Dialysis History of Innovation

NANT – Tuesday – 2/21/2017

John A. Sweeny
Old Dialysis Technician
St. Petersburg, Florida
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 replaces 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

A. Blood Inflow
B. Blood outflow
C. Anticoagulants
D. Thermometer
E. Support rod
F. Manifold
G. Jacket
H. Stand
I. Dialysis solution out
J. Dialysis solution in
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
Before.....

Photo from Global Education Museum – Largo, Florida
After....

Photo from Global Education Museum – Largo, Florida
The Kolff Brigham Kidney

Photo: Genesis of the Artificial Kidney, Pat McBride, Baxter Healthcare, 1987, pg. 25
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 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
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 9\textsuperscript{th}, 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

Photo: Genesis of the Artificial Kidney, Pat McBride, Baxter Healthcare, 1987, pg. 50
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

Photo: Genesis of the Artificial Kidney, Pat McBride, Baxter Healthcare, 1987, pg. 62
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

Baxter Dialysis Historical Museum – Largo, Florida
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 Centrystem 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 Innovational 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


