Hemodialysis Vascular Access

How we started
Where we are
How we got here
Where we’re going

Theodore F. Saad, MD, FASDIN
Nephrology Associates, P.A.
Chief, Section of Renal & Hypertensive Diseases
Christiana Care Heath System, Newark DE

tsaad@delawarekidney.com
www.delawarekidney.com
Dialysis Access “Potpourri”

- History
- Medical economics
- Ethics
- Policy/politics
- Clinical science
- New technologies

Highlight areas that our practice and/or Christiana Care colleagues have studied
Heroes of this Story

- Patients
- Families
- Advocates
- Caretakers
- Pioneers
- Politicians
Hemodialysis Vascular Access:

- Essential for everything we do with dialysis
  - Clearance of uremic toxins & electrolytes
  - Volume & BP control
  - Anemia & iron management
  - Phosphorous and bone-mineral management
- Reliable
- Safe
- Comfortable
- Durable
- Cost-effective
Fistula

Catheter

Graft
United States Renal Data System
https://www.usrds.org

• National data system that collects, analyzes, and distributes information about chronic kidney disease (CKD) and end-stage renal disease (ESRD) in the United States.

• All US patients with ESRD included

• Funded by NIH Institute of Diabetes & Digestive & Kidney Diseases (NIDDK)
  • Centers for Medicare & Medicaid Services (CMS)
  • United Network for Organ Sharing (UNOS)
  • ESRD networks

• All data open and publicly available

University of Michigan Kidney Epidemiology and Cost Center
United States Renal Data System
Six Central Goals of USRDS

1. Characterize the ESRD population
2. Describe the prevalence and incidence of ESRD along with trends in mortality and disease rates
3. Investigate relationships among patient demographics, treatment modalities, and morbidity
4. Report the costs of ESRD treatments and total burden of ESRD program in the United States
5. Identify new areas for special renal studies and support investigator-initiated research
6. Provide data sets and samples of national data to support research by the Special Studies Centers
CMS Form 2728
Declaration of ESRD

• Required by CMS for all new ESRD patients
  • Demographics
  • Pre-dialysis care
  • Co-morbidities
  • Dialysis Access
  • Treatment modality
vol 2 Figure 3.6 Trends in vascular access type use among ESRD prevalent patients, 2003-2016

Data Source: Special analyses, USRDS ESRD Database and Fistula First data. Fistula First data reported from July 2003 through April 2012, CROWNWeb data are reported from June 2012 through May 2016. Abbreviations: AV, arteriovenous; CROWNWeb, Consolidated Renal Operations in a Web-enabled Network; ESRD, end-stage renal disease.
The Association of Initial Hemodialysis Access Type With Mortality Outcomes in Elderly Medicare ESRD Patients
Jay L. Xue, DVM, PhD, David Dahl, MD, James P. Ebben, BS, and Allan J. Collins, MD
Mortality Associated with Access Type

Ravani, et al., CJASN 12:955-964, 2017

<table>
<thead>
<tr>
<th>Covariates in each mortality model</th>
<th>Hazard Ratio</th>
<th>HR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1: Baseline access type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graft vs. Fistula</td>
<td>1.33</td>
<td>1.33</td>
<td>[0.96; 1.85]</td>
</tr>
<tr>
<td>Catheter vs. Fistula</td>
<td>2.00</td>
<td>2.00</td>
<td>[1.55; 2.58]</td>
</tr>
<tr>
<td>Model 2: Time-varying complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-infectious (0-90; yes vs. no)</td>
<td>1.99</td>
<td>1.99</td>
<td>[1.48; 2.68]</td>
</tr>
<tr>
<td>Non-infectious (91-180; yes vs. no)</td>
<td>1.27</td>
<td>1.27</td>
<td>[0.96; 1.68]</td>
</tr>
<tr>
<td>Local infection (yes vs. no)</td>
<td>2.23</td>
<td>2.23</td>
<td>[1.43; 3.48]</td>
</tr>
<tr>
<td>Systemic infection (yes vs. no)</td>
<td>3.36</td>
<td>3.36</td>
<td>[2.23; 5.07]</td>
</tr>
<tr>
<td>Model 3: Access type and complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graft vs. Fistula</td>
<td>1.29</td>
<td>1.29</td>
<td>[0.93; 1.79]</td>
</tr>
<tr>
<td>Catheter vs. Fistula</td>
<td>2.01</td>
<td>2.01</td>
<td>[1.56; 2.59]</td>
</tr>
<tr>
<td>Non-infectious (0-90; yes vs. no)</td>
<td>2.11</td>
<td>2.11</td>
<td>[1.57; 2.85]</td>
</tr>
<tr>
<td>Non-infectious (91-180; yes vs. no)</td>
<td>1.35</td>
<td>1.35</td>
<td>[1.02; 1.78]</td>
</tr>
<tr>
<td>Local infection (yes vs. no)</td>
<td>2.13</td>
<td>2.13</td>
<td>[1.37; 3.31]</td>
</tr>
<tr>
<td>Systemic infection (yes vs. no)</td>
<td>3.20</td>
<td>3.20</td>
<td>[2.13; 4.81]</td>
</tr>
</tbody>
</table>
Willem J. Kolff, MD: 1911-2009
“Father of Dialysis”

• Visionary in biomedical technology
• Acute renal failure from GN, sulfa drugs
• 1st successful human dialysis 1945
  • After 14 failures
• Nobel nominee 2003
• Fascinating life & professional history

https://www.rsnhope.org/health-library/know-willem-j-kolff-md-father-dialysis-dialyzer/
Kollf Dialysis Machine 1945
WWII in Occupied Netherlands

- **Frame**: Downed German bomber
- **Tank**: Repurposed bathtub
- **Drum**: Wooden fence slats
- **Dialysis membrane**: 25-30 meters cellophane sausage casing
- **Dialysate**: 75-100L NaCl + glucose
- **Anticoagulation**: Heparin*
- **Power**: Sewing machine motor
- **Access**: Metal needles or glass tubes in artery and/or vein
  - 150-300 ml aliquots drained, dialyzed then returned to patient by gravity

* Newly available since 1930’s; hirudin from leeches proved to be too toxic/difficult
The Artificial Kidney: a dialyser with a great area.

By

W. J. KOLFF, Specialist for internal diseases at the Municipal Hospital of Kampen (The Netherlands);

H. TH. J. BERK, Managing Director of the Kampen Enamel Works, with the collaboration of

NURSE M. ter WELLE; Miss A. J. W. van der LEY;
Messrs. E. C. van DIJK and J. van NOORDWIJK.

(Submitted for publication October 6, 1943).

Fig. 1. A cellophane tube has been wound spirally round an aluminium cylinder. The blood within the cellophane always sinks to the lowest point.
When the drum is rotating the blood moves from left to right.

Fig. 2. I. Connection with dialyser shut off. Burette low: impure blood is flowing from the patient's body into the burette.
II. Tube to patient shut off. Burette high: impure blood is flowing from the burette into the dialyser.
III. Tube to patient shut off. Burette low: purified blood is flowing from the dialyser into the burette.
IV. Connection with dialyser shut off. Burette high: purified blood is flowing from the burette into the patient's body.
70-years After Kolff’s 1st Hemodialysis
Trends in the number of ESRD prevalent cases, by modality, in the U.S., 1980-2015

Data Source: Reference Table D.1. Abbreviation: ESRD, end-stage renal disease.

Scribner Shunt
Belding Scribner, M.D.

• 1960: Seattle, University of Washington
• Cannulae inserted into peripheral artery and vein, connected with Teflon tube
• Semi-permanent exteriorized A-V shunt
• Allowed for long-term hemodialysis
  • Cumbersome and difficult to use
  • Prone to separate between dialyses
  • Infection & thrombosis
  • Destructive to veins & arteries
Clyde Shields
First “Chronic” Hemodialysis Patient

- 39 year-old machinist
- Hemodialysis 1960-71
Christiana Hospital, August 2018
Infection Control: Hepatitis B & C

• Transfusion dependence pre-erythropoietin
  • 1989 Epogen® approved

• Blood borne diseases, hepatitis
  • 1963: “Australia antigen”
    • Hepatitis B Surface Antigen
  • 1969: Hepatitis B vaccine
  • “Non-A, Non-B” hepatitis
  • 1989: HCV

• 1972 European Renal Registry
  • 499 staff contracted hepatitis across 568 renal units in Europe
  • 12 deaths (2.4%)

• Dr. Baruch Blumberg
  • 1976 Nobel Prize in Medicine
“Death Panels” were not part of the ACA
Very real in early days of dialysis

The Scribner Shunt expanded the number of patients who could benefit from hemodialysis, far beyond the limited capacity at Swedish Hospital.

The “Admissions and Policies Committee” of the Seattle Artificial Kidney Center was formed in 1961 to choose which patients would receive hemodialysis

The “God Committee” consisted of seven citizens:
Lawyer, minister, banker, housewife, state govt. official, labor-leader, & surgeon
Selected by the King County Medical Society

We had a big controversy in the United States when there was a limited number of dialysis machines. In Seattle, they appointed what they called a 'God committee' to choose who should get it, and that committee was eventually abandoned. Society ended up paying the whole bill for dialysis instead of having people make those decisions.

— Ezekiel Emanuel —

http://www.ezekielemanuel.com/

“I am 43 years old, married for 20 years, with two children ages 14 and 10.

I was a salesman until a couple of months ago until it became necessary for me to supplement my income to pay for the dialysis supplies. I tried to sell a non-competitive line, was found out, and was fired.

Gentlemen, what should I do? End it all and die? Sell my house for which I worked so hard, and go on welfare? Should I go into the hospital under my hospitalization policy, then I cannot work?

Please tell me. If your kidneys failed tomorrow, wouldn't you want the opportunity to live? Wouldn't you want to see your children grow up?”

Patient advocacy group “American Association of Patients on Hemodialysis” which later became the American Association of Kidney Patients

VP of AAPH, Shep Glazer underwent hemodialysis in the Ways & Means Committee meeting room

Senate kidney amendment was added to H.R. 1 on the Senate floor, with no prior hearings, on a Saturday morning, September 30, 1972.

The joint House-Senate conference committee agreed to the Senate amendment barely two weeks later. On October 30, 1971 the brief kidney provision was included in the 300-page bill signed by then President Nixon.

https://www.nap.edu/read/1793/chapter/6#187
https://aakp.org/our-history
https://www.youtube.com/watch?v=njvGCYrHjfk
ESRD: The first & only disease-specific entitlement to Medicare benefits

“A person with ESRD is entitled to Medicare if he/she is fully or currently insured for benefits under Social Security, or is a spouse or dependent of an insured person”

• 92 percent of all persons with ESRD qualify for Medicare coverage
• Since 1973, the Medicare-ESRD program has functioned as a de facto single-payer national health system
• From the inception of Medicare in 1965 through the creation of the ESRD program in 1972, there was expectation that Medicare expand into a full national health coverage system

“Both liberals and conservatives took for granted that some form of national health insurance would be enacted in the next few years, obviating the need for special funding for patients like Glazer.”

http://pensandneedles.org/the-man-hooked-up-to-the-machine/
Beware of “Experts!”

Experts agreed that the End-Stage Renal Dialysis program might ultimately serve 10,000 people with kidney failure and would cost Medicare about $135 million dollars. They expected many of those on dialysis would return to work — paying taxes that would help cover the costs involved.

The experts were wrong!

12/30/2010: Arthur Caplan, Ph.D., Director of the Center for Bioethics at the University of Pennsylvania.
vol 2 Figure 9.1 Trends in ESRD expenditures, 2004-2015

Data Source: USRDS ESRD Database; Reference Table K.1. Abbreviation: ESRD, end-stage renal disease.
vol 2 Figure 9.2 Trends in costs of the Medicare & ESRD programs, 2004-2015

vol 2 Figure 9.8 Total Medicare ESRD expenditures per person per year, by modality, 2004-2015

Data Source: USRDS ESRD Database; Reference Tables K.7, K.8, & K.9. Period prevalent ESRD patients; includes all claims with Medicare as primary payer only. Abbreviation: ESRD, end-stage renal disease.
Per person per year total expenditures, by access type

Figure 11.22 (Volume 2)

Cost of HD Vascular Access Management

- $2.8 billion dollars/year for pure Medicare patients
- ≈$5 billion dollars/year for all ESRD, commercial, Medicare managed care, & co-pays
- ≈12% of cost for ESRD patient care

vol 2 Figure 4.2 Adjusted all-cause & cause-specific hospitalization rates for ESRD patients, by treatment modality, 2006-2015

(b) Hemodialysis

Admissions per patient year

Year

06 07 08 09 10 11 12 13 14 15

0.0 0.5 1.0 1.5 2.0 2.5

All-cause
Cardiovascular
Infection
Vascular access
Michael Brescia, James Cimino, Kenneth Appel
• Radial artery to cephalic vein
• 14/16 procedures successful
• Unlocked potential for long-term chronic hemodialysis
  • Freed patients from the Scribner shunt

Origins of hemodialysis access connect with palliative care

Before the AV fistula, patients with ESRD were often destined to die in weeks to months

French-fry & ketchup story

Fear of cardiac complications from AV fistula

Altruism over profit

We sat down with Dr. Michael J. Brescia, Executive Medical Director and co-founder of Calvary Hospital, to talk about his experiences at the Catholic palliative care facility and hospice in the Bronx. His kind and warm nature, along with his ability to relate to patients and their families, is a testament to his genuine concern for their well-being. Dr. Brescia has always been a strong advocate for palliative care and hospice services, and he has worked tirelessly to expand these services in the Bronx.

I heard that you were responsible for a famous invention. I joined the VA hospital in the Bronx because they had a lot of patients coming back from Vietnam who were dying of kidney disease. One day I was feeling very desperate; I had about ten men upstairs in the VA. These were all young fellows, but they were all going to die.

I'm down in the lunch shop with my colleague, thinking about the problem. There are two french fries lined up side by side on my plate. I take a bite out of my hamburger and a blob of ketchup falls down perfectly in between the french fries. It was like Gabriel whispering in my ear. "Don't move it! Don't move it! Not yet! There's the answer." I looked at my plate and I thought, "It's like a vein and an artery in the wrist. I wonder...if I connect this vein and artery with a fistula, would this vein, and all the other veins, actually change and become like arteries?"

Then we wouldn't just have one artery; we'd have 200 arteries! We could keep putting the people on the blood-cleansing machine indefinitely! I ran upstairs and said, "We're going to do a fistula." Would you believe it—it worked! That was 50 years ago, and they are still using it.
Dr. Michael Brescia
Lifetime Achievement Award
American Society of Diagnostic & Interventional Nephrology,
Salt Lake City 2008
Vein Preservation
Publications:
PICC Avoidance in CKD Patients at CCHS
Smooth Muscle Proliferation & Neointimal Thickening Of Arteriovenous Grafts & Fistulae

PTFE Graft Venous Anastomosis
Typical Stenosis
Post-PTA 8 mm
8 x 50 mm
FLAIR® Stent Graft
3 Years Post-Stent Graft
No thrombosis, 1-intervention
Stent-Grafts for AV Graft Venous Anastomotic Stenosis

Propective, Randomized, Concurrently-Controlled Study of a Stent Graft versus Balloon Angioplasty for Treatment of Arteriovenous Access Graft Stenosis: 2-Year Results of the RENOVA Study

Ziv J Haskal, MD, FSIR, Theodore F. Saad, MD, Jeffery G. Hoggard, MD, Randy I. Cooper, MD, George S. Lipkowitz, MD, Anwar Gerges, MD, John R. Ross, MD, Timothy A. Pflederer, MD, and Samuel W. Mietling, MD
Figure 3. Survival curve of TAPP.
Drug-Eluting Balloons in Dialysis Access
A Prospective, Multicenter, Randomized, Controlled Study Comparing Lutonix® AV Paclitaxil-coated Balloon PTA Catheter vs. Standard Balloon PTA Catheter for the Treatment of Dysfunctional AV Fistulae

- **Study team**
  - Scott Trerotola, MD, PI
    - University of PA, Radiology
  - Jeff Lawson, MD
    - Duke University, Vascular Surgery
  - Prabir Roy-Chaudhury, MD
    - University of AZ, Nephrology
  - Theodore Saad, MD
    - Nephrology Associates, P.A.

- **Primary endpoints**
  - Target-lesion primary patency @ 6 months
  - Safety: Freedom of access circuit AE @ 30 days

- **Secondary endpoints**
  - TL Primary patency at 12 months
  - Access circuit PP at 6 & 12 months
  - Number of interventions at TL in 12 months

- **285 patients in 25 centers**
  - USA & Canada
Drug Coated Balloon Angioplasty in Failing AV Fistulas
A Randomized Controlled Trial

Scott O. Trerotola,¹ Jeffrey Lawson,²,³ Prabir Roy-Chaudhury,⁴ and Theodore F. Saad,⁵ for the Lutonix AV Clinical Trial Investigators
Lutonix® AV IDE Clinical Trial
Primary Efficacy Endpoint: TLPP @ 180 days

<table>
<thead>
<tr>
<th></th>
<th>LTX DCB (N=141)</th>
<th>Standard PTA (N=144)</th>
<th>Difference % (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>180 Day Event</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate (SE)</td>
<td>71.4% (4.0%)</td>
<td>63.0% (4.1%)</td>
<td>8.4% (6.7%)</td>
<td>NS</td>
</tr>
<tr>
<td>95% CI</td>
<td>(62.7%, 78.4%)</td>
<td>(54.4%, 70.4%)</td>
<td>(-2.8%, 19.6%)</td>
<td></td>
</tr>
<tr>
<td><strong>210 Day Event</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate (SE)</td>
<td>64.1% (4.3%)</td>
<td>52.5% (4.3%)</td>
<td>11.6% (6.0%)</td>
<td>0.024</td>
</tr>
<tr>
<td>95% CI</td>
<td>(55.1%, 71.8%)</td>
<td>(43.9%, 60.5%)</td>
<td>(-0.2%, 23.4%)</td>
<td></td>
</tr>
</tbody>
</table>
“High-maintenance” AVF
Reduced frequency of intervention post-DCB PTA
Cardiovascular Implantable Electronic Devices in Hemodialysis Patients: Prevalence and Implications for Arteriovenous Hemodialysis Access Interventions


*Nephrology Associates, PA, Vascular Access Center, Newark, DE, †Section of Renal & Hypertensive Diseases, Department of Medicine, Christiana Care Health System, Newark, DE, and †Value Institute Christiana Care Health System, John H. Ammon Education Center, Newark, DE

Seminars in Dialysis 2015; 28:94-100

<table>
<thead>
<tr>
<th>TABLE 1. CIED in hemodialysis patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIED</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>ICD</td>
</tr>
<tr>
<td>Pacemaker</td>
</tr>
<tr>
<td>Total CIED</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Undetermined</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Seminars in Dialysis 2015; 28:94-100.
## TABLE 2. Instances of CIED and AV access

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Contralateral</th>
<th>Ipsilateral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instances</td>
<td>137</td>
<td>78</td>
<td>59</td>
</tr>
<tr>
<td>CIED left-sided</td>
<td>101 (74%)</td>
<td>45 (58%)</td>
<td>56 (95%)</td>
</tr>
<tr>
<td>CIED right-sided</td>
<td>36 (26%)</td>
<td>33 (42%)</td>
<td>3 (5%)</td>
</tr>
<tr>
<td>CIED prior to AV</td>
<td>82 (60%)</td>
<td>34 (44%)</td>
<td>48 (81%)</td>
</tr>
<tr>
<td>AV access prior</td>
<td>54 (39%)</td>
<td>44 (56%)</td>
<td>10 (17%)</td>
</tr>
<tr>
<td>to CIED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

## TABLE 3. Intervention rates

<table>
<thead>
<tr>
<th></th>
<th>All (1.48)</th>
<th>Contralateral (1.44*)</th>
<th>Ipsilateral (1.53)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of access</td>
<td>506</td>
<td>261</td>
<td>245</td>
</tr>
<tr>
<td>circuit interventions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(access circuit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rate per AY)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of</td>
<td>145 (0.43)</td>
<td>50 (0.28*)</td>
<td>95 (0.59)</td>
</tr>
<tr>
<td>central venous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>interventions (central</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Seminars in Dialysis 2015; 28:94-100.
Stents for pacemaker or defibrillator lead-associated stenosis
Outcome of stenting central vein stenosis
Saad TF, Myers GR, Cicone JS. *Journal of Vascular Access* 2010; 11: 293-302

Central vein stenosis or occlusion associated with cardiac rhythm management device leads in hemodialysis patients with ipsilateral arteriovenous access: A retrospective study of treatment using stents or stent-grafts

Theodore F. Saad¹, G. Robert Myers², Jeffrey Cicone¹

¹Nephrology Associates, PA, Newark, DE - USA; Vascular Access Center, Newark, DE - USA; Nephrology, Christiana Care Health System Department of Medicine, Newark, DE - USA
²Cardiology, Christiana Care Health System Department of Medicine, Newark, DE - USA

Fig. 2 - Kaplan-Meier graph of post-intervention patency following initial stent or stent-graft placement for treatment of CRMD lead-associated central vein stenosis.
Primary Patency: ...
Primary Assisted Patency: ...
Secondary Patency: ...........
Position Papers re. Cardiac Implantable Rhythm Devices in ESRD Patients

Cardiovascular Implantable Electronic Device Leads in CKD and ESRD Patients: Review and Recommendations for Practice

Theodore F. Saad,* Dirk M. Hentschel,† Bruce Kaplan,‡ Haimanot Wasse,§ Afril Asif,* Daniel V. Patel,*, Loay Salman,† Roger Carrillo†† and Jeff Hoggard,‡‡
ASDIN Clinical Practice Committee Workgroup
*Department of Medicine, Section of Renal and Hypertensive Diseases, Christiana Care Health System, Newark, Delaware, †Interventional Nephrology, Renal Division, Department of Medicine, Brigham and Women’s Hospital, Boston, Massachusetts, ‡Cardiac Arrhythmia Section, Brigham and Women’s Hospital, Boston, Massachusetts, §Department of Medicine, Renal Division, Emory University School of Medicine, Atlanta, Georgia, †Department of Medicine, Division of Nephrology and Hypertension, University of Miami Miller School of Medicine, Miami, Florida, ‡‡Volusia–Flagler Vascular Center, Daytona Beach, Florida, ††Division of Thoracic Surgery (Cardiothoracic Vascular Surgery), Department of Surgery, University of Miami Miller School of Medicine, Miami, Florida, and ‡‡Capital Nephrology Associates, Raleigh, North Carolina

Venous Hemodialysis Catheters and Cardiac Implantable Electronic Devices: Avoiding a High-Risk Combination

Theodore F. Saad* and Henry L. Weinert
*Section of Renal and Hypertensive Diseases, Christiana Care Health System, Newark, Delaware, and †Section of Cardiology, Christiana Care Health System, Newark, Delaware

Seminars in Dialysis 2008; 21: 186-191
Seminars in Dialysis 2017; 30:187-192
Alternative Devices:
Subcutaneous Defibrillator Leadless Pacemaker
Percutaneous Arteriovenous Fistula Creation
Two Newly FDA-Approved Devices

TVA Medical: everlinQ®
https://www.youtube.com/watch?v=tAV9JV8-GxE

Avenu Medical: Ellispsys®
https://www.youtube.com/watch?v=VoRR7LzyPGM
Dialysis is a Medical Miracle: Replicate function of critical organ

- Quality of life
  - Employment
  - School
  - Travel
  - Family
- Cost-effective
  - Covered condition
- Widely available
  - USA & worldwide
- Sustainable
  - Years-decades
Selected References


- Eggers P: Medicare’s End Stage Renal Disease Program. Health care financing review 2000; 22:55-60


• https://www.davita.com/treatment-services/dialysis/the-history-of-dialysis
