, Cardiac patients
- Central venous catheter
- Recent AVF or poorly developed AVF
- Small bore needle or catheter
- High hematocrit
- High protein/albumin
- Short treatment time
- High ultrafiltration weight loss
Convective Dose Adapted to Patient Characteristics
Patient-Dependent Prescription

- **Total Ultrafiltered Volume**
- **Convective Dose**
- **Diffusive Dose**
  - $Kt/V$ or $Kt$

Biochemical Parameters:
- **Body Weight**, kg
- **Body Surface Area**, 1.73 m$^2$
- **Body Mass Index**, kg/m$^2$

**Patient Metabolic Needs**
- Personalized Ultrafiltered Volume
  - a surrogate of convective dose adjusted to patient’s characteristics
Filtration Fraction (FF)
Probing Ultrafiltration Capacity

\[
FF = \frac{Q_{UF}}{Q_B}
\]

\[
Q_P = QB (1 - H)
\]

\[
Q_P = 400 (1 - 0.30) = 280
\]

\[
FF = \frac{100}{280} = 0.36
\]

FF = 100/400 = 0.25

QP = QB (1 - H)
QP = 400 (1 - 0.30) = 280
FF = 100/280 = 0.36

QP = blood flow
QP = plasma flow
Pressure Equilibrium and Ultrafiltration Flow

Blood pressure
Negative UF pressure
Oncotic pressure
Filtration pressure
Trans Membrane pressure
Protein Cake Formation onto the Membrane
Second Membrane Layer - Reduce Ultrafiltration Capacity

1. Blood Flow
2. Ultrafiltration
3. Hematocrit
4. Protein concentration
Effect of Blood Flow on UF Flow
Increase QB increase Shear Stress & Reduce Protein Layer formation

Blood flow plays an important role in achieving the convective volume

**‘Good’ blood flow**

Amount of blood treated per session

100 L / session

416ml/min x 240min

**Filtration Fraction**

FF 0.25

Total Ultrafiltration Volume

25 L / session

**‘Poor’ blood flow**

Amount of blood treated per session

70 L / session

292ml/min x 240min

**Filtration Fraction**

FF 0.37

Total Ultrafiltration Volume

25 L / session
Ultrafiltration Flow, Trans Membrane Pressure
Manual Mode and Automated Control Mode

Favoring Convective Vol. ‘Efficacy’
Favoring TMP ‘Safety’

Automatic Mode
AutoSub+
Target Range
Innovative Technology & Intelligent HDF Machine Facilitate Achievement of High Convective Volume

Continuous analysis of hemorheological conditions

Continuous adaptation of ultrafiltration flow

Filtration Fraction $= \frac{Q_{UF}}{Q_B}$ in %

AutoSub plus with FX CorDiax
Automatic Control of Ultrafiltration by AutoSub Plus Increases Filtration Fraction and Convective Volume

Automatic Control of Ultrafiltration Increases Convective Volume

<table>
<thead>
<tr>
<th></th>
<th>FX Cordiax 60</th>
<th>FX Cordiax 600</th>
<th>FX Cordiax 800</th>
<th>FX Cordiax 100</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patients (N)</strong></td>
<td>325</td>
<td>2572</td>
<td>121</td>
<td>464</td>
<td>3315</td>
</tr>
<tr>
<td><strong>Sessions (N)</strong></td>
<td>10022</td>
<td>78177</td>
<td>3740</td>
<td>4888</td>
<td>106827</td>
</tr>
<tr>
<td><strong>Dialyzer surface area (m²)</strong></td>
<td>1.40</td>
<td>1.60</td>
<td>2.00</td>
<td>2.20</td>
<td>1.63±0.19</td>
</tr>
<tr>
<td><strong>Blood flow (mL/min)</strong></td>
<td>352±54</td>
<td>361±70</td>
<td>381±68</td>
<td>386±70</td>
<td>379±68</td>
</tr>
<tr>
<td><strong>Dialysate flow (mL/min)</strong></td>
<td>434±54</td>
<td>400±67</td>
<td>398±54</td>
<td>447±69</td>
<td>407±69</td>
</tr>
<tr>
<td><strong>Treatment Time (min)</strong></td>
<td>241±11</td>
<td>255±19</td>
<td>260±20</td>
<td>263±18</td>
<td>253±19</td>
</tr>
<tr>
<td><strong>Kt/V</strong></td>
<td>1.61±0.42</td>
<td>1.89±0.45</td>
<td>1.64±0.33</td>
<td>1.97±0.51</td>
<td>1.85±0.45</td>
</tr>
<tr>
<td><strong>Substitution fluid volume</strong></td>
<td>22.6±4.3</td>
<td>24.8±4.6</td>
<td>25.0±3.9</td>
<td>31.6±7.2</td>
<td>24.8±6.2</td>
</tr>
<tr>
<td>(L/treatment)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Convection volume</strong></td>
<td>25.1±4.1</td>
<td>27.3±4.6</td>
<td>28.1±3.9</td>
<td>37.0±6.7</td>
<td>27.4±6.3</td>
</tr>
<tr>
<td>(L/treatment)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mean Filtration Fraction</strong></td>
<td>29.6±3.9</td>
<td>28.0±3.8</td>
<td>30.3±3.8</td>
<td>32.2±4.4</td>
<td>28.3±4.1</td>
</tr>
<tr>
<td>(%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sessions with</strong></td>
<td>70.2</td>
<td>84.4</td>
<td>89.7</td>
<td>92.8</td>
<td>81.5</td>
</tr>
<tr>
<td><strong>substitution fluid volume ≥ 21 L (%)</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Total Ultrafiltered Volume: Convective Dose
Patient, Practice & Technique

HDF Machine Performances

Blood Flow

Interaction

Hemodiafilter Performances

Substitution Volume

Total Ultrafiltered Volume (Convective)

UF Weight Loss

Time & Duration of Sessions

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- Why HDF is necessary as RR option?
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  - Nurse-dependent factor
- Where are the problems?
- How to fix them?
- Take home message
Typical Difficulties

• Insufficient blood flow
• Unsuitable hemodialyzer
• Inappropriate anticoagulation
• Unfavorable hemorheologic conditions
• Inadequate HDF prescription
## Insufficient blood flow

<table>
<thead>
<tr>
<th>Problems</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent non-mature fistula</td>
<td>Increase treatment time</td>
</tr>
<tr>
<td>Small size needles</td>
<td>Change needle size</td>
</tr>
<tr>
<td>Small dialysis catheter</td>
<td>Improve vascular access performances</td>
</tr>
<tr>
<td>Low blood flow fistula</td>
<td>Remove catheter</td>
</tr>
<tr>
<td>Central venous catheter</td>
<td>Change HDF modality</td>
</tr>
<tr>
<td>Cardiac failure</td>
<td>- Pre-dilution</td>
</tr>
<tr>
<td>Elderly</td>
<td>- Mixed-Dilution</td>
</tr>
</tbody>
</table>
The Mode of Substitution Matters

Post-Dilution HDF:  
*as reference*

Pre-Dilution HDF:  

Post-Dilution  

Mixed-Dilution HDF:  
*as alternative*

Pre-Dilution  

Post-Dilution  

Choice Depends on Patient Hemorheology and Clinical Performance
Hemodiafilter vs hemodialyzer design

High Internal Resistance Favors Internal Back Transport Phenomenon is Not Suitable for Hemodiafiltration

FX.0
FX60
FX80
FX100

Low Internal Resistance Reduces Internal Back Transport is Favorable for Hemodiafiltration

FX.00
FX600
FX800
FX1000
Regular Internal Hemodialyzer
Minimal Back Transport Phenomenon

UF Balancing System
Zero UF

Blood Pressure
Dialysate Pressure

ΔP [mmHg]

Ultrafiltration
Backfiltration

Dialyzer

0
L/2
L
Forced Internal Hemodiafiltration:
Back Transport Phenomenon

Revised UF Balancing System

Zero UF

Blood Pressure
Dialysate Pressure

ΔP [mmHg]

Ultrafiltration
Backfiltration

Dialyzer

0
L/2
L
Inappropriate Anticoagulation
Clotted Hemodiafilters
Anticoagulation of Extracorporeal Circuit

Right Way of Injection LMWH

Wrong Way of Injection LMWH

LMW loss (20-30%)
# Inappropriate Anticoagulation

## Problems
- No anticoagulation
- Insufficient heparin dosage
- Loss of low molecular weight heparin
- Inflammation
- Thrombocytosis
- Clotting disorder

## Solutions
- Introduce low dose heparin
- Propose citrate-calcium anticoagulation
- Revise heparin dosage
- Infuse low molecular weight heparin into the venous side
- Correct inflammation
- Explore coagulation disorder
Not All CKD Patients Are the Same
Unfavorable hemorheologic conditions
Protein Concentration and Oncotic Pressure Relationship

![Graph showing the relationship between protein concentration (g/l) and oncotic pressure (mmHg). The graph includes a line representing normal plasma and another line predicted by van't Hoff's law.]
## Unfavorable hemorheologic conditions

<table>
<thead>
<tr>
<th>Problems</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>High hematocrit</td>
<td>Increase treatment time</td>
</tr>
<tr>
<td>High protein/albumin</td>
<td>Change HDF modality</td>
</tr>
<tr>
<td>High fibrinogen</td>
<td>- Pre-dilution</td>
</tr>
<tr>
<td>High lipid (lactescent)</td>
<td>- Mixed-Dilution</td>
</tr>
<tr>
<td>Inflammation</td>
<td>Treat inflammation</td>
</tr>
<tr>
<td>Hematologic disorder</td>
<td>Treat hematologic disorder</td>
</tr>
</tbody>
</table>
Total Ultrafiltered Volume : Convective Dose
Patient, Practice & Technique

- Patient Profile
- Hemodiafilter & HDF Machine Performances
- Interaction

Substitution Volume
+ UF Weight Loss

- Total Ultrafiltered (Convective) Volume
- Blood Flow
- Time & Duration of Sessions

Canaud B et al, Blood Purif. 2013
## Implementing Best Clinical Practices Improve Success Rate

<table>
<thead>
<tr>
<th>Study</th>
<th>Volume Designation</th>
<th>Threshold Volume for Survival Benefit</th>
<th>% Patients Achieving Threshold Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DOPPS</strong> Canaud et al.</td>
<td>Substitution volume</td>
<td>&gt; 15 L</td>
<td>n.a.</td>
</tr>
<tr>
<td><strong>RISCAVID</strong> Panichi et al.</td>
<td>Substitution volume</td>
<td>&gt; 23 L</td>
<td>n.a.</td>
</tr>
<tr>
<td><strong>CONTRAST</strong> Grooteman et al.</td>
<td>Convection volume</td>
<td>&gt; 21.95 L</td>
<td>33%</td>
</tr>
<tr>
<td><strong>Turkish OL-HDF</strong> Ok et al.</td>
<td>Substitution volume</td>
<td>&gt; 17.4 L</td>
<td>~50%</td>
</tr>
<tr>
<td><strong>ESHOL</strong> Maduell et al</td>
<td>Convection volume</td>
<td>&gt; 23 L</td>
<td>90%</td>
</tr>
</tbody>
</table>
Agenda of the presentation

• Why HDF is necessary as RR option?
• What is HDF?
• What is the target in HDF treatment?
  – Convective dose
• What are the factors implicated?
  – Patient-dependent factor
  – Technical-dependent factor
  – Nurse-dependent factor
• Where are the problems?
• How to fix them?

• Take home message
Take home message

- **HDF is not a generic term** applicable to all convective renal replacement modalities
- **HDF efficacy** and improved outcomes rely on the achievement of a target ultrafiltration volume as surrogate of convective dose
- **HDF** relies on adequate prescription
- **HDF** implementation is facilitated by technology, machines and filter design
- **HDF** optimal achievement relies on nurse and skill expertise
- **HDF** quantification of performances is easy (convective volume)
- **HDF** should comply with best clinical practices