IDMP 2014: Recognizing the Great Contribution of Medical Physics to Medical Imaging Progress

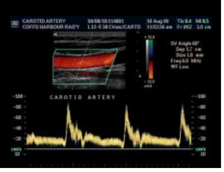
Prof. John Damilakis
IOMP Education and Training Committee Chair
EFOMP Vice-President and President Elect

AAPM Annual Meeting 2014 - Austin, TX

1842

Doppler Effect

Christian Andreas Doppler



1880

Piezoelectric Effect

Pierre and Jacques Curie

Wilhelm Roentgen

1895

X-rays

Henri Becquerel

Pierre and Marie Curie

1896

Radioactivity

Frederic and Irene Joliot-Curie

1930s

Artificial Radioactivity

John Hundale Lawrence

1930s

Leukemia Treatment

with P-32

John Lawrence with his brother Ernest

at the controls of a cyclotron

Emilio Segre

1937

Tc-99m

Felix Bloch

Edward Purcell

1946

NMR

1950s

Positron Imaging

A HISTORY OF POSITRON IMAGING

Gordon L. Brownell *
Physics Research Laboratory, Massachusetts General Hospital
Division of Radiological Sciences, Massachusetts Institute of Technology

The first application of positron annihilation radiation for medical imaging is well documented. In a discussion with William Sweet, then the Chief of the Neurosurgical Service at the Massachusetts General Hospital (MGH), in the early part of 1950, I made several suggestions to improve the quality of nuclear images for the detection of brain tumors and other brain diseases. In particular, I suggested that the use of annihilation radiation following positron emission might improve the quality of brain images by increasing sensitivity and resolution. The Physics Research Laboratory (PRL) at MGH had just been established under my direction and, with support from the Neurosurgical Service, a simple positron scanner using two opposed sodium iodide detectors was designed and built within six months. Imaging of patients with suspected brain tumors was commenced almost immediately. The results

1950s

1950s

H. Anger & B. Cassen

1951

Rectilinear Scanner

The first rectilinear scanner

H. Anger

1957

γ - camera

The first Tc-99m generator

1958

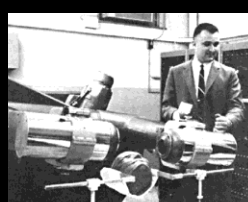
Mo-Tc Generator

1960s

Powell Richards and Walter Tucker

1960s

SPECT



David Kuhl

1960s

Ultrasound

William Fry

Peter Wells

1960s

1963

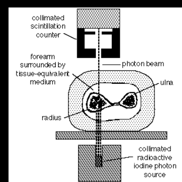
CT

Allan MacLeod Cormack

1963

SPA

John Cameron



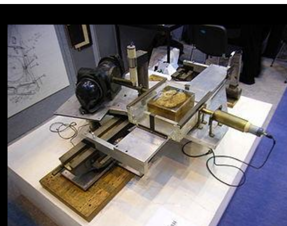
Science, 142:230-232, 1963

1965

Mammography

1971

CT



COMPUTED MEDICAL IMAGING

Nobel Lecture, 8 December, 1979

BY
GODFREY N. HOUNSFIELD
The Medical Systems Department of Central Research Laboratories EMI, London, England

THE EARLY TESTS

I decided to do some lab experiments with gamma rays to test if the system would work. The equipment was very much improvised. A lathe bed provided the lateral scanning movement of the gamma-ray source, and sensitive detectors were placed on either side of the object to be viewed which was rotated 1° at the end of each sweep. The 28,000 measurements from the detector were digitized and automatically recorded on paper tape. After the scan had been completed this was fed into the computer and processed.

Many tests were made on this machine, and the pictures were encouraging despite the fact that the machine worked extremely slowly, taking 9 days to scan the object because of the low intensity gamma source. The pictures took 2 ½ hours to be processed on a large computer. The results of

Fig. 3. Picture of the first brain scanned on Laboratory machine Fig. 2.

Fig. 5. First clinical picture obtained from prototype machine.

WHAT IMPROVEMENTS SHOULD WE EXPECT TO SEE IN THE FUTURE?

Various attempts have been made to achieve useful pictures of the heart. The time available for taking a picture of the heart is obviously longer than one heart beat. Some experiments were conducted some time ago using conventional CT machines but in which the traverse of the detectors was synchronised to the heart beat via an electro-cargiograph, passing over the heart in diastole (when the heart movement is at a minimum). Fig. 14 shows a picture from the experiment.

The heart chambers can be discerned by a little intravenous injected contrast media.

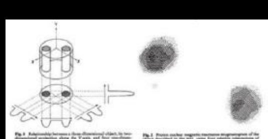
Another approach is being made at the Mayo clinic, Rochester, America, where a large machine is being constructed with 27 X-ray tubes designed to fire sequentially. It is hoped to take a sequence of pictures in a fraction of a second during one heart beat. However, the complexity and cost may rule out such a machine being used world-wide.

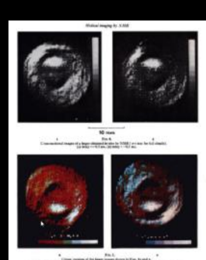
A further promising field may be the detection of the coronary arteries. It may be possible to detect these under special conditions of scanning.

Peter Mansfield Paul Lauterbur

1974

MRI





1975

PET

A Positron-Emission Transaxial Tomograph for Nuclear Imaging (PETT)[1]

Michel M. Ter-Pogossian, Ph.D., Michael E. Phelps, Ph.D., Edward J. Hoffman, Ph.D., and Nizar A. Mullani

An apparatus was developed for obtaining emission transaxial images of sections of organs containing positron-emitting radiopharmaceuticals. The detection system is a hexagonal array of 24 NaI(Tl) detectors connected to coincidence circuits to achieve the "electronic" collimation of annihilation photons. The image is formed by a computer-applied algorithm which provides quantitative reconstruction of the distribution of activity. Computer simulations, phantom and animal studies show that this approach is capable of providing images of better contrast and resolution than are obtained with scintillation cameras. Advantages of positron vs. single photon reconstruction tomography are discussed.

INDEX TERMS: Computers • Positron Imaging • Radionuclide Imaging, apparatus and equipment • Radionuclide Imaging, technique • Tomography, radionuclide

Radiology 114:89-98, January 1975

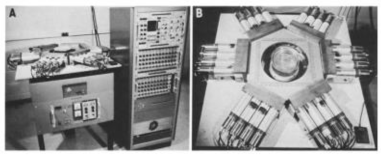
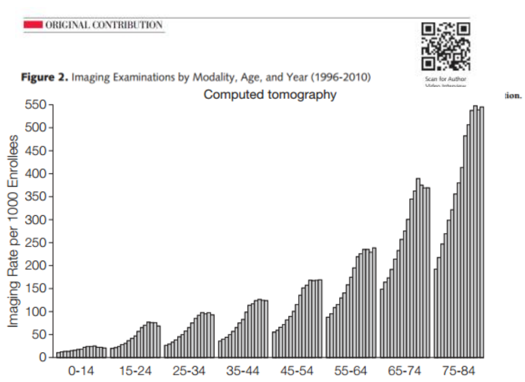
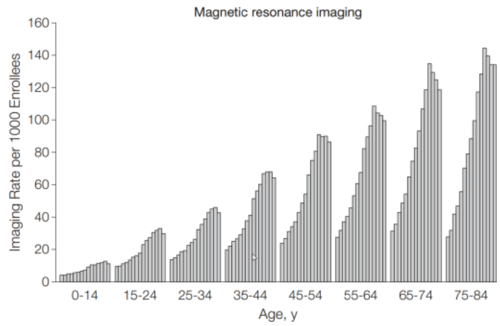


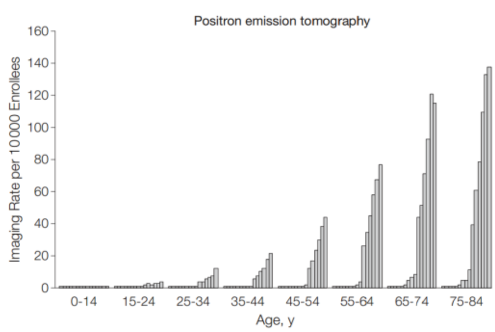
Fig. 2. A. Photograph of prototype PETT. The object examined (phantom or animal) is placed on a turntable at the center of the hexagon. The turntable rotates under computer control, with its axis of rotation perpendicular to the plane of the hexagon.
B. Phantom is shown on the turntable.

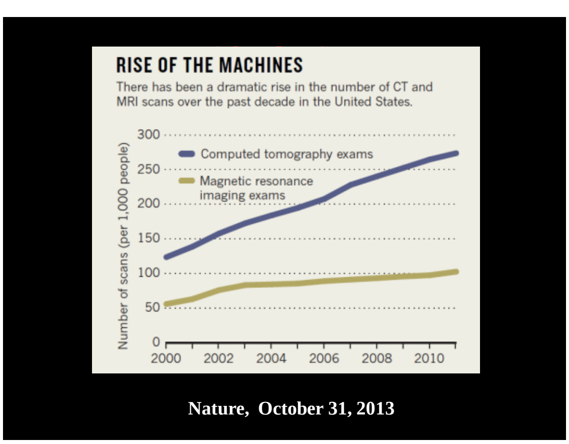
1990 - 2014

- **MDCT**
- **PET/CT**
- **PET/MR**
- **CBCT**
- **IGT**
- .
- .
- .
- .



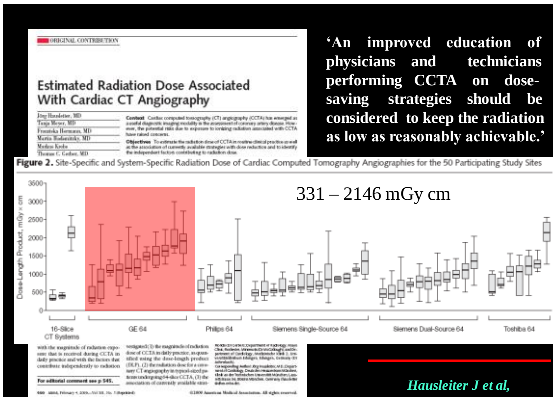

Magnetic resonance imaging
Imaging Rate per 1000 Enrollees
160
140
120
100
80
60
40
20
0
0-14
15-24
25-34
35-44
45-54
55-64
65-74
75-84
Age, y


Positron emission tomography
Imaging Rate per 10 000 Enrollees
160
140
120
100
80
60
40
20
0
0-14
15-24
25-34
35-44
45-54
55-64
65-74
75-84
Age, y


RISE OF THE MACHINES
There has been a dramatic rise in the number of CT and MRI scans over the past decade in the United States.
Computed tomography exams
Magnetic resonance imaging exams
Number of scans (per 1,000 people)
300
250
200
150
100
50
0
2000
2002
2004
2006
2008
2010
Nature, October 31, 2013

400 patients received radiation overdoses during perfusion CT of the brain

Food and Drug Administration (FDA) Website
http ://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/ucm185898 . htm



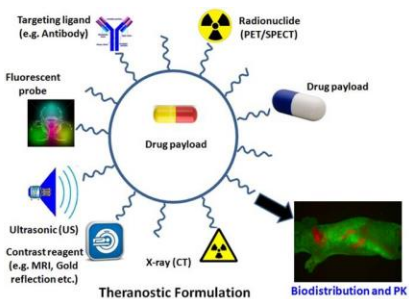
'An improved education of physicians and technicians performing CCTA on dose-saving strategies should be considered to keep the radiation as low as reasonably achievable.'

Hausleiter J et al,
JAMA 301: 500-507, 2009

The Future of

Medical Physics

Theranostics

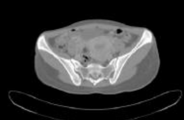


Radiogenomics

It is very important to use Genetics to identify cancer patients at risk for development of adverse effects following radiotherapy.

Individualized patient dose and risk assessment

in medical imaging with ionizing radiations



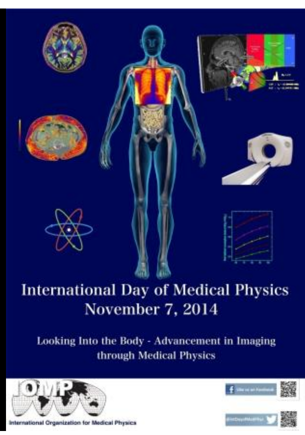
Clinical decision support (CDS) available at the point of care

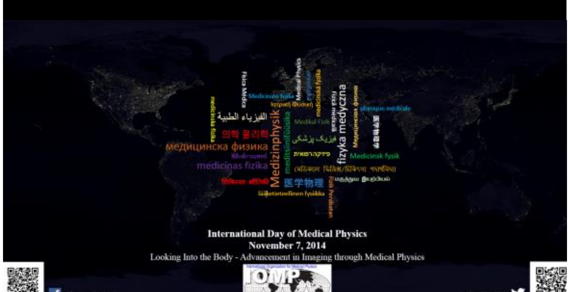
Who the MP is?

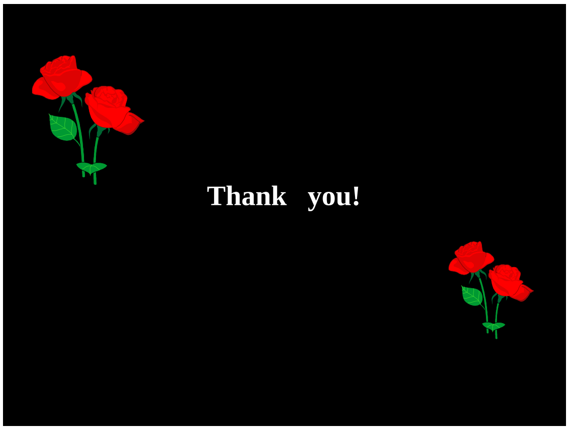
What he/she does?

How he/she does it?

Why so many people are unfamiliar with the MPs contribution to their care?






Thank you!