The Landscape of Dialysis Innovation

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• Epidemiology and unmet needs
• Measuring and improving dialysis quality
• Changing societal landscape supports innovation
• Technological innovation is underway at last
Purchasing Power and Use of Renal Replacement Therapy

Kidney failure imposes a substantial burden for individuals and population health.
History of dialysis ‘adequacy’ as a quality measure

1960s
- Eradication of uremic manifestations
  - Symptoms
  - Hypertension
  - Adequate “rehabilitation”

Early 1970s
- Advent of objective measurement of dialysis dose
  - Nerve conduction velocity
  - Albumin > 3.0g/L
  - Hct >20% without transfusion

Late 1970s
- “Middle molecule” theory
- Eventual mainstream adoption of urea kinetics

Why urea kinetics?

Dialysis most effectively removes small solutes – urea is one example.

Blood urea accumulates in patients with kidney failure.

Easily measured.

Assumption that other toxins correlated with urea generation.

Data from 1970s that high BUN actually does cause symptoms.

HEMO Study: Survival By Dose-Flux Combination

Eknoyan et al, NEJM, 2002
High Burden of Residual Symptoms

Davison, '06  Weisbord, '07  Weisbord, '08  Abdel-Kader, '09  Son, '09

Number of Symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>US vs. Italy</th>
<th>Depressed vs. Not Depressed</th>
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<tr>
<td>Davison, '06</td>
<td>N=507</td>
<td>7.5</td>
</tr>
<tr>
<td>Weisbord, '07</td>
<td>N=160</td>
<td>9</td>
</tr>
<tr>
<td>Weisbord, '08</td>
<td>N=136</td>
<td>9  14</td>
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<tr>
<td>Abdel-Kader, '09</td>
<td>N=90</td>
<td>11.2</td>
</tr>
<tr>
<td>Son, '09</td>
<td>N=146</td>
<td>18  10.9</td>
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Edmonton Dialysis Symp. Index

Dialysis Symp. Index
SONG-HD Initiative: Patient and Caregiver Preferences
Summary of Prioritization Efforts

Rehabilitation in Kidney Disease

*a promise unfulfilled*

“If the treatment of chronic uremia cannot fully rehabilitate the patient, the treatment is inadequate.”

Belding Scribner, 1963

2002 Albert Lasker Research Award
What could rehabilitation look like?
Dialysis Frequency Determines Toxin Levels
The Case for More Continuous Therapy

![Graph showing solute concentration over time for different dialysis frequencies: 3x, 6x, 12x, and continuous. The graph indicates that more frequent dialysis (higher number of sessions) results in lower peak and average pre-dialysis solute concentrations compared to less frequent dialysis.]
Portable/Wearable Artificial Kidney (WAK) — Initial Evaluation

R L STEPHENS, S C JACOBSEN, ELISABET ATKIN-THOR, W J KOLFF
Division of Artificial Organs, University of Utah, Salt Lake City, Utah, USA

Figure 1. Concept of wearable kidney

Figure 2. Diagram of portable wearable kidney
Device pioneers in the 1970s

The 1st insulin pump

The 1st wearable artificial kidney
US Federal Agencies Collaborating to Accelerate Innovation Through Public-Private Partnerships

Advancing American Kidney Health

- Executive Order to Advance American Kidney Health signed on July 10, 2019

- HHS released its strategy to achieve three goals:
  - Reduce the number of Americans developing end-stage renal disease by **25 percent** by 2030.
  - Aim to have **80 percent** of new American ESRD patients in 2025 receiving dialysis in the home, receiving a transplant, or **other alternates**
  - Double the number of kidneys available for transplant by **2030**.
Patient priorities
- Physical symptoms (fatigue, insomnia, cramps, pain)
- Mood symptoms (depression, anxiety, frustration, wash-out)
- Rehabilitation priorities (ability to work, ability to travel, impact on family and friends, mobility)

Top-down efforts (by government agencies, societies, NGOs, etc.)
- Regulatory considerations
- Reimbursement and other financial incentives
- Guidance on product development and clinical end points
- Support for comprehensive kidney care strategies
- Policy considerations

Bottom-up efforts
- Patients
- Researchers and innovators

The goal
- Low-cost options
- Miniaturized devices for greater mobility (wearable, portable, implantable)
- Greener, water-efficient technology
- Technology that more closely mimics kidney function
- Better toxin removal
- Improved mortality and morbidity
- Improvements in physical and mood symptoms
- Robust, safe, complication free
From portable dialysis to a bioengineered kidney

After decades of relative technological stagnation change is underway.

There is growing momentum from patients, nephrologists, payors, regulators and governments to support transformative innovation.

Dialysis technology must become greener, smaller, more affordable, use less water, and be more continuous.

True rehabilitation should be the goal of technology innovation.

It is our collective community responsibility to make change happen for the simple reason that our patients deserve hope for better options.

“The best way to predict the future is to create it.”
Abraham Lincoln