Nuclear Medicine: Past, Present, and Future

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Objectives:

- The origins of Nuclear Medicine
- Evolution of Cardiac, Bone, PET Imaging
- Future of Nuclear Medicine
What is Nuclear Medicine?

- The use of radioactive material in the diagnosis and treatment of disease
- Sealed vs unSealed sources
- Tracer Principle
X-ray and Computed Tomography vs Nuclear Medicine

- X-ray – Structural
- Nuclear Medicine – Functional
What do we use

- Radiopharmaceuticals
  - For diagnosis and treatment
  - Isotopes
    - Alpha and beta rays good for therapy
    - Gamma rays are used to image organs
- Gamma Camera
  - Used to image the radiopharmaceutical in the body
Where did Nuclear Medicine Come from?

- Pioneers in nuclear medicine:
  - Henri Becquerel
  - Mari Curie
  - Henri Alexandra Danlos and Eugene Bloch
    - In 1901 placed radium in contact with skin for TB
  - Alexander Graham Bell
    - 1903 suggested placing radium sources in or near tumors
  - Fredrick Proesher
    - Published the first study on the intravenous injection for therapy
Madame Curie
1867-1934

- THEORY OF RADIOACTIVITY (A TERM SHE COINED)
- TECHNIQUES FOR ISOLATING RADIOACTIVE ISOTOPES
- 1903 NOBEL PRIZE IN PHYSICS
- 1911 NOBEL PRIZE IN CHEMISTRY
George Hevesy
Noble Laureate Chemistry (1943)

- Hungarian Radiochemist and Nobel laureate
- Recognized for his key role in the development of radioactive tracers
- Obtain physiologic localization without any pharmacologic effect
- Used Pb to study the metabolism of plants
Where did Nuclear Medicine Come from?

- Different fields contribution – Physics, medicine chemistry, and engineering
- It’s unclear exactly when – 1930’s -1970
- 1934 – Artificial radioactivity first discovered
- 1946 – Radionuclides first produced for medical use by Oak Ridge National Laboratory
- 1946 – Sam Seidlin reported on the success of I-131 in treating a patient with advance thyroid cancer.
Brothers of Nuclear Medicine

Ernest O. Lawrence  John Lawrence
Mallinckrodt Institute of Radiology (MIR) cyclotron Facility can trace its roots to 1938 when Arthur L. Hughes suggested to build the first cyclotron dedicated to producing isotopes for medical and biological research.

Funded by the Rockefeller Foundation and completed in 1941, the cyclotron facility was located on the Washington University (WU) main campus.

In March 1942, the cyclotron facility established a precedent, producing P-32.
Dr. Samuel M. Seidlin

- Treated metastases of Adenocarcinoma of the Thyroid using I-131
- Most important Nuclear Medicine Paper Ever Written*

*according to Marshall Brucer
JAMA, Dec. 7, 1946
Figure 2. Changes in the appearance of patient B. B. from 1943, when radioiodine therapy commenced, to 1949, one year after cessation of demonstrable radioiodine uptake by metastases. (Reproduced with permission from Life, October 31, 1949.)
DISCOVERY OF TECHNETIUM-99m

- Glenn T. Seaborg
- Emilio Segre
MOLY-TC GENERATOR

- WALTER TUCKER
- MARGARET GREENE
Tc-99m: Progress

- 1937 Discovery of the element Tc
- 1947 Isolation of long-lived Tc-99
- 1958 Technetium Tc-99m Generator
- 1970 Instant One-step DTPA, HAS, & RBC kits
- 1978 Crystal structures of potential Tc radiotracers
- 1970s – present Radio tracers for high Capacity Process
- 2014 Technetium-99m is the most common radionuclide used in diagnosis, with >30 million procedures per year, accounting for >80% of all nuclear medicine procedures worldwide.
Imaging Instrument Pioneers

- The output was recorded on white paper with a series of black marks.
- A single moving radiation detector sampled the photon at a small region at a time.
- The intensity corresponded with the concentration of radioisotopes.
Examples of Rectilinear Scanner

Thyroid  |  Lung  |  Liver
Picker 3 Magnascanner
Hal O. Anger 1958

- Invented the scintillation camera in 1958
- Basic Design: NaI(Tl) crystal, PMT array, Position weighted signals
Evolution of Cardiac and Bone Imaging
EVOLUTION OF NUCLEAR CARDIOLOGY
EVO\LUTION OF NUCLEAR CARDIOLOGY

- Potassium-43
- RBC tagged
- Thallium-201
- Technetium-99m
- PET tracers
  - Rb-82
  - N-13
  - F-18
EVO LUT I O N O F NUC LEAR CARDIOLOGY

1972 REST/STRESS MYOCARDIAL PERFUSION IMAGING WITH POTASSIUM-43
EVO LUT I O N OF NUC LEA R CARDI OLOG Y

- Most common procedure
- Technology has been in use for over 25 yrs
EVO LUT I O N O F NUC LE AR C AR DIOLOG Y

- 21st Century
- 1st clinical Cadmium Zinc Telluride (CZT) based for cardiac imaging system
- Hardware and reconstruction
EVO LUT I O N O F NUC LEAR 
C ARDIO LO G Y

➢ ADVANTAGES
➢ ABILITIES
➢ REDUCED EXPOSURE
E V O L U T I O N O F N U C L E A R C A R D I O L O G Y

- Hybrid cardiac imaging
- PET/CT or SPECT/CT
- Improvements in software and hardware
EVO L U T I O N O F N U C L E A R M E D I C I N E
BONE SCAN

- Initial isotopes used:
  - F18, Sr85, and Sr87m
  - Tc99m labeled pyrophosphate
  - Scan time was double
EVOLUTION OF NUCLEAR MEDICINE

BONE SCAN

- Bone seeking radiopharmaceuticals
- HEDP
  - MDP – Most common

1990 TC 99m-MDP
Tc 99m-polyphosphate
EVO L U T I O N O F N U C L E A R M E D I C I N E
B O N E S C A N

- Clinical Indications

- F18- Fluoride 5-10 mCi (A higher dose of activity may be used for obese patients)

- PET/CT
FUSION TECHNOLOGY
Today’s Nuclear Medicine cameras

- SPECT-CT
- PET-CT
- D-Spect
The Future of Nuclear Medicine
THE FUTURE

- MOLECULAR IMAGING
  - What is it
  - More personalized to treatment
THE FUTURE

- BRAIN DISORDERS
  - AMYLOID
  - PARKINSON’S DISEASE
  - ALZHEIMER’S DISEASE
THE FUTURE

- MOLECULAR IMAGING
  - CANCERS
    - LYMPHOMA
    - LUNG
    - GI
    - COLONRECTAL
THE FUTURE

- THERAPY
- RADIOISO TOPE THERAPY
- TARGETED RADIO NUC LI DE THERAPY AND PROSTATE CANCER
- PEPTIDE REC EPTOR RADIO NUC LI DE THERAPY (PRRT)
- RADIO IM MUNO THERAPY
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“The only constant in life is change”

BUDDHA
“As scientists (technologists), we step on the shoulders of science, building on the work that has come before us aiming to inspire a new generation of young scientists (technologist) to continue once we are gone.”

STEPHAN HAWKING
1942-2018