

Dialysis History of Innovation

NANT – Tuesday – 2/21/2017

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What is Innovation?

- **The introduction of something new**
 - A device that improves quality, reduces labor, or increases availability (the dialysis machine)
 - A method or procedure that saves time, increases safety or reduces cost (dialyzer reuse automation)
 - Something that deviates from established doctrine or practice (home dialysis)
 - A application of scientific principals to perform a known function in an entirely different manner. (CAPD)

Membrane Innovation

- **In order to dialyze at all, there needs to be a semipermeable membrane to separate the blood from the dialyzing fluid**
- **The development of this membrane occurred indirectly by accident, but innovation took over after that**

The first practical membrane

- 1845 – Friedrich Schoenbeim spills a combination of nitric and hydrochloric acids and wipes it up with his wife's cotton apron.
- The reaction synthesizes cellulose trinitrate (gun cotton).
- He patents the process and forms his own company making the product which proved to be a fairly safe explosive for construction and mining.
- The material is modified by Alfred Nobel of Sweden into a controlled explosive called dynamite.
- Nobel uses his wealth to create the Nobel Prizes.
- Schoenbeim also created cellulose dinitrate which could be dissolved in ether and then dried to make thin films of the material.

The development of Collodion

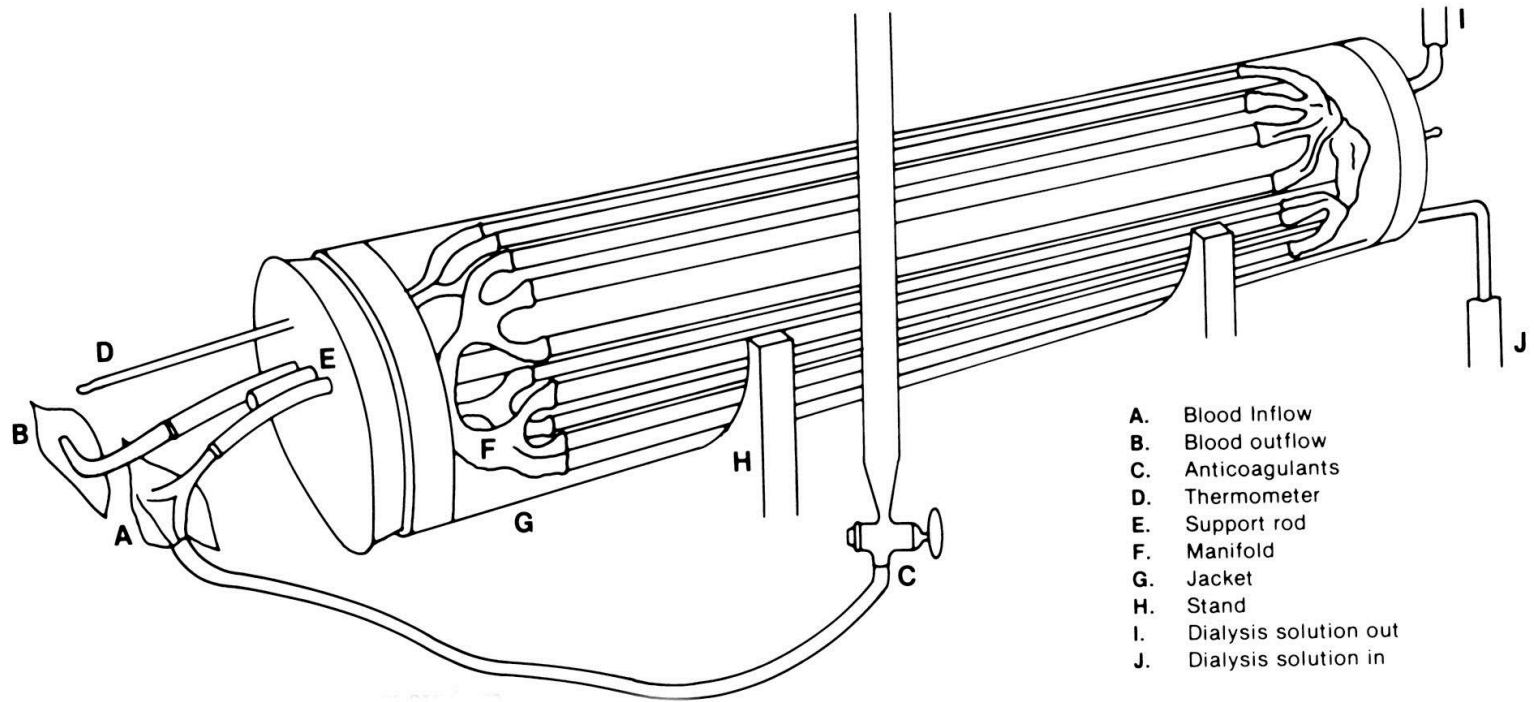
- Sheets of cellulose dinitrate were used as surgical dressings and the basis for photographic film until 1935.
- The material was called “collodion” from the Greek word “*Kolla*” for glue like substance.
- In the laboratory it became known as a good semipermeable membrane and was used by Fick to study diffusion.
- 1913 – It was used by Able, Roundtree, and Turner to perform the first in vivo studies of blood. They made the collodion into tubes by dipping glass rods into the collodion solution.
- 1924 - Haas dialyzed patients using collodion for two years but none of the patients lived.
- 1929 - Collodion was replaced by cellulose acetate when the Visking company in Chicago started making tubes of cellulose acetate for sausage casing.

Abel, Roundtree, and Turner

(1912 –14)

- **The Team:**
 - John Jacob Abel – Pharmacologist
 - Leonard Roundtree – MD
 - Bernard B. Turner - Biochemist
- **The Innovation:**
 - **First artificial kidney apparatus**
 - Able did the chemical analysis
 - Roundtree was the glass blower
 - Turner made the membrane

The First ARTificial Kidney



Equipment Innovation

- **Dr. Kolff's rotating drum dialyzer was a crude device. The drum was made of wood and there was no cover.**
- **Improvement to this system's design to expand its use to more patients was needed**

Kolff, Walter, and Olson (1948)

- **The Team:**
 - Willem Kolff – MD
 - Carl Walter – Surgeon (the “wal” in Fenwal)
 - Edward Olson – Engineer
- **The Innovation:**
 - The Kolff Brigham Kidney

After....

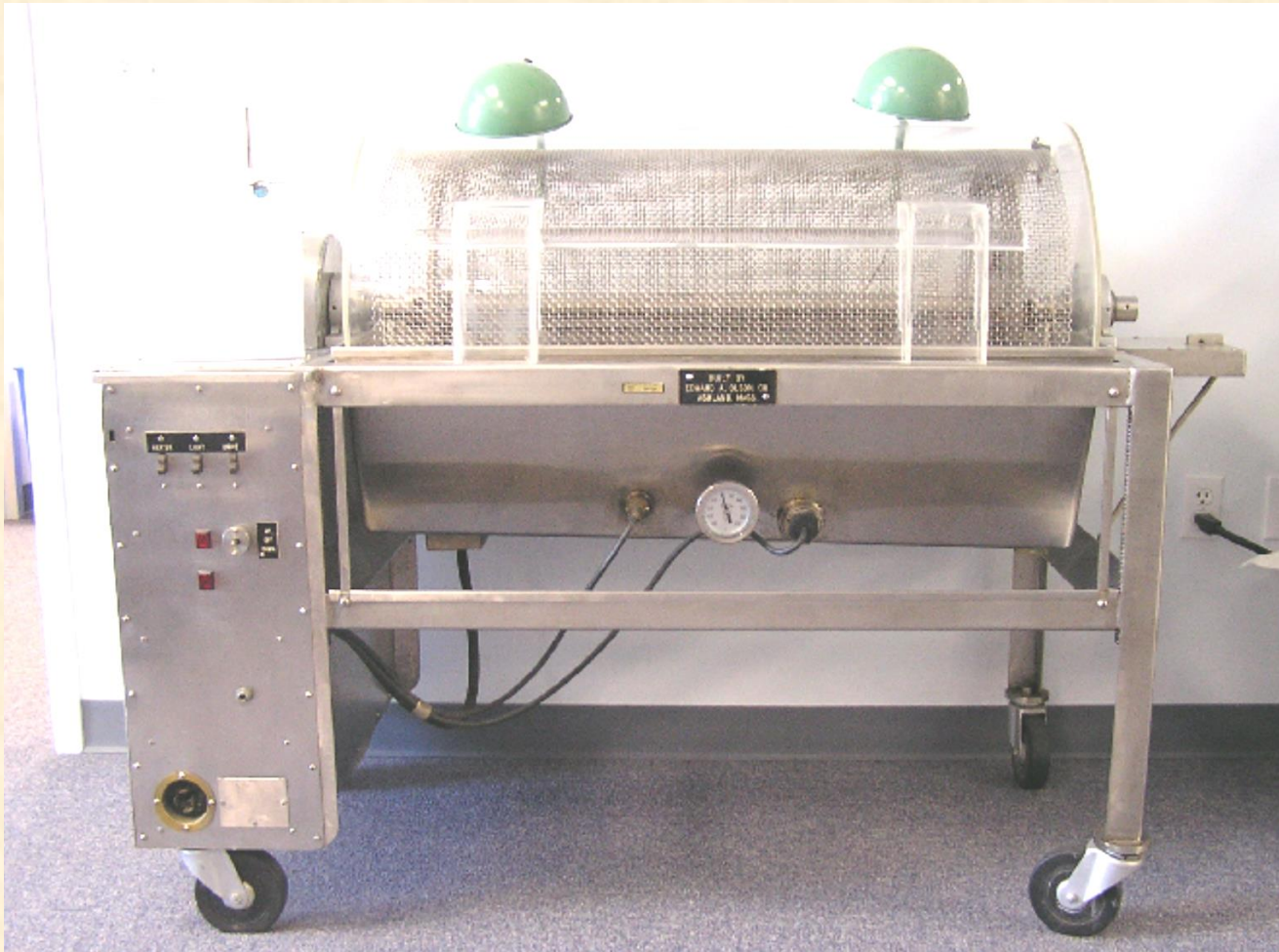
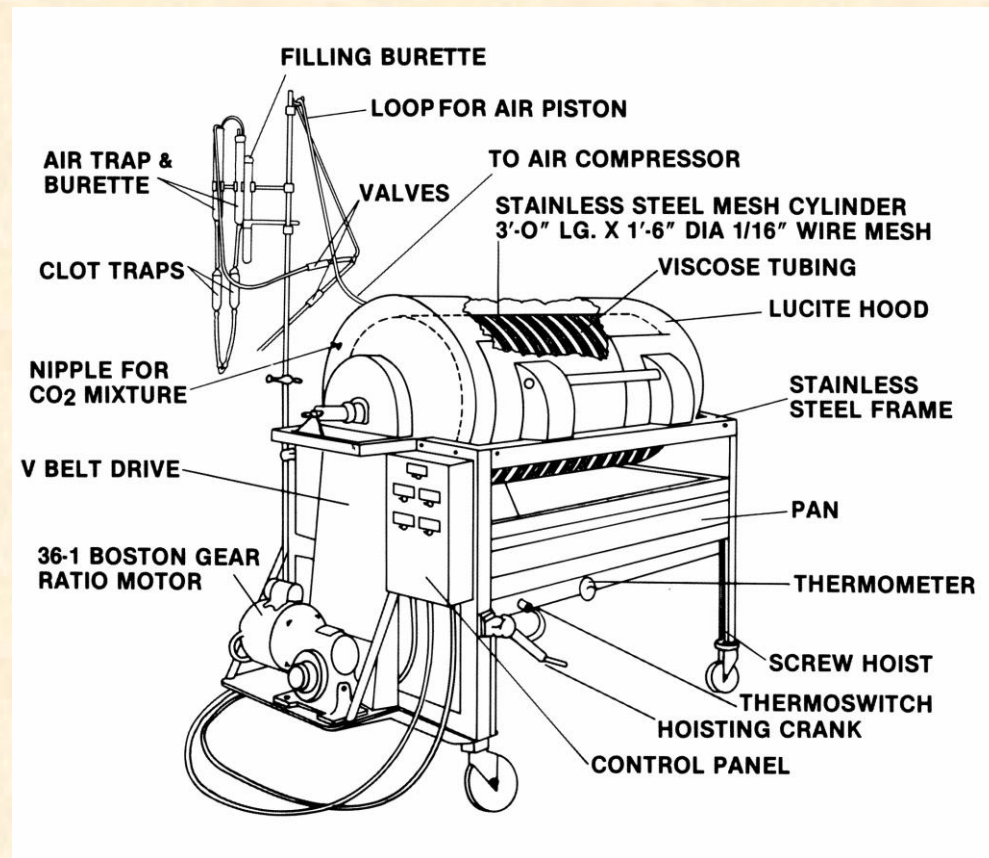


Photo from Global Education Museum – Largo, Florida

The Kolff Brigham Kidney



Reducing the Blood Required for Dialysis

- **The Kolff- Brigham dialyzer was definitely a better mouse trap than the Kolff rotating drum, but it still needed more blood than the patient could provide in order to operate.**
- **Two creative MD's, both from Scandinavian countries, designed dialyzers to address the problem.**

Nils Alwall Dialyzer - 1946

- Created in Lund, Sweden
- Called a vertical drum
- Required a blood pump
- Positive pressure on blood created UFR
- Alwall built 1st dialysis center – 1950
- Founded Gambro - 1964



Fred Kiil Dialyzer - 1960

- Created in Oslo, Norway
- Used cuprophan membrane
- Priming volume = 300 cc
- No blood pump needed if patient had shunt
- Negative pressure on dialysate created UFR
- Scribner used for overnight unattended HD



First mass produced dialyzer and machine

- **Even with “modern” dialyzers like the Kill and Alwall design, there was a need to to have a dialyzer that could be used quickly and conveniently.**
- **In the early 50’s, Kolff traveled to Chicago to see if Abbott Laboratories was interested in manufacturing his latest coil dialyzer design.**
- **Abbott quickly and politely said “no thanks”.**
- **Having some unexpected extra time before his plane back to Cleveland, Kolff took a short cab ride down the street....**

1956

- **Kolff meets William B. Graham, Chemist and Senior Chairman of Baxter Healthcare.**
- **Baxter develops the first disposable coil.**
- **The model number is: U200A**
- **It comes with arterial and venous blood lines for “only” \$59.00.**
- **UA 10 = 100 liter batch tank = \$975.00**
- **UA 11 = Sigmamotor Pump = \$310.00**
- **Date: October 30, 1956**

First complete hardware system



Baxter Dialysis Historical Museum – Largo, Florida

The First Shunt

- **Even in the 1950's access was still a problem. The number of dialysis treatments per patient was limited to the number of access sites a patient could tolerate.**
- **The need for a single site that could be utilized multiple times would enable a patient to live longer and increase the possibility of the return of renal function**

Scribner, Quinton, Shields, Dillard

(March 9th, 1960)

- **The Team:**
 - **Belding Scribner – MD**
 - **Wayne Quinton – Biomed Engineer**
 - **David Dillard – Surgeon**
 - **Clyde Shields - Patient**

- **The Innovation:**
 - **First permanent shunt**

The First Cannula

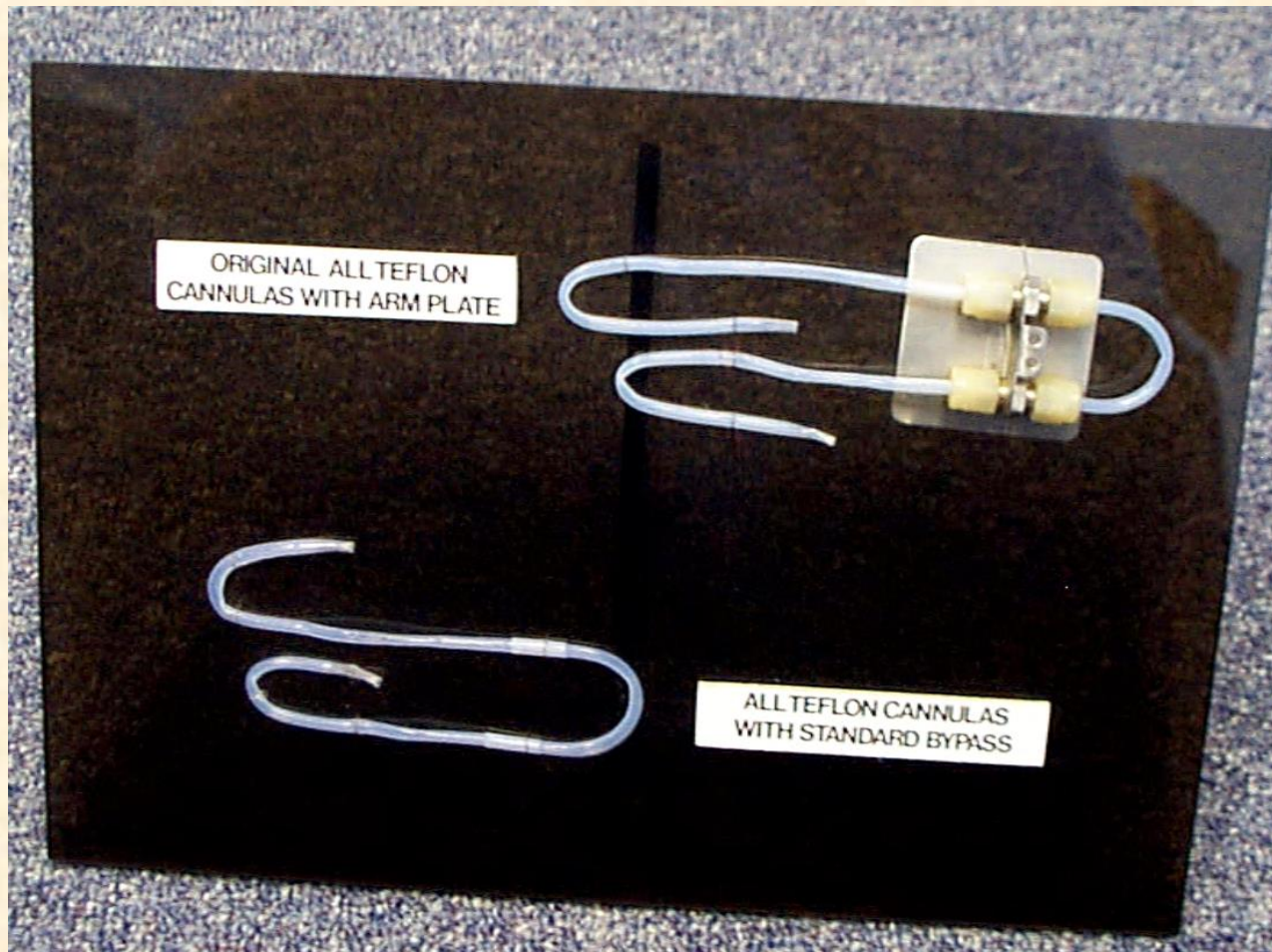
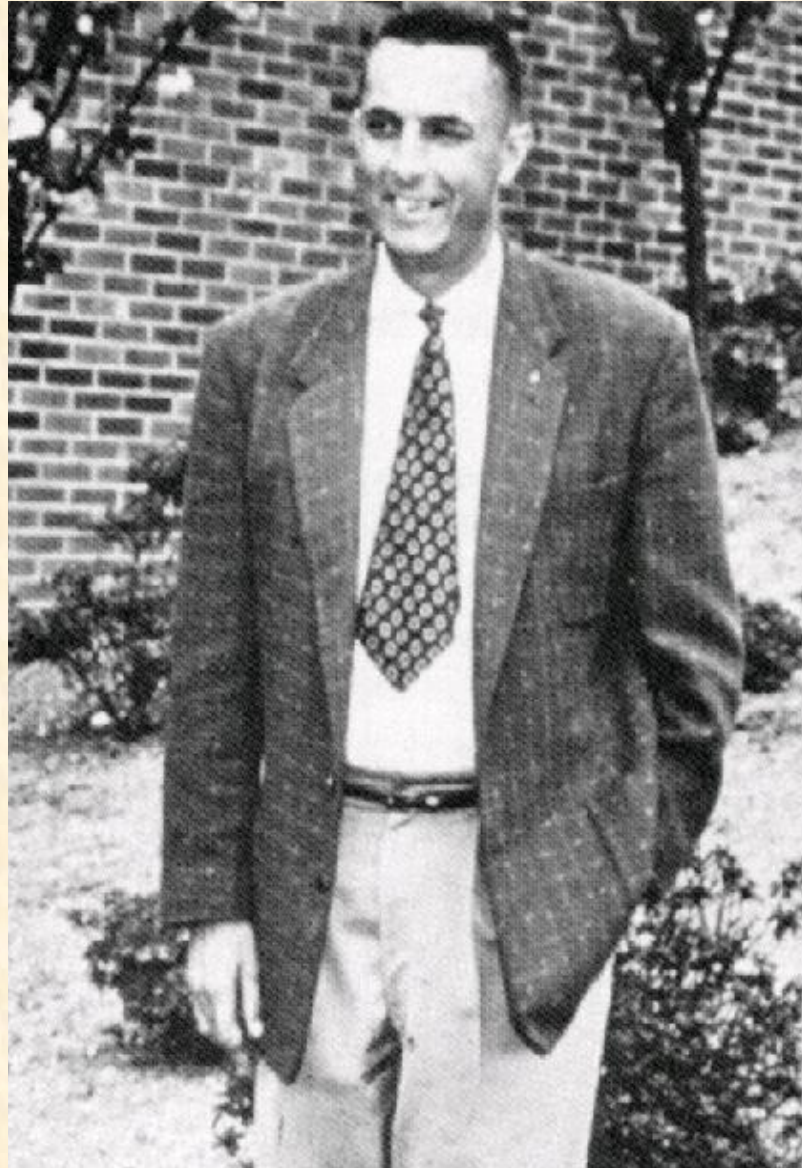


Photo from Global Education Museum – Largo, Florida

Clyde Shields



Quinton, Palmer (1964)

- **The Team:**
 - **Wayne Quinton – Biomed Engineer**
 - **Robert Palmer – MD**
- **The Innovation**
 - **First silicone catheter for PD**

Palmer Catheter

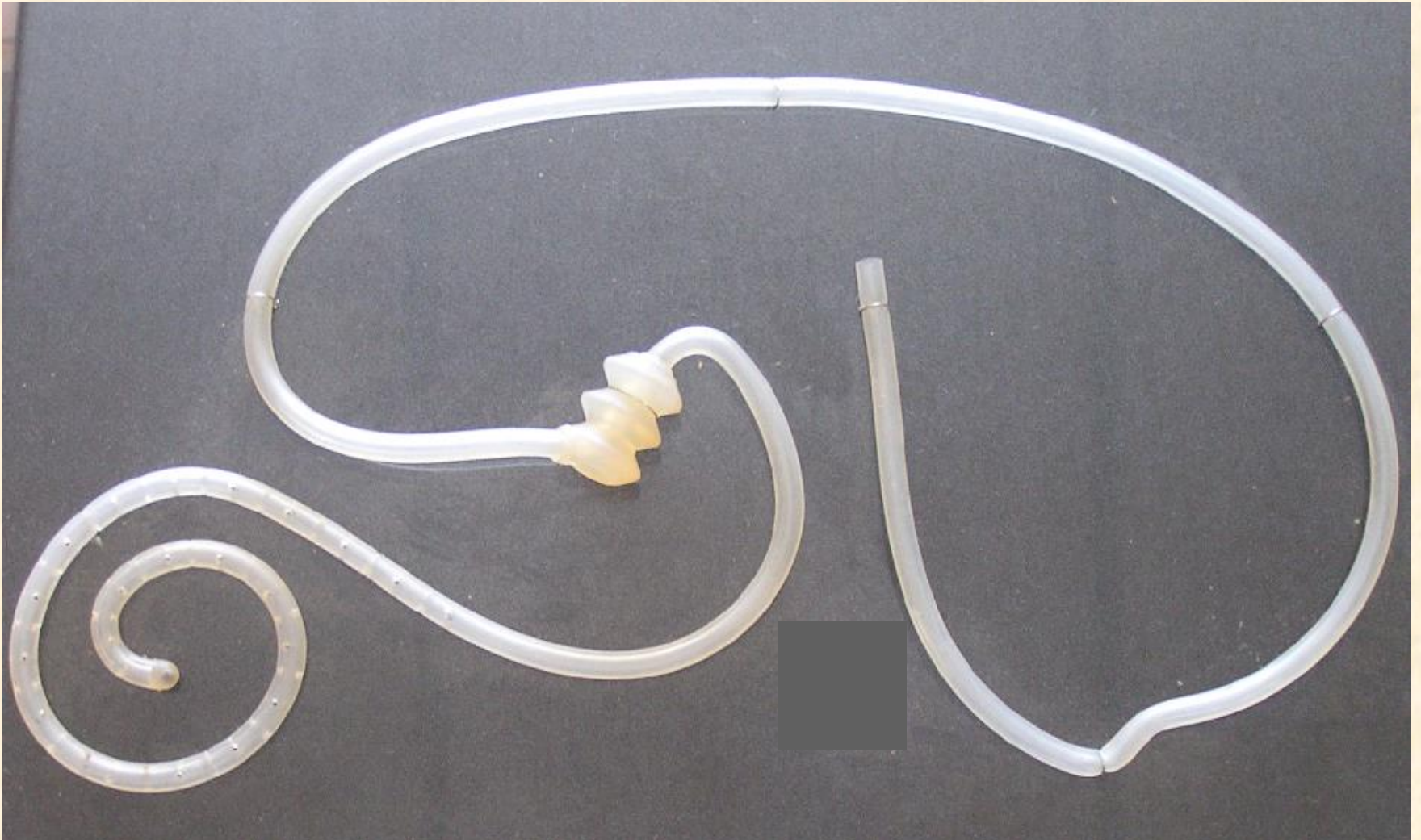


Photo from Global Education Museum – Largo, Florida

The individual dialysis machine

- In the early days of dialysis kidney centers used central dialysis systems. One dialysate chemistry for all patients.**
- As centers reached capacity new patients had to be turned away.**
- The idea that a patient could dialyze themselves was basically unheard of.**
- The need was for an automated machine that a patient could use.**

Scribner, Babb, Helm

(1964)

- **The Team:**
 - **Belding Scribner – MD**
 - **Albert “Les” Babb – Chemical Engineer**
 - **Caroline Helm – 1st Patient**
- **The Innovation:**
 - **First single patient machine**

Albert Leslie Babb



- **Univ. of British Columbia – 1948
B.S. Chemical Engineering**
- **Univ. of Illinois – 1951
PhD – Chemical Engineering**
- **Univ. of Washington – 1961-1981
Head of Nuclear Engineering Dept.**
- **Created 1st Proportioning Dialysis
Machine in 1963**
- **Created 1st Home Dialysis Machine
in 1964**
- **Nominated for Noble Prize in 1977**
- **Professor Emeritus - 1992**

The Mini - I

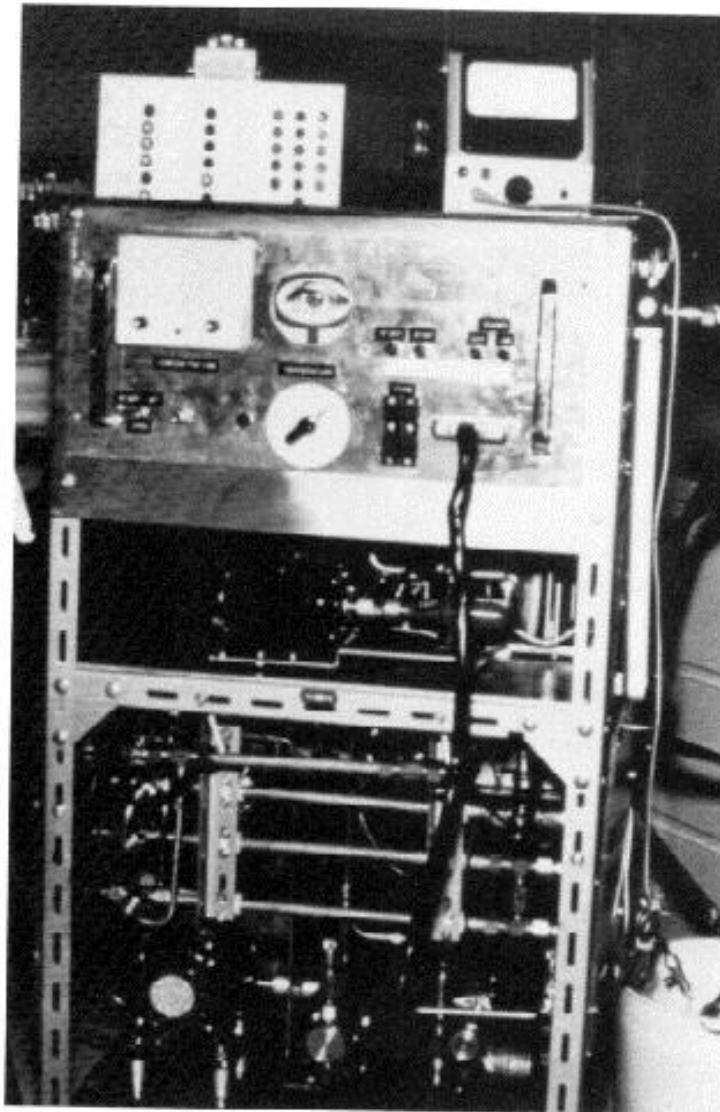


Photo: Genesis of the Artificial Kidney, Pat McBride, Baxter Healthcare, 1987, pg. 77

Caroline Helm and her machine



The 1st Commercial Proportioning HD Machine

- Chronic dialysis creates a large ESRD patient population.
- Mass production of equipment/dialyzers becomes a necessity.
- The collaboration of individuals to fill this need are:
 - **University of Washington**
 - Belding Scribner – Nephrologist, Head of Nephrology Dept.
 - Albert “Les” Babb – Chemical Engineer
 - **Milton Roy Company**
 - Robert T Sheen – Chemical Engineer, Cofounder and CEO
 - John Martin – Mechanical Engineer
- Albert Babb created the prototype and John Martin refined the device to enable mass production.
- The machine was called the Model A. The Model B and Model C would follow over the next 5 years.

Milton Roy Model A - 1965

Solid state logic circuit

Electronics –
“works in a drawer”

Automated
hot water sterilization
system (90°C)

Pre-treatment
alarm testing



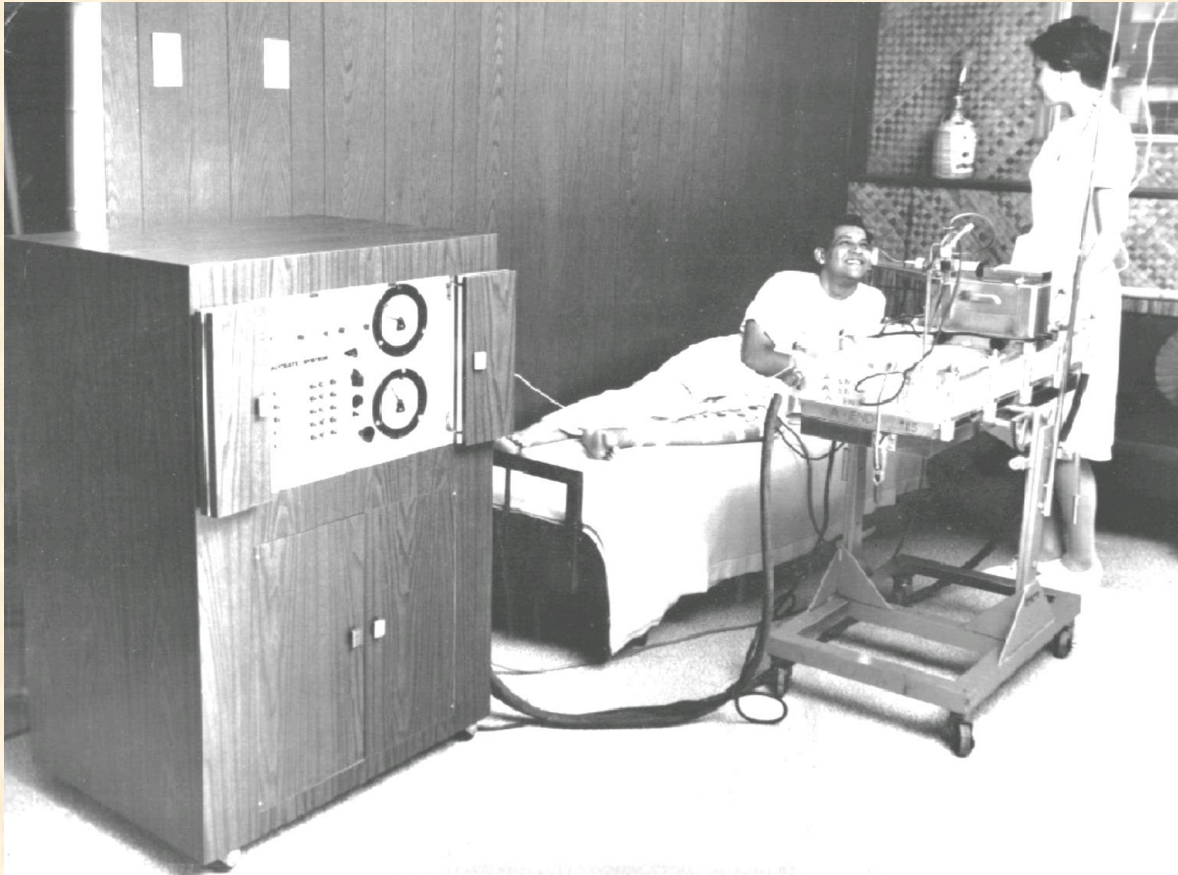
Patient remote control

Wood veneer for that
“furniture” look

Acoustic tile to
reduce noise

Adjustable
Dialysate Prescription

Model A with Patient



Carlos Clar and his wife dialyze at their home in Seattle Washington.
(Milton Roy Annual Report – 1965)

Dialysis Machine Evolution

- **As good as the Model A was it had drawbacks:**
 - **Needed 220 V to run**
 - **Took up a lot of bedroom space**
 - **Sophisticated electronics**
 - **Was expensive (\$7200 in 1965)**
- **What was needed was a “Chevy” to replace the “Cadillac”**

Drake, Willock, Smith (1965)

- **The team:**
 - **Richard Drake – MD**
 - **Charles Willock – Engineer**
 - **Robert Smith - Business**
- **The Innovation:**
 - **DWS Model 4002 Hemodialysis Machine**

DWS Model 4002 (1965)



Photo from Global Education Museum – Largo, Florida

HD Equipment Progression

- 1967 – Gambro AK 1
- 1969 – Drake Willock 4215
- 1970 – Milton Roy Model BR
- 1971 – Gambro AK 3
- 1972 – B Braun HD 103
- 1972 - Marquardt REDY
- 1975 – Cobe Centry 2
- 1977 – Gambro AK 10
- 1978 – Extracorporeal SPS 350
- 1980 – Cobe Centry 2Rx
- 1981 – Cobe Centry 2000
- 1984 – B. Braun HD-secura
- 1984 - Drake Willock DWS-480
- 1984 - Fresenius 2008C
- 1984- Travenol SPS 450
- 1987 – Cobe Centrysystem 3
- 1988 – Baxter SPS 550
- 1991 – Baxter 1550
- 1991 - Althin System 1000
- 1992 – Fresenius 2008H
- 1995 – B. Braun Dialog
- 1996 – Gambro AK 95
- 1997 – Althin Tina

A New Therapy to Replace HD

- Although peritoneal dialysis had been around a long time (actually before HD) it was never considered to be a therapy for continuous dialysis of a patient.**
- The development of CAPD truly fits the quote, “Where there is a will, there’s a way.”**

Moncrief, Popovitch, Pilcher (1975)

- **The Team: (1975)**
 - Jack Moncrief – MD
 - Robert Popovich – Biomedical Engineer
 - Peter Pilcher - Patient

- **The Innovation:**
 - Continuous Ambulatory Peritoneal Dialysis

Moncrief and Popovich



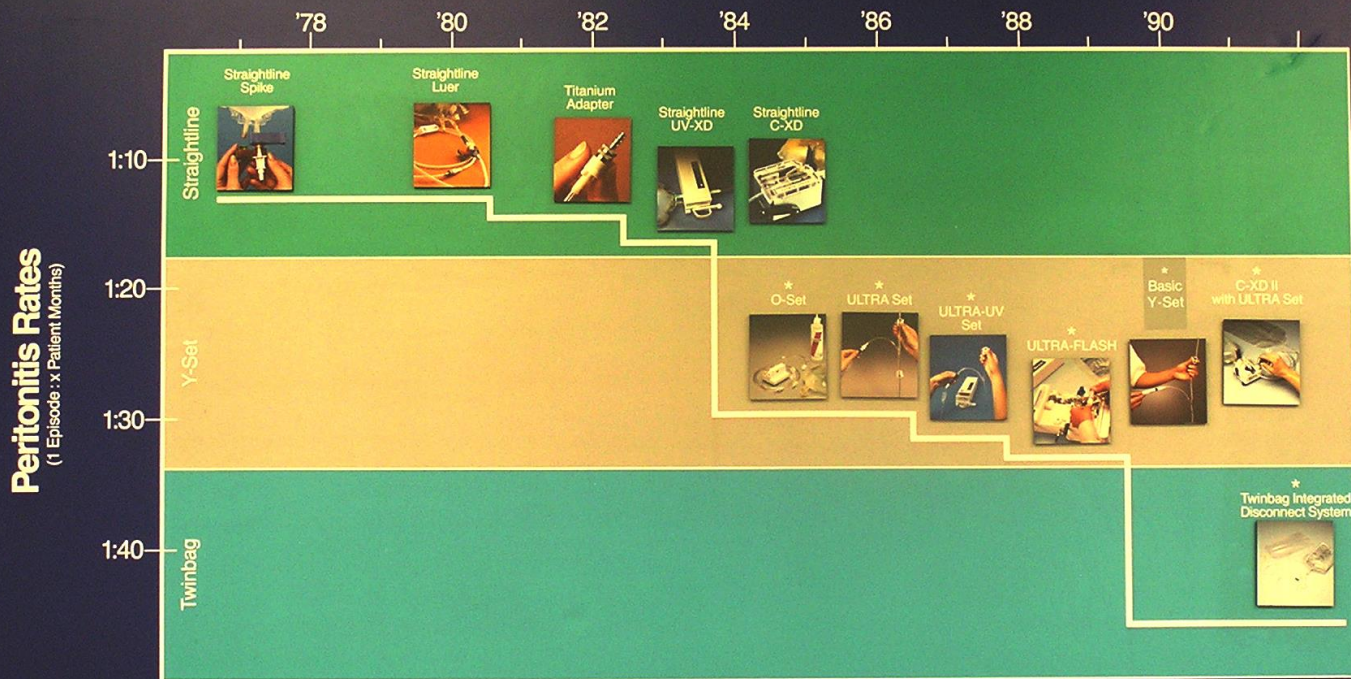
Photo: Genesis of the Artificial Kidney, Pat McBride, Baxter Healthcare, 1987, pg. 95

Peter Pilcher



Photo: PD Milestones Poster (5K9314), Pat McBride, Baxter Healthcare Corp.

Baxter CAPD System Innovation Worldwide Results in Improved Patient Safety and Convenience



*All products are not currently available in every country

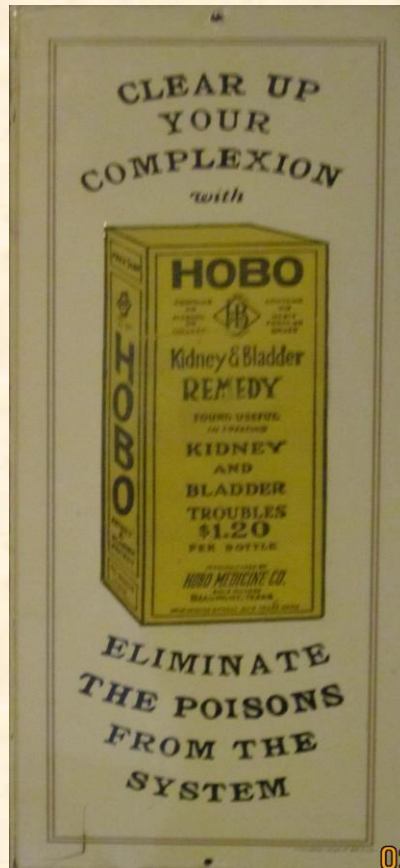
What needs Innovating in Your Facility?

- **Simplification of complex procedures.**
- **Updating of training materials for new employees.**
- **Reorganization of the storage area to make it more efficient.**
- **Action items list for when there's an emergency.**
- **Plan to reduce patient time spent in the waiting room.**

Qualities of Innovative People

- **Desire to fill a need.**
- **Knowledge of the subject.**
- **Don't mind asking for help.**
- **Possess organizational skills.**
- **Attitude to learn from experience.**
- **Discipline to follow through.**
- **Satisfaction in accomplishment.**

Where would we be without Innovation?



References

- ***History of the treatment of renal failure by dialysis*, J. S. Cameron, Oxford Press, copyright 2002, pp.32-43.**
- ***Genesis of the Artificial Kidney*, Patrick McBride, Baxter, copyright 1987, pp. 3,50,62.77.**
- ***The Introduction of CAPD*, Jack W. Moncrief, Trans Am Soc Artif Intern Organs, Volume XXXIV, 1988, pp.86-87.**
- ***Chronic Hemodialysis in Seattle: 1960-1966, Part I*, Belding H. Scribner and Albert L. Babb, DIALYSSIS & TRANSPLANTATION, Volume 11, Number3, March 1982, pp. 223-229**
- ***Laudation – Albert Leslie Babb, PhD, PE*, Twardowski, Hemodialysis International, Vol. 7, No. 4, 2003, pp.269-276**